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Learning Unit 1

INTRODUCTION TO THE COURSE

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

HOW TO USE THE TRAINING COURSE

1. The 10 learning units are designed to be used together, as a series (the time needed to complete the full course is 36 hours) or separately as individual units in other management training programmes.

2. Each learning unit is devided into four sections:

- The *Introduction* outlines the objectives of the learning unit and the key learning points. At the end of the *Introduction* it is suggested that you take the short test in the last section, *Review,* and get a feeling for what you want to learn;
- The second section, *Study Materials,* is the body of the learning unit. The text presents the principal points of the learning unit and guides you to the *Reading Excerpts* at the end of the learning unit or to the relevant video. At the end of most topics a short test helps you to review and assess your comprehension of the material;
- The section entitled *Case Studies* presents one or more case studies designed to help you think about and discuss with your colleagues some of the issues and questions covered in the learning unit;
- The *Review* section contains a short test to help you review the learning unit and some ideas to stimulate thought and discussion about some of the policy implications of the learning unit.

3. The following equipment is required for use with the course: a VCR and a TV monitor; a personal computer (IBM-compatible); and an audiotape recorder/player. The VCR should play back PAL videos; it will be used with Learning Units 2-7 and 9. The personal computer will be needed for Learning Unit 8; the tape recorder/player will be used after all the Learning Units have been completed, as part of the learning recall process.

4. Whether you use one or all of the learning units, read Learning Unit 1, *Introduction,* after you have finished reading this instruction sheet.

5. The material can be studied without an instructor, in a small group, with a partner or alone. Alternatively, it can be taught by an instructor, with each learning unit taking about four or five hours to complete.

6. You should prepare a study plan for the course, preferably setting aside the same half day each week for each learning unit or setting aside one week if you want to complete the course in one stretch.

7. At the end of your study, complete the course appraisal in Learning Unit 10 and send it to the Environment and Energy Branch, United Nations Industrial Development Organization, P.O. Box 300, A-1400 Vienna, Austria. We in turn will send you a certificate acknowledging that you have completed the course.

Contents

Introduction

This training course is designed primarily for UNIDO field staff but is suitable for all staff of the United Nations as well as for anyone interested in industrial development.

Objectives

The objectives of the course are as follows:

- To examine the environmental impacts of industrial development.
- To understand ecologically sustainable industrial development (ESID) as an appropriate response to past and future trends in industrial development and the environment.
- To introduce Cleaner Production as a practical approach for achieving ESID.
- To become informed about the analytical tools that can be used to identify Cleaner Production opportunities.
- To become familiar with the economic analysis techniques that can be used to justify investments in Cleaner Production.
- To examine the potential role of Governments in encouraging the adoption of Cleaner Production.
- To recognize and use sources of information about Cleaner Production.
- To develop skills in incorporating environmental considerations into industrial development projects.
- To motivate further study.

UNIDO

UNIDO, established in 1967, is the lead agency for industrial development in the United Nations system. It promotes industrial development by means of technical assistance, training, the exchange of information, investment promotion, national and regional planning and institution-building, and the transfer of technology.

It is closely involved in the growing international cooperation on environmental matters related to small and medium-sized enterprises. At the Conference on Ecologically Sustainable Industrial Development, held at Copenhagen in October 1991, the representatives of member States said that one of the major directions for possible UNIDO action was to assist developing countries, upon request, in building the technical and scientific institutional capacity to develop, absorb and diffuse Cleaner Production techniques and technologies.

The environment and energy programmes of UNIDO are interlinked and complementary efforts to assist developing countries. UNIDO activities in support of these programmes are described in an information packet, *A Better World with Clean Industry*, published in July 1993.

Course Content

This course is taught in ten Learning Units (LUs):

LU1

Introduction provides a general overview of the course content and its objectives. It includes an introductory test to assess existing knowledge about the subject matter.

LU2

The Need For Ecologically Sustainable Industrial Development (ESID) explains the significance of trends in industrial development and the environment.

LU3

Defining Ecologically Sustainable Industrial Development presents the concept of ESID and the three criteria (eco-capacity, efficiency and equity) for measuring progress in achieving it. It also sets out the actions that industry can take to meet the criteria.

LU4

Cleaner Production explains the concept of Cleaner Production, describes many of the activities that constitute such production and outlines the advantages of and barriers to implementing Cleaner Production programmes in developing countries.

LU5

Analytical Tools for Identifying Cleaner Production Opportunities introduces techniques that may be profitable for enterprises and beneficial to the environment: waste reduction audits, environmental compliance audits, product life-cycle analyses and environmental impact assessments.

LU6

Economic Techniques for Assessing Cleaner Production Options introduces economic analysis techniques that can be used to justify investments in Cleaner Production: financial analysis, micro-economic impact analysis, benefit-cost analysis and macroeconomic impact analysis.

LU7

The Role of Government in Industrial Environmental Management describes the range of government activities that are used to manage the environment and discusses which of them are most effective for promoting Cleaner Production. It covers the basics of an environmental regulatory programme as well as innovative approaches such as economic incentives, multimedia permits, national sustainable development strategies and international agreements.

LU8

Sources of Information on Cleaner Production explains how to obtain information about Cleaner Production from UNIDO, the United Nations Environment Programme (UNEP) and many other sources.

LU9

Environmental Considerations in Project Design describes how UNIDO staff can incorporate environmental considerations into project designs consistent with the goals of the UNIDO environment programme, with the recommendations of the Conference on Ecologically Sustainable Industrial Development convened by UNIDO at Copenhagen, 14-18 October 1991, and with Agenda 21 of the United Nations Conference on Environment and Development (UNCED), held at Rio de Janeiro, 3-14 June 1992.

LU10

Review, with a Course Appraisal, provides a few exercises to help students recall the main points of the training course.

Integral to the course, and required for its completion, are the following materials, which are included in the kit:

- Excerpts for reading, generally chapters of books or portions of reports or journal articles, which are bound in at the back of each Learning Unit.
- A video cassette containing seven short films:
  - *Our Common Future*
  - *Greenbucks*
  - *Pollution Prevention: Swedish Experiences*
  - *Competitive Edge*
  - *Money Down the Drain*
  - *Development and the Environment: A New Partnership*
  - *Paper Forest*
- A floppy disc containing, MICRO-METADEX^{PLUS} and *Case Studies* from the International Cleaner Production Information Clearinghouse (ICPIC).
- A floppy disc containing the sample project document "Pollution prevention at the (name) industrial facility".
- *Cleaner Production Worldwide*, a UNEP booklet.
- *Audit and Reduction Manual for Industrial Emissions and Wastes*, a UNEP/UNIDO technical report.
- *Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century*, a booklet written by G. Heaton, R. Repetto and R. Sobin for the World Resources Institute.
- A learning recall tape (LRT).

Structure of the Learning Units

Each Learning Unit is divided into four sections:

The *Introduction* outlines the objectives of the Learning Unit and the key learning points. At the end of the *Introduction* it is suggested that you take the short test in the last section, *Review*, and get a feeling for what you want to learn.

The second section, *Study Materials*, is the body of the Learning Unit. The text presents the principal points of the Learning Unit and guides you to the *Reading Excerpts* at the end of the Learning Unit or to the relevant video. At the end of most topics a short test helps you to review and assess your comprehension of the materials.

The section entitled *Case Studies* presents one or more case studies designed to help you think about and discuss with your colleagues some of the issues and questions covered in the Learning Unit.

The *Review* section contains a short test to help you review the Learning Unit and some ideas that will stimulate thought and discussion about some of the policy implications of the Learning Unit.

The Learning Units have been designed to require about four hours study time apiece. The time, which includes that needed to read the body of the unit and the excerpts and to take the test, is estimated on the contents page of each Learning Unit. To work through the Learning Unit, simply start at the *Introduction* and follow the text and the *Next Steps* boxes, which will guide you along.

Acknowledgements

This training course is based on workshops held at Vienna by the Environment Coordination Unit of UNIDO, which on 1 January 1994 was absorbed into the Environment and Energy Branch, Industrial Sectors and Environment Division.

The course was designed by Ralph (Skip) Luken, Senior Environmental Advisor, with contributions from consultants R.G.A. Boland and Lyman Clark. Environment Coordination Unit staff members Robert O. Williams, Mats Zackrisson, Muki Daniel, Mari Ito and Silva Garabedian also contributed, as did other UNIDO staff: Jaroslav Navratil, Caj Falcke, Lech Kurowski, Ritu Kumar, Harriet Gabbert and Peter Pembleton. Five interns assisted in the effort: Jose Mario Carneiro, Jacques Demajorovic, Ulli Kastner, Philippe Leservoisier, and Anne-Sylvie Senechal.

Earlier versions of the course were reviewed by Fritz Balkau and John Kryger of the Industry and Environment Programme Activity Centre at the United Nations Environment Programme (UNEP) in Paris, Susan Becker of the United Nations Development Programme (UNDP) in New York and Klaus North and specialist staff of the International Labour Organisation (ILO) at Geneva and Turin.

Financial support for the development and production of the training course was provided by the Government of Norway.

Next Steps

1 On the following three pages are registration sheets. Please fill them out, taking some time to think about your objectives for the course and your reactions to the environmental policy statements.

2 When you have answered all of the questions, tear the three pages out and either give them to your instructor or mail them to the Environment Coordination Unit of UNIDO.

3 Then take the introductory test that follows the registration sheets.

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Registration Sheet

Basic Data

Date:

Location:

Name:

Organizational unit:

Previous Background

Please describe your relevant training and experience in environmental issues.

Your Course Objectives

1 What do you personally think about environmental issues? What does your organizational unit think?

2 Briefly, what is your present working knowledge of ESID?

3 Briefly describe a situation you faced in the last six months that involved industrial development and the environment. How did it arise? What did you do? What was the result? What did you feel?

4 Can you now identify two very specific things that you hope to gain from this course?

a.

b.

Environmental Attitudes

Please record your current opinion on each of the following statements on a scale of 10 (strongly agree) to 0 (strongly disagree):

1 Environment is of key importance for industrial development in most developed countries. __________

2 Environment is of key importance for industrial development in most developing countries. __________

3 ESID and Cleaner Production are realistic goals in developing countries. __________

4 Multinational corporations incorporate Cleaner Production in their activities in developing countries. __________

5 Environmental protection measures by industry are usually just cost without much benefit. __________

6 Waste minimization is a high industrial priority in developing countries. __________

7 The best way to achieve environmental protection by industry is strict enforcement of tougher environmental legislation. __________

8 Small and medium-sized industries in developing countries have nothing to gain from environmental concern. __________

9 Environmental protection is for the rich countries of the world. __________

10 The major industrial countries are willing to pay the developing countries for environmental protection measures. __________

11 Developing countries cannot afford the investment for Cleaner Production. __________

12 Developing countries perceive higher environmental standards as new trade barriers imposed by developed countries. __________

13 Pollution prevention always pays. __________

14 Technology is more important than training in helping developing countries to achieve ESID. __________

15 Developing countries have more important priorities than environmental concerns. __________

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Introductory Test

You will take this test now and again at the end of the course, in Learning Unit 10. At this point, you should do the test rapidly, perhaps by answering only the odd-numbered questions. Do not spend more than 60 minutes on this task. The test will serve as an introduction to the materials presented in this course and will help you assess your current knowledge of the subject matter. Compare your answers with those suggested.

LU2 The Need for Ecologically Sustainable Industrial Development

1 The developing countries' share of industrial output in 1990 was approximately

a. 10 per cent
b. 15 per cent
c. 20 per cent
d. 25 per cent

2 The region with the highest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia/South-East Asia
c. Latin America
d. Africa

3 The region with the lowest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia/South-East Asia
c. Latin America
d. Africa

4 Industry uses approximately

a. One fifth of the world's energy
b. One quarter of the world's energy
c. One third of the world's energy
d. One half of the world's energy

5 Emissions of CO_2 from fossil fuel burning are a major cause of

a. Greenhouse effect
b. Aquatic system damage
c. Ozone depletion
d. All of the above

6 Emissions of CFCs come from

a. Refrigerators
b. Solvents
c. Foams
d. All of the above

7 Acid rain results primarily from emissions of

a. Sulfur dioxide
b. Nitrogen oxides
c. Hydrocarbons
d. Particulate matter

8 All of the following are toxic heavy metals except

a. Mercury
b. Lead
c. Cadmium
d. Dioxin

9 The most polluting fuel per unit of energy is

a. Oil
b. Coal
c. Nuclear
d. Natural gas

10 The World Commission on Environment and Development called for

a. Zero economic growth
b. Economic growth that is equitable and compatible with the environment
c. Large-scale financial transfers to developing countries
d. Preservation of the world's resources

LU3 Defining Ecologically Sustainable Industrial Development

11 Sustainable development means meeting the needs of the present without

a. Compromising the needs of the future
b. Creating pollution problems for those over 60 years of age
c. Increasing population
d. Creating greenhouse effects

12 To achieve ESID, we need all of the following except

a. Eco-capacity
b. High GNP per capita
c. Efficiency
d. Equity

13 The critical load of industrial pollutants beyond which the quality of life and the proper management of natural assets are affected is called

a. Clean production limit
b. Effluent standard
c. Eco-capacity
d. Ambient environmental standard

14 Waste minimization is an objective of environmental

a. Eco-capacity
b. Equity
c. Economic analysis
d. Efficiency

15 The concept of a fair opportunity to share in the benefits of industrialization refers to

a. Efficiency
b. Eco-capacity
c. Dreams
d. Equity

16 The key to achieving ESID is

a. Transfer of clean technology
b. Government financial subsidies
c. Reduction of pollution intensity
d. Commitment to the Business Charter of the International Chamber of Commerce (ICC)

17 ESID is justified mainly by

a. Limited capacity for absorbing wastes from human activities
b. Shortage of natural resources
c. The need for new business ethics
d. UNCED

18 Agenda 21, chapter 30, "Strengthening the role of business and industry", calls for

a. Support of the Valdez Principles
b. Shipment of hazardous wastes to developing countries
c. Annual environmental reporting
d. Preparation of emergency response plans

19 The Rio Declaration is

a. A call for reform of the United Nations system
b. A statement of principles of sustainable development
c. A commitment to address climate change issues
d. Industry's response to sustainable development issues

20 Agenda 21 is

a. A global action plan to implement the Rio Declaration
b. A call for a new international order
c. A tropical forest action plan
d. A UNDP initiative for capacity building

LU4 Cleaner Production

21 The first step in improving Cleaner Production in industry is a change in

a. Technology
b. Customer preference systems
c. Attitudes
d. Legislation on recycling

22 Industrial environmental management has evolved through

a. Abatement to prevention to dilution
b. Prevention to dilution to abatement
c. Dilution to prevention to abatement
d. Dilution to abatement to prevention

23 The most cost-effective management choice for combating industrial pollution is

a. Prevention
b. Dilution
c. Abatement
d. Control

24 Cleaner Production eliminates waste

a. During production
b. At every stage of the life cycle of a product
c. By disposing of wastes safely in approved facilities
d. By recycling processing residues

25 Cleaner Production does not include

a. Better housekeeping
b. Ecologically benign products
c. Recycling of wastes by outside contractors
d. Low- and non-waste technology

26 From the practical business point of view, pollution prevention

a. Often pays
b. Does not pay
c. Has a long payback period
d. Is not possible

27 The implementation of Cleaner Production actions does not need

a. Training
b. Cooperation between government and industry
c. Change in management attitudes
d. Advanced technology

28 "Cleaner Production is just not realistic in developing countries where per capita GNP is below $1,000". This statement is

a. False
b. Correct
c. True
d. Helpful

29 The 10 steps for introducing Cleaner Production in an enterprise include all of the following except

a. Involvement of senior employees
b. Seeking government subsidies
c. Monitoring and evaluation
d. Disseminating information to employees

30 All of the following are barriers to Cleaner Production except

a. Lack of financial resources, awareness, training, expertise and know-how and access to existing knowledge
b. Uncertainty about the right information, technology and regulations
c. Attitudes of employees who feel threatened by change
d. Demonstration projects

LU5 Analytical Tools for Identifying Cleaner Production Opportunities

31 Pollution prevention opportunities may best be identified through

a. Environmental impact assessment
b. Waste reduction audit
c. Environmental compliance audit
d. Product life-cycle analysis

32 A waste reduction audit makes a detailed analysis of plant processes and wastes with the purpose of

a. Producing wastes
b. Completely eliminating wastes
c. Identifying wastes
d. Hiding wastes

33 A waste reduction audit is best described as

a. An input characterization
b. A material balance
c. A balanced financial statement
d. A least-cost production programme

34 The main purpose of an environmental compliance audit is to

a. Ensure that a firm is complying with environmental norms
b. Provide information to environmental management agencies
c. Meet the requirements of the Business Charter of ICC
d. Protect environmental quality

35 Conducting a waste reduction audit requires a commitment of

a. Top management
b. Supervisors
c. Workers
d. All of the above

36 A product life-cycle analysis considers

a. Only the design of a product
b. The potential for product recycling
c. All stages of production and consumption
d. The production process

37 The most controversial step in a product life-cycle analysis is

a. Cost analysis
b. Inventory analysis
c. Impact analysis
d. Improvement analysis

38 An environmental impact assessment predicts

a. Effects on the environment
b. Effects on production cost
c. Effects on management
d. Effects on pollutant discharge

39 Scoping for an environmental impact assessment means

a. Finding the best environmental location for a project
b. Identifying the major environmental impacts
c. Choosing the least-cost mitigation strategy
d. Finding the most qualified team of experts

40 All of the following are important principles in managing an environmental impact assessment except

a. Balancing the benefits and costs of mitigation measures
b. Involving the appropriate persons and groups
c. Linking information to decisions about the project
d. Presenting clear options for the mitigation of impacts

LU6 Economic Techniques for Assessing Cleaner Production Options

41 To justify a Cleaner Production investment, the economic technique that measures cash flows and profitability over a future period at the plant level is

a. Financial analysis
b. Micro-economic analysis
c. Macroeconomic analysis
d. Environmental impact assessment

42 A payback period of one year is equivalent to a

a. 25 per cent return on capital
b. 50 per cent return on capital
c. 100 per cent return on capital
d. 200 per cent return on capital

43 Payback analysis is a limited measure of investment because it fails to account for

a. Economic life of the investment
b. Income tax
c. Present value of cash flows
d. All of the above

44 The technique that estimates the economic impact of Cleaner Production investment at an industry level is

a. Environmental impact assessment
b. Micro-economic analysis
c. Macroeconomic analysis
d. Financial analysis

45 Micro-economic impact analysis examines all of the following except

a. Plant closure
b. Product price increases
c. Capacity expansion
d. Balance of payments

46 The economic technique that measures the cost of a Cleaner Production activity against possible benefits is

a. Marginal cost analysis
b. Financial analysis
c. Macroeconomic analysis
d. Benefit-cost analysis

47 The main difficulty with benefit-cost analysis is usually

a. Quantifying health effects
b. Estimating the costs
c. Valuing the benefits
d. Arithmetical

48 In environmental benefit-cost analysis, values can be

a. Market values based on prices and cost savings
b. Surrogate values based on land values, wage premiums, travel costs etc.
c. Survey values
d. All of the above

49 To justify a Cleaner Production investment, the economic tool that measures the effect of environmental expenditures on GDP, consumer prices and unemployment is

a. Environmental impact assessment
b. Micro-economic analysis
c. Macroeconomic analysis
d. Financial analysis

50 Expenditure on pollution prevention and control in most developed countries accounts for

a. 2 per cent of GDP
b. 5 per cent of GDP
c. 8 per cent of GDP
d. 10 per cent of GDP

LU7 The Role of Government in Industrial Environmental Management

51 The concept of market failures in environmental management refers to

a. State ownership of enterprises
b. Subsidies for energy use
c. Accelerated depreciation for pollution control equipment
d. Treating environmental resources as free goods

52 An example of policy failure in environmental management is

a. Absence of environmental laws
b. Subsidies for water use
c. Absence of a national environmental action plan
d. Subsidies for building municipal waste-water treatment plants

53 One essential environmental management activity that needs to be undertaken by Governments is

a. Support for environmental non-governmental organizations (NGOs)
b. Tax credits to industry for installing pollution control equipment
c. Collection and dissemination of environmental data
d. A ministerial appointment for the head of the environmental management agency

54 An effective command-and-control regulatory programme requires

a. Issuing discharge permits
b. Monitoring compliance
c. Enforcing permit conditions
d. All of the above

55 A multimedia approach to environmental management means

a. Using both command and control regulations and economic incentives
b. Documenting pollution problems with a video film
c. Using both self-monitoring and independent inspections to ensure compliance
d. Simultaneously regulating pollutant discharges to air, water and soil

56 Economic incentives include all of the following except

a. Effluent taxes
b. Marketable permits
c. Corporate income taxes
d. Deposit refund schemes

57 Economic incentives can

a. Promote least-cost solutions
b. Provide flexibility in pollution control technology
c. Stimulate the development of technology
d. All of the above

58 An essential component of a national sustainable development strategy is

a. Funding environmental research
b. Signing international protocols
c. Reducing pollutants in all sectors (agriculture, industry etc.)
d. Setting qualitative targets to be met at some unspecified time

59 The Montreal Protocol calls for

a. Information exchange on ozone depletion
b. Research on ozone depletion
c. Prior approval for the transboundary shipment of hazardous wastes
d. Limits on the production and consumption of ozone-depleting substances

60 A government action that directly encourages Cleaner Production is

a. A national strategy for sustainable development
b. Economic incentives
c. Negotiated environmental compliance that allows for innovation
d. Multimedia environmental permits

LU8 Sources of Information on Cleaner Production

61 The information system that supports 70 focal points around the world is

a. INTIB
b. IE/PAC
c. REED
d. ICPIC

62 Data on UNIDO energy- and environment-related industrialization activities in developing countries are obtained from UNIDO via

a. METADEX
b. REED
c. Energy Technology Clearinghouse
d. ICPIC

63 The name of the UNEP on-line pollution prevention clearinghouse is

a. Pollution Prevention Information Clearinghouse
b. Awareness and Preparedness for Emergencies at a Local Level (APELL)
c. ICPIC
d. Energy and Environment Information Systems

64 A United Nations-sponsored source of data on hazardous chemicals and health is

a. INTIB
b. IRPTC
c. International Occupational Safety and Health Information Centre
d. REED

65 One source of information in setting up a national environmental management association for enterprises is

a. World Environment Centre
b. Business Council for Sustainable Development
c. International Network for Environmental Management Organizations (INEM)
d. World Industry Council for the Environment (WICE)

LU9 Environmental Considerations in Project Design

66 The United Nations organization that has prepared guidelines for the rapid assessment of sources of air, water and land pollution is

a. World Health Organization (WHO)
b. UNIDO
c. UNEP
d. UNDP

67 The UNIDO *Guidelines for Environmental Appraisal* are most useful at which stage of the project cycle?

a. Design
b. Identification
c. Approval
d. Evaluation

68 All of the following measures might be appropriate environmental measures for projects without capital implications except

a. Environmental awareness
b. Technology change
c. Training
d. Information management

69 All of the following measures might be appropriate environmental measures for projects with capital implications except

a. Information management
b. Good housekeeping
c. Process changes
d. Treatment and disposal of wastes

70 The UNDP *Handbook and Guidelines for Environmental Management and Sustainable Development* focuses on

a. Identifying environmental problems
b. Assessing environmental impacts
c. Designing environmental management agencies
d. Planning technical assistance

Answers to questions 1-70

1-10	*b b c c a d a d b b*
11-20	*a b c d d c a c b a*
21-30	*c d a b c a d a b d*
31-40	*b c b a d c c a b a*
41-50	*a c d b d d a d c a*
51-60	*d b c d d c d c d c*
61-70	*a b c b c a a b a d*

Further information may be obtained from:

Environment and Energy Branch, UNIDO
Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49

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- The *Introduction* outlines the objectives of the learning unit and the key learning points. At the end of the *Introduction* it is suggested that you take the short test in the last section, *Review*, and get a feeling for what you want to learn;
- The second section, *Study Materials*, is the body of the learning unit. The text presents the principal points of the learning unit and guides you to the *Reading Excerpts* at the end of the learning unit or to the relevant video. At the end of most topics a short test helps you to review and assess your comprehension of the material;
- The section entitled *Case Studies* presents one or more case studies designed to help you think about and discuss with your colleagues some of the issues and questions covered in the learning unit;
- The *Review* section contains a short test to help you review the learning unit and some ideas to stimulate thought and discussion about some of the policy implications of the learning unit.

3. The following equipment is required for use with the course: a VCR and a TV monitor; a personal computer (IBM-compatible); and an audiotape recorder/player. The VCR should play back PAL videos; it will be used with Learning Units 2-7 and 9. The personal computer will be needed for Learning Unit 8; the tape recorder/player will be used after all the Learning Units have been completed, as part of the learning recall process.

4. Whether you use one or all of the learning units, read Learning Unit 1, *Introduction*, after you have finished reading this instruction sheet.

5. The material can be studied without an instructor, in a small group, with a partner or alone. Alternatively, it can be taught by an instructor, with each learning unit taking about four or five hours to complete.

6. You should prepare a study plan for the course, preferably setting aside the same half day each week for each learning unit or setting aside one week if you want to complete the course in one stretch.

7. At the end of your study, complete the course appraisal in Learning Unit 10 and send it to the Environment and Energy Branch, United Nations Industrial Development Organization, P.O. Box 300, A-1400 Vienna, Austria. We in turn will send you a certificate acknowledging that you have completed the course.

Learning Unit 2

THE NEED FOR ECOLOGICALLY SUSTAINABLE INDUSTRIAL DEVELOPMENT

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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Contents

Additional Course Material

Video: *Our Common Future*, a film by the Centre for Our Common Future

Introduction

Learning Unit 2 is designed to acquaint you with environmental problems that have led to a worldwide call for ecologically sustainable industrial development (ESID). It also contains a glossary of environmental terms that may be useful to you throughout the course.

Objectives

The specific learning objectives of this unit are as follows:

- To relate trends in economic development since 1970 to the most important industry-related environmental issues.
- To describe the main environmental problems that result from industrial development.
- To begin to use the language of environmental management.

Key Learning Points

1 Past development trends have resulted in very limited well-being for developing countries. In 1992, 80 per cent of the world population received only about 20 per cent of the world's income and produced only a small share of industrial output.

2 Industrial activity is a major contributor to environmental deterioration.

3 It currently seems inevitable that both global population numbers and per capita income will increase. The challenge we face is to reconcile the demands of population growth, the desire for continued industrial development and the need to preserve our environment.

4 We must find new approaches to industrial development, both in developed and developing countries, that will allow us to preserve the ability of our environment to sustain us. In short, we must achieve ecologically sustainable industrial development.

5 The only way to do this is to reduce the "pollution intensity" of industrial activities.

Suggested Study Procedure

1 Look at the test at the beginning of the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.

2 Work through the *Study Materials*, including the *Reading Excerpts* and the video.

3 Prepare answers to the questions posed for the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

4 Complete the exercises in the *Review*.

Study Materials

This Learning Unit is designed to help you become familiar with worldwide environmental problems that have prompted the call for ecologically sustainable industrial development. Learning Unit 2 contains information on economic and environmental trends, water pollution, atmospheric pollution, toxic chemicals and hazardous wastes, acidification and global climate change.

Economic Trends

Since 1970, overall world industrial output (manufacturing value added, or MVA) grew at about 3.6 per cent annually, compared with a population increase of about 1.8 per cent.

Compare the average annual growth rates, 1970-1990, in developed and developing countries:

Region	MVA	**Population**
Developed countries	3.1%	0.7%
East Asia/South-East Asia	9.1%	2.1%
Latin America	1.0%	2.1%
Africa	2.1%	3.0%

The growth in industrial output of developing countries failed to meet expectations. Overall, their share of global industrial output, in current prices, increased from only 9.3 per cent to 13.8 per cent between 1970 and 1990, mainly in the years 1970-1980.

This small share of global industrial output was achieved by only a few developing countries. Thus, 60 per cent of the growth was achieved by 12 of the 118 countries and 80 per cent by 18 of them.

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Environmental Trends

While there are natural emissions of most major pollutants, industrialization is still a major threat to the biosphere.

Emissions of carbon dioxide (CO_2) from fuel burning are a primary contributor to the greenhouse effect.

Emissions of chlorofluorocarbons (CFCs) from refrigerators and air-conditioners, solvents and plastic foam blowing are major causes of the "ozone hole", leading to ultraviolet radiation, skin cancers, loss of immunity, crop/fishery yield reduction, smog etc.

Emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_X) create acidity in the natural environment (freshwater lakes, rivers, forests and soils) and the deterioration of metal and building structures etc.

Emissions of toxic chemical substances, heavy metals (lead, cadmium, mercury and arsenic) and aromatic polychlorinated compounds (PCBs, pentachlorophenol, dioxin) threaten aquatic ecosystems and soils in whole regions and seas.

Industry is a major contributor to these environmental concerns with its manufacturing, mining, utilities and construction activities. The table on the next page summarizes the environmental effects of some of the major industrial polluters.

For a long time such energy- and pollution-intensive industries were confined mainly to developed countries, but they are now growing twice as fast in developing countries.

Table 1. Environmental Effects of Selected Industrial Sectors

			Water resources				
Industrial sector	**Raw material use**	**Air**	**Quantity**	**Quality**	**Solid wastes and soil**	**Risk of accidents**	**Other (noise, workers' health and safety, consumer products)**
Textiles	Wool, synthetic fibres, chemicals for treating	Particulates, odours, SO^2, HC	Process water	BOD, suspended solids, salts, sulphates, toxic metals	Sludges from effluent treatment		Noise from machines, inhalations of dust
Leather	Hides, chemicals for treating and tanning		Process water	BOD, suspended solids, sulphates, chromium	Chromium sludges		
Iron and steel	Iron ore, limestone, recycled scrap	Major polluter: SO^2, particulates, NO_x, HC, CO, hydrogen sulphide, lead, and mists	Process water	BOD, suspended solids, oil, metals, acids, phenol, sulphides, sulphates, ammonia, cyanides, effluents from wet-gas scrubbers	Slag, wastes from finishing operations, sludges from effluent treatment	Risk of explosions and fires	Accidents, exposure to toxic substances and dust, noise
Petrochemical refineries	Inorganic chemicals	Major polluter: SO^2, HC, NOx, CO, particulates, odours	Cooling water	BOD, COD, oil, phenols, chromium, effluent from gas scrubbers	Sludges from effluent treatment, spent catalysts, tars	Risk of explosions and fires	Risk of accidents, noise, visual impact
Chemicals	Inorganic and organic chemicals	Major polluter: organic chemicals (benzene, toluene), odours, CFCs		Organic chemicals, heavy metals, suspended solids, COD, cyanide	Major polluter: sludges from air and water pollution treatment, chemical process wastes	Risk of explosions, fires and spills	Exposure to toxic substances, potentially hazardous products
Non-ferrous metals (e.g. aluminium)	Bauxite	Major local polluter: fluoride, CO, SO^2, particulates		Gas scrubber effluents containing fluorine, solids and hydrocarbons	Sludges from effluent treatment, spent coatings from electrolysis cells (containing carbons and fluorine)		
Micro-electronics	Chemicals (e.g. solvents, acids)	Toxic gases		Contamination of soils and groundwater by toxic chemicals (e.g. chlorinated solvents), accidental spillage of toxic material			Risk of exposure to toxic substances
Biotechnology				Used for effluent treatment	Used for clean-up of contaminated land		Fears of hazards from the release of micro-organisms into the environment

Source: *The State of the Environment* (OECD, 1991).

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The Challenge: To Develop Industry While Protecting the Environment

The challenge is to reconcile the demands of population growth, the desire for continued industrial development and the need to protect our environment.

Trends	**1900-1990** (actual)	**1990-2040** (projected)
Population	4x	2x
Economic activity	20x	3.5x
Fossil fuel use	30x	3x
Industrial production	50x	3x

Past development trends have resulted in very limited well-being for developing countries. In 1992, 80 per cent of the world population received only about 20 per cent of the world income and produced only a small share of industrial output.

In 1990, WHO admitted that the goal of health for all by the year 2000 could not be achieved under the existing world conditions of poverty and inequality. Will UNIDO find in the year 2000 that environmental protection cannot be achieved under such conditions?

New approaches to industrial development must be found, both in developed and developing countries, that will allow us to preserve the ability of our environment to sustain us. In short, we must achieve ecologically sustainable industrial development.

Next Steps

1 Look at the questions below.

2 Read the excerpt from "The road to ecologically sustainable industrial development", included at the end of this Learning Unit.

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What is industry's share of fossil fuel combustion? Is this share increasing or declining?

2 The anthropogenic emissions of which heavy metal dramatically exceed its emissions from natural sources?

3 What are the "smokestack" industries? During 1970-1988, how did the growth of smokestack industries in developing countries compare with their growth in developed countries?

4 Is industry the sector that uses the most water?

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5 What is the difference between ambient standards and total loading standards?

6 In 1985, what were the industrialized countries' share of emissions of CO_2, CFCs and SO_2?

Answers

1. *About 33 per cent. Worldwide, industry's share is declining, but in many developing countries it is increasing.*
2. *Lead.*
3. *Smokestack industries are the most energy-, material- and pollution-intensive industries. They include iron and steel, non-ferrous metals, non-metallic minerals, pulp and paper and chemicals. In 1970-1988, the smokestack industries grew faster in developing countries than in developed countries; in 1980-1985, they grew twice as fast.*
4. *No, in most countries, agriculture is the biggest water user, but industry pollutes the water more.*
5. *Ambient standards were formulated to protect local environments. They focus on ambient concentrations of single pollutants. Total loading standards focus on the cumulative stock of pollutants in the environment.*
6. *CO_2—50%; CFCs—70%; SO_2—40%.*

Next Steps

1 Look over the questions below so that you have some idea of what you will want to learn from the video.

2 Watch the video *Our Common Future.*

3 Test your comprehension of the video by answering the questions below. Compare your answers with those suggested.

Questions

1 What are some of the unintended environmental consequences of development?

2 How did the World Commission on Environment and Development (WCED) define sustainable development?

3 What did WCED call for? Do you think this is a controversial statement?

4 Is protection of the environment incompatible with economic growth?

5 Does WCED believe that the world has the potential to achieve sustainable development?

Answers

1. *Global warming, ozone depletion, acid rain and deforestation.*
2. *Sustainable development was defined as meeting the needs of the present without compromising our ability to meet those of the future.*
3. *WCED called for a new era of economic growth that is more equitable and more responsive to environmental limits. This conclusion is controversial because many say that "zero" growth and large-scale financial transfers are the only actions that are compatible with environmental limitations. WCED, however, argues that growing populations and poor populations require goods and services to meet their essential needs and that only economic growth can meet those needs.*
4. *No, protection of the environment is a sound economic investment needed to help living standards rise. Long-term economic growth is not possible if it destroys the natural resource base on which it is based.*
5. *Yes, WCED believes it technically possible to use less energy and resources to produce more goods and to grow enough food without destroying the natural resource base.*

Understanding Environmental Problems

Next Steps

This section and the associated *Reading Excerpts* are designed to acquaint you with the major environmental problems associated with industrial development. For those familiar with environmental problems, it may not be necessary to read this section. For those not familiar with environmental problems, the following *Study Materials* will serve as an introduction and the *Reading Excerpts* may be read at another time.

Global Climate Change

The natural concentration of CO_2 in the atmosphere is controlled by the interactions between the atmosphere, the oceans and the biosphere in what is known as the geochemical carbon cycle. Human activities can disturb this cycle by injecting additional CO_2 into the atmosphere, thereby aggravating the natural greenhouse effect. Over the past 100 years, the global mean temperature has risen by 0.3° to 0.6°C. A doubling of atmospheric concentrations of CO_2 is expected to increase the global mean temperature in the range of 1.5° to 4.5°C.

It has been thought that CO_2 was the only greenhouse gas. However, research over the last two decades has found that other gases such as nitrous oxide, methane, chlorofluorocarbons (CFCs) and tropospheric ozone may also be greenhouse gases.

Ozone Depletion

In contrast to the harmful ozone formed as a photochemical oxidant at ground level (tropospheric ozone), ozone in the stratosphere, between 25 and 40 km above the earth's surface, is a natural filter that absorbs and blocks the sun's short-wave-length ultraviolet (UV-B) radiation, which is harmful to life.

CFCs are used as propellants and solvents in aerosol sprays; as fluids in refrigeration and air-conditioning equipment; as foam-blowing agents in plastic foam production; and as solvents, mainly in the electronics industry. Studies in the 1980s showed that emissions of bromine can also lead to a significant reduction in stratospheric ozone. Bromofluorocarbons are widely used to extinguish fires, and ethylene dibromide and methyl bromide are used as fumigants.

Acidification

Acidification refers to the gradual increase in acidic conditions in soils, forests and lakes. Such an increase occurs in urban environments as well where it contributes to the deterioration of metals and stone. Acid deposition may be absorbed, even in sensitive areas, by the natural buffering capacity of the environment. However, the onset of acid conditions in an environment may occur long after an increase in acid deposition.

The main anthropogenic source of acid-forming gases, primarily SO_2 and NO_x, is the burning of fossil fuels. Additional sources include metal ore smelting, sulphuric acid manufacture and other industrial processes.

Toxic Chemicals and Hazardous Wastes

All chemicals are toxic to some degree. The health risks from a chemical depend mainly on its toxicity and on the exposure. Only a few parts per billion of a highly toxic compound like dioxin may constitute a threat to health after only brief exposure. In contrast, only high doses of compounds like iron oxide or magnesium carbonate pose problems after extended exposure. An important development has been the shift from a focus on just the acute effects of chemicals to a focus on their chronic effects as well. These chronic effects include birth defects, genetic and neurological disorders and cancer.

Although the term "hazardous" has different connotations among countries, it is widely applied to wastes containing metallic compounds, halogenated organic solvents, organohalogen compounds, acids, asbestos, organophosphorus compounds, organic cyanides and phenols. Most hazardous wastes are produced by industry, but it is now recognized that there are hundreds of thousands of facilities that generate hazardous wastes. These include households, medical facilities, garages and auto-repair workshops, petrol stations and small-scale industries and businesses.

Atmospheric Pollution

Air pollution refers to gaseous or particulate contaminants in quantities, characteristics or durations that are injurious to human, plant or animal life or to property. The combustion of fossil fuels, both for power generation and transportation, is the major source of atmospheric pollution.

The previously known common airpollutants are SO_2, NO_x, suspended particulate matter (SPM), hydrocarbons (HC), carbon monoxide (CO) and lead (Pb). More recently, research has demonstrated the adverse effects of volatile organic compounds and trace metals. Both particulate matter and lead are serious threats to human health in the rapidly urbanizing areas in developing countries.

Water Pollution

Some water pollutants, such as organic wastes from agro-industries and human settlements, are easily decomposed into substances that are normally harmless. However, at high concentrations, they may seriously disturb the ecosystem. Other pollutants, such as metals and persistent organic compounds, cannot be degraded; they usually remain adsorbed on bottom sediments near the source of discharge. Some organisms have a remarkable ability to accumulate such pollutants, even when they are present in extremely low concentrations.

Both the atmosphere and rivers contribute to marine pollution. The atmospheric pathway accounts for more than 90 per cent of the lead, cadmium, copper, iron, zinc, arsenic nickel, PCBs, DDT and hexachlorofluorohexane found in the waters of the open ocean. The chief contaminant of fresh waters is untreated or inadequately treated waste water from cities and industrial plants. Contaminants from agricultural lands, forests and roads can be significant in rural areas.

Next Steps

1 Look at the questions below.

2 Read the *Reading Excerpts* on Understanding Environmental Problems.

3 Test your comprehension of the information presented below by answering the questions below. Compare your answers with those suggested.

Questions

1 Name five greenhouse gases.

2 Which of these causes the most harm?

3 Name two natural carbon sinks.

4 What are the two kinds of ozone? What is the difference between them?

5 How do CFCs affect the ozone layer?

6 Name six uses of ozone-depleting substances.

7 Name four adverse health and environmental risks resulting from increased UV-B radiation.

8 What is the major cause of acid deposition?

9 What are the four main adverse effects of acid deposition?

10 List two heavy metals of environmental concern.

11 Give three examples for the direct release of chemicals and three for their indirect release.

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12 List some health effects associated with exposure to toxic chemicals.

13 List three common air pollutants along with their chemical names or their acronyms.

14 What is the primary source of common air pollutants?

15 Name two air pollutants of special concern in cities.

16 Describe the health effects that result from burning biomass.

17 Name two land-based toxic pollutants that affect coastal areas.

18 Why do small quantities of metals and persistent organic compounds cause a problem in aquatic environments?

19 Describe two types of contamination of fresh water that can be partially attributed to industrial activities.

Answers

1. CO_2, nitrous oxide, methane, CFCs and tropospheric ozone.

2. CO_2.

3. The ocean and the forests.

4. Tropospheric ozone exists at the ground level and is harmful. Stratospheric ozone exists between 25 and 40 km above the earth's surface and serves as a filter against ultraviolet radiation.

5. They are destroyed by ultraviolet radiation and the resulting elements destroy the stratospheric ozone (chemical chain reaction).

6. Aerosol sprays, solvents, foam production, fire extinguishers, refrigerator fluids and fumigants.

7. Negative effects on the human immune system, on maritime organisms and on some plants, and increased risk of skin cancer.

8. Fossil fuel combustion.

9. Decline in the forests, acidification of inland waters, direct and indirect impacts on human health and corrosion of metals and erosion of stone and paint.

10. Lead, mercury.

11. Direct release: use of pesticides, fertilizers, solvents. Indirect release: mining, incineration, fuel combustion.

12. Cancer, birth defects, genetic and neurological disorders.

13. Carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x).

14. Combustion of fossil fuels.

15. Lead and suspended particulate matter.

16. The most important effects are chronic obstructive pulmonary disease and naso-pharyngeal cancer.

17. Cadmium and arsenic.

18. Some marine organisms accumulate these substances and some convert them into more toxic ones.

19. Contamination by heavy metals and acidification.

Next Steps

A glossary of environmental terms is provided at the end of this Learning Unit. Read through the definitions in the *Glossary* and then answer the questions below.

Exercise

Locate the technical term for each of the following in the *Glossary*:

1 The level of atmospheric pollutants prescribed by regulations that may not be exceeded during a specified time in a defined area.

2 The amount of oxygen consumed in the biological processes that break down organic matter in water.

3 Treating pollutants at the end of a process, by filters, catalysts or scrubbers, instead of preventing their occurrence.

4 The slow aging process in which a lake, estuary or bay becomes a bog or marsh and eventually disappears.

5 A site used to dispose of solid wastes without environmental controls.

6 Minimizing the generation of waste by recovering usable products that might otherwise become waste.

7 A pollutant remaining in the environment after a natural or technological process has taken place.

8 An air pollution control device that uses a spray of water or reactant or a dry process to trap pollutants in emissions.

9 Market mechanism for controlling pollution; it entails issuing permits to pollute up to fixed limits and grants the right to sell unused portions of these permits.

Answers

1. Air quality standard.
2. Biochemical oxygen demand.
3. End-of-pipe treatment.
4. Eutrophication
5. Dump.
6. Recycling.
7. Residual.
8. Scrubber.
9. Tradeable permits.

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Additional Suggested Reading

This concludes the study section of Learning Unit 2. For additional information on global environmental problems, you may refer to the following sources.

UNEP, *The World Environment 1972-1992: Two Decades of Challenge*, M.K. Tolba and others, eds. (London, Chapman and Hall, 1992).

UNIDO, *Industry and Development: Global Report 1990/91* (UNIDO publication, Sales No. E.90.III.E.12), chap. III.

WCED, Sustainable Development—A Guide to Our Common Future: The Report of the World Commission on Environment and Development (Geneva, The Centre for Our Common Future, 1990).

World Resources Institute, World Resources 1992-93: A Guide to the Global Environment (New York, Oxford University Press, 1992).

Case Studies

Next Steps

1 Study the case below, adapted from UNIDO, *Industry and Development: Global Report* 1990/91 (UNIDO publication, Sales No. E.90.III.E.12), pp.132-133, and answer the questions that follow, if possible working in a small group.

2 Compare your answers with those suggested.

Case Study 1: Metal Contaminants in Poland

Industrial pollution problems encountered in the region around Katowice, Poland, situated 250 km south of Warsaw, adjacent to the Czech Republic, may typify the severity of environmental damage caused by industrial pollution in other highly industrialized regions of eastern Europe. Most of the so-called dirty-process plants in Poland are concentrated in the Katowice region. The bulk of these plants use out-of-date technologies.

This region accounts for nearly all the zinc and lead minerals mined and processed in Poland, 98 per cent of the hard coal produced, 52 per cent of the steel and 31 per cent of the coke manufactured, and 32 per cent of the coal-fired electric power generated. All these activities occur in an area that covers 2.1 per cent of Poland. As a result, more than 20 out of 54 pollutants listed by the Council of Ministers of Poland exceeded national standards in the Katowice region; worse yet, many of these pollutants have annual average concentrations that exceed the national standards by 500-2,000 per cent.

Air and water pollutants in the Katowice region contain a large variety of hazardous substances, including carcinogenic compounds, hydrogen cyanide, phenol and heavy metals. The Institute of Environmental Protection at Katowice recently measured the exposure of the local population (10 per cent of the Polish population live in that region) to two toxic metals, lead and cadmium, by the consumption of vegetables grown in the metal-contaminated soils of the region.

Lead is known to be harmful to the circulatory system and to cause neurological disorders. The main sources of lead emission is non-ferrous metallurgical plants, mainly zinc and lead smelters in this region. Other sources, such as iron and steel plants (mainly open-hearth furnaces) and automobiles, are also important. Cadmium is known to damage the lungs, blood, liver and kidneys. The main sources of cadmium emission are zinc smelting plants (cadmium is a trace element in zinc ores). Not surprisingly, the highest concentrations of cadmium are found around such plants in the Katowice region.

To estimate the average weekly per capita intake of lead and cadmium through vegetable consumption by the local population, a study was conducted covering 431 vegetable plots in the Katowice region, on the basis of a random sample of the most commonly consumed vegetables from each plot, that is, carrots, parsley, celery, red beets and potatoes. From each selected plot, 30-50 sample vegetables were picked, washed as normally done in households, dried, ground and mineralized, and then the metal content for each vegetable was measured.

The sample results show that vegetable leaves are, not surprisingly, more readily exposed to metal contamination than roots. Thus, the highest concentrations were found in celery leaves and parsley leaves, followed by celery roots, carrot roots, red-beet roots, parsley roots and potatoes. The study group also estimated the average weekly per capita consumption of selected vegetables from a sample survey of 205 households in the Katowice region to arrive at the weekly intake of lead and cadmium through vegetable consumption. The estimates of weekly vegetable consumption and weekly metal intake are given below. Particularly notable is a very high per capita consumption of potatoes, around 2 kg per week.

Given the maximum concentration limits, recommended by the Food and Agriculture Organization of the United Nations (FAO) and WHO, of 3 mg per week for lead and 0.4-0.5 mg for

Metal Consumption from Selected Vegetables in the Katowice Region

District	Metal	Weekly metal intake (mg)
Katowice	Lead	2.80
	Cadmium	0.71
Chorzow	Lead	3.30
	Cadmium	0.81
Zabkowice	Lead	3.50
	Cadmium	0.99

Source: R. Kucharski and E. Marchwinska, "Exposure of edible and pasture plants and consumers in the Katowice District", Institute of Environmental Protection (Katowice, 1990).

cadmium, the estimated lead intakes of the local population all exceeded the desired limits except in the Katowice region. Cadmium intakes are almost twice the maximum limits for all districts. These estimates of metal intake are based on the measurement of metal concentrations in a small number of selected vegetables grown in the region and exclude the local consumption of many other vegetables and fruits that may be exposed to metal contamination, as well as intakes from other sources such as inhalation of air-borne pollutants and consumption of contaminated livestock products. They are, therefore, likely to be considerable underestimates.

These results are much more shocking than comparable results obtained from west European countries. Investigations carried out in Austria, Belgium, Denmark, France and the Federal Republic of Germany in 1979-1982 showed that the weekly per capita consumption of vegetables, fruits and corn products resulted in an intake of between 0.5 and 1.5 mg of lead and between 0.11 and 0.34 mg of cadmium. The intakes of lead and cadmium in the Katowice region are several times higher than comparable figures in west European countries.

The study showed that the thorough washing of vegetables in tap water reduced their lead content by over 20 per cent but had little effect on their cadmium content. Peeling root vegetables also removed some of the metals: 20 per cent of the lead and 20-30 per cent of the cadmium. Over 90 per cent of lead and cadmium was removed from potatoes and deposited in the waste when potatoes were subjected to alcoholic fermentation. These contaminated wastes are, however, often fed to livestock as a fodder in the Katowice region.

Given the relatively large quantities of potatoes consumed in Poland as a staple food (the per capita weekly consumption ranges between 2 and 5 kg, nearly twice the consumption in other countries), scientists at the Institute of Environmental Protection at Katowice investigated lead and cadmium concentration in raw potato samples from 13 regions in Poland. Four of these regions, including the Katowice region, are highly industrialized and the remaining nine are less so. As expected, all the districts in the Katowice region as well as the region as a whole showed much higher concentrations of lead and cadmium than other regions. In fact, most of the districts in the Katowice region greatly exceeded the maximum tolerance limits set by the Government of Poland for lead and cadmium concentrations in potatoes, 0.4 and 0.6 mg/kg of potatoes, respectively. By contrast, lead and cadmium concentrations in raw potatoes in other regions of Poland appear to be less serious, with a few exceptions.

Questions

1 What activities are most likely to be responsible for the high emissions of lead in the Katowice region? For cadmium?

2 Are the estimates of lead and cadmium consumption produced by this survey likely to be close to the actual levels of lead and cadmium consumed? Why or why not?

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3 Do you think that the people of Poland can reduce their consumption of lead and cadmium significantly if they wash their vegetables? Why or why not? Can you suggest any other things that the people might do to reduce lead and cadmium content of their vegetables?

Answers

1. *The main sources of lead emissions are non-ferrous metallurgical plants, mainly zinc and lead smelters in the region. Other sources such as iron and steel plants (mainly open-hearth furnaces) and automobiles are also important. The main source of cadmium emissions are zinc smelting plants, as cadmium is a trace element in zinc ores. Not surprisingly, the highest concentrations of cadmium are found around zinc-processing plants in the Katowice region.*
2. *These estimates of metal intake are based on the measurement of metal concentrations in a small number of selected vegetables grown in the region and exclude local consumption of many other vegetables and fruits that may be exposed to metal contamination as well as intakes from other sources such as inhalation of air-borne pollutants and consumption of contaminated livestock products. They are, therefore, likely to be considerably underestimated.*
3. *The study showed that the thorough washing of vegetables in tap water reduced their lead content by only 20 per cent and had little effect on their cadmium content. Peeling root vegetables also removed some of the metals: 20 per cent of the lead and 20-30 per cent of the cadmium. Over 90 per cent of the lead and cadmium was removed from potatoes and deposited in the waste when potatoes were subjected to alcoholic fermentation. These contaminated wastes were, however, often fed to livestock as a fodder in the Katowice region.*

Case Study 2: Industrial Pollution in Pakistan

Next Steps

1 Read the excerpt from *The Pakistan National Conservation Strategy,* included in this Learning Unit.

2 Prepare a table like that outlined on the opposite page summarizing the principal industries that contribute to pollution in Pakistan and the environmental problems they create. If it is possible to get the relevant information (from, for example, a national report to UNCED), prepare a table for your own country. Obviously, no single correct answer can be provided for this assignment.

Industrial Pollution Problems in Pakistan

Media	Polluting industries	Major pollutants	Environmental problems
Water			
Air			
Land			

Review

Test ✓

The following test will help you review the material presented in Learning Unit 2.

1 The developing countries' share of industrial output in 1990 was approximately

a. 10 per cent
b. 15 per cent
c. 20 per cent
d. 25 per cent

2 The region with the highest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia/South-East Asia
c. Latin America
d. Africa

3 The region with the lowest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia/South-East Asia
c. Latin America
d. Africa

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4 In developing countries, the main cause(s) of pollution is (are) usually

a. Old heavy industry
b. Population, poverty and agriculture
c. Women
d. Business

5 Industry uses approximately

a. One fifth of the world's energy
b. One quarter of the world's energy
c. One third of the world's energy
d. One half of the world's energy

6 Emissions of CO_2 from fossil fuel burning are a major cause of

.

a. Greenhouse effect
b. Aquatic system damage
c. Ozone depletion
d. All of the above

7 Emissions of CFCs come from

a. Refrigerators
b. Solvents
c. Foams
d. All of the above

8 Increases in UV-B radiation, as a result of the destruction of the ozone layer, contribute to all of the following effects except

a. Suppression of the body's immune system
b. Alteration of the reproductive capacity of plants
c. Non-melanoma skin cancer
d. Leukemia

9 Acid rain results primarily from emissions of

a. Sulfur dioxide
b. Nitrogen oxides
c. Hydrocarbons
d. Particulate matter

10 Which of the following is not a toxic heavy metal?

a. Mercury
b. Lead
c. Cadmium
d. Dioxin

11 The most polluting fuel per unit energy is

a. Oil
b. Coal
c. Nuclear
d. Natural gas

12 The official name of the report prepared by WCED is

a. Brundtland Report
b. *Saving Our Planet*
c. *Our Common Future*
d. *Sustainable Development*

13 The WCED called for

a. Zero economic growth
b. Economic growth that is equitable and compatible with the environment
c. Large-scale financial transfers to developing countries
d. Preservation of the world's resources

14 Which percentage (approximately) of world income did 80 percent of the world population receive in 1992?

a. 30
b. 20
c. 40
d. 50

15 The challenge for industry is how to reconcile environment with projected

a. Growth of population and gross national product (GNP) per capita
b. Growth of technology
c. Pollution
d. Growth of industrial output

Anwers

1-5 bbcbc

6-10 addad

11-15 bcbbd

Some Ideas to Think About

The following are some additional questions about the environment. Take some time to think about them. If possible, work in a small group and try to achieve a consensus.

1 Which pollution do you find most disturbing? Why?

2 If the earth's axis were to tip by just two degrees, would it make any difference to the environment and the world of business?

3 Is zero pollution possible in old or new industries?

4 Should a developing country have lower environmental standards than developed countries?

5 Which is more fragile, the environment or mankind?

Glossary of Environmental Terms

Acid deposition. A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either a wet or dry form. The wet forms, popularly called acid rain, can fall as rain, snow or fog. The dry forms are acidic gases or particulates.

Acid rain. See **Acid deposition**.

Air quality standards. The level of pollutants prescribed by regulations that may not be exceeded during a specified time in a defined area.

APELL. Awareness and Preparedness for Emergencies at a Local Level, UNEP training courses offerred by the Industry and Environment Programme Activity Centre of UNEP.

Assimilation. The ability of a body of water to purify itself of pollutants.

Basel Convention. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) aims to control the transboundary movement and disposal of hazardous wastes.

BATNEEC. Best available techniques not entailing excessive cost.

LU2

Baghouse filter. Large fabric bag, usually made of glass fibers, used to eliminate intermediate and large (greater than 20 microns in diameter) particles. This device operates in a way similar to the bag of an electric vacuum cleaner, passing the air and smaller particular matter while entrapping the larger particulates.

Biochemical oxygen demand (BOD). A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the pollution.

Biodegradable. The ability to break down or decompose rapidly under natural conditions and processes.

Biological magnification. Refers to the process whereby certain substances such as pesticides or heavy metals move up the food chain, work their way into a river or lake and are eaten by aquatic organisms such as fish, which in turn are eaten by large birds, animals or humans. The substances become concentrated in tissues or internal organs as they move up the chain.

Biological oxidation. The way bacteria and micro-organisms feed on and decompose complex organic materials. Used in self-purification of water bodies and in activated sludge waste-water treatment.

Biological treatment A treatment technology that uses bacteria to consume waste. This treatment breaks down organic materials.

Biosphere. The portion of the earth that supports life, including the surface waters and the air. Similar to ecosphere.

Biotechnology. Techniques that use living organisms or parts of organisms to produce a variety of products, from medicines to industrial enzymes, to improve plants or animals or to develop micro-organisms for specific uses such as removing toxics from bodies of water or killing pests.

Brundtland Report. Popular name for report produced in 1987 by the World Commission on Environment and Development. This United Nations-sponsored body produced a global agenda for change and specified how sustainable development could be achieved. The commission was chaired by Gro Harlem Brundtland, the then—and subsequently re-elected—Prime Minister of Norway.

Cadmium. Toxic heavy metal used mainly for metal plating and as a plastic pigment. Significant by-product in zinc smelting and concern in phosphate manufacture.

Carbon cycle. The circulation of carbon in the biosphere. Carbon is an essential part — a building block — of the molecules that make up all living cells. In the atmosphere it circulates as carbon dioxide, which is released by respiration, combustion and decay and fixed in complex carbon compounds during photosynthesis in plants and certain micro-organisms.

Carbon dioxide (CO_2). A colorless, odorless, non-poisonous gas that results from respiration, combustion and decay and is normally a part of the ambient air.

Carbon sink. See **Sink**.

Carcinogen. Any substance that can cause or contribute to the onset of cancer.

Catalytic converter. An air pollution abatement device that removes pollutants from motor vehicle exhaust, either by oxidizing them into carbon dioxide and water or reducing them to nitrogen and oxygen.

Chemical oxygen demand (COD). A measure of oxygen required to oxidize all compounds in water, both organic and inorganic.

Chlorofluorocarbons (CFCs). A family of inert, nontoxic and easily liquefied chemicals used in refrigeration, air conditioning, packaging and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere they drift into the upper atmosphere, where their chlorine components destroy ozone.

Cleaner Production. A concept of industrial production that minimizes all environmental impacts through careful management of resource use, of product design and use, systematic waste avoidance and management of residuals, safe working practices and industrial safety. Sometimes called pollution prevention or waste minimization.

Clean technologies. Production processes or equipment with a low rate of waste production. Treatment or recycling plants are not classed as clean technologies.

Cradle-to-grave. Term used to imply the whole life cycle of a product, from raw material to final disposal.

DDT. The first chlorinated hydrocarbon insecticide (chemical name: dichlorodiphenyltrichloroethane). It has a half-life of 15 years and can collect in fatty tissues of certain animals. USEPA banned registration and interstate sale of DDT for virtually all but emergency uses in the United States in 1972 because of its persistence in the environment and accumulation in the food chain.

Dilution ratio. The relationship between the volume of water in a stream and the volume of incoming water. If affects the ability of the stream to assimilate waste.

Dioxin. Any of a family of compounds known chemically as dibenzo-*p*-dioxins. They are of concern because of their potential toxicity and contamination in commercial products. Tests on laboratory animals indicate that dioxins are among the more toxic man-made chemicals known.

Disposal. Final placement or destruction of toxic, radioactive or other wastes; surplus or banned pesticides or other chemicals; polluted soils; and drums containing hazardous materials from removal actions or accidental releases. Disposal may be accomplished through use of approved secure landfills, surface impoundments, land farming, deep well injection, ocean dumping or incineration.

Dissolved oxygen (DO). The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, its level has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to protect DO in waste-receiving waters.

Dump. A site used to dispose of solid wastes without environmental controls.

Eco-capacity. Refers, on the one hand, to the capacity of an ecosystem to be resilient, that is, to maintain its patterns of behaviour in the face of disturbance and, on the other hand, to its capacity to remain stable, that is, to maintain its equilibrium in response to normal fluctuations in the environment.

Eco-efficiency. Maximization of industrial output from a given level of resource input, thus ensuring waste minimization and appropriate use of human, renewable and non-renewable resources.

Ecology. The relationship of living things to one another and their environment, or the study of such relationships.

Ecologically sustainable industrial development(ESID). Patterns of industrialization that enhance the contribution of industry to economic and social benefits for present and future generations without impairing basic ecological processes.

Ecosystem. The interacting system of a biological community and its non-living environmental surroundings.

EEIS. Energy and Environment Information System.

End-of-pipe treatment (abatement). Treating pollutants at the end of a process (by, for example, filters, catalysts and scrubbers) instead of preventing their occurrence.

Environment. The sum of all external conditions including physical and social factors, affecting the life, development and survival of an organism.

Environmental compliance audit Systematic review and testing by professional environmental auditors of the management, production, marketing, product development and organizational systems of an enterprise to determine and assess compliance with environmental regulations.

Environmental impact assessment. An analysis to determine whether an action would significantly affect the environment.

Equity. 1. The opportunity for all countries to share the wealth of industrial development at present, i.e. intra-generational equity. 2. Equal opportunity for present and future generations to share such wealth, i.e intergenerational equity.

Eutrophication. The slow aging process in which a lake, estuary or bay becomes a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by overabundant plant life as the amounts of nutritive compounds such as nitrogen and phosphorus increase. Human activities can accelerate the process.

Externality. The cost or benefits to parties other than the supplier and the purchaser of an economic transaction.

FAO. Food and Agriculture Organization of the United Nations.

GDP. Gross domestic product. The total market value of all the goods and services produced within a nation (excluding income from abroad) during a specified period.

GEMS. Global Environment Monitoring System, managed by UNEP. Makes comprehensive assessments of major environmental issues and thus provides the scientific data needed for the rational management of natural resources and the environment; provides early warning of environmental changes by analyzing monitoring data.

Global warming. The consequences of the greenhouse effect, caused by rising concentrations of greenhouse gases. The suspicion is that global warming will disrupt weather and climate patterns. It could lead to drought in some areas and flooding in others. One of the most serious environmental problems facing the world.

GNP. Gross national product. The total market value of all the goods and services produced by a nation (including income from abroad) during a specified period.

Good housekeeping. Efficient management of the property and equipment of an institution or organization. In the context of Cleaner Production, it often refers to the procedures applied in the operation of a production process.

Greenhouse effect. The warming of the earth's atmosphere, caused by a build-up of carbon dioxide or other trace gases. It is believed by many scientists that this build-up allows light from the sun's ray to heat the earth but prevents a counterbalancing loss of heat.

Greenhouse gases. The gases, such as carbon dioxide, water vapor, methane, nitrous oxides and CFCs, that trap the sun's heat in the lower atmosphere and prevent it from escaping into space.

Major source of increased concentration in the atmosphere is the combustion of fossil fuels. See **Greenhouse effect**.

Groundwater. The supply of fresh water found beneath the earth's surface (usually in aquifers) that is often used for supplying wells and springs. Because groundwater is an important source of drinking water, there is growing concern about areas where agricultural or industrial pollutants or substances from leaking underground storage tanks are contaminating groundwater.

Halons. Bromine-containing compounds with long atmospheric lifetimes whose breakdown in the stratosphere can cause depletion of ozone. Halons are used in fire-fighting.

Hazardous waste. By-products of society that can pose a substantial hazard to human health or the environment when improperly managed. Characterized by at least one of the following: ignitability, corrosivity, reactivity or toxicity.

Heavy metals. Metallic elements with high atomic weights, e.g. mercury, chromium, cadmium, arsenic and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Hydrocarbon (HC). Chemical compounds consisting entirely of carbon and hydrogen.

ICC. International Chamber of Commerce.

ICPIC. International Cleaner Production Information Clearinghouse.

IDA. Industrial Development Abstracts database of INTIB.

IE/PAC. Industry and Environment Programme Activity Centre of UNEP, in Paris; formerly called the Industry and Environment Office.

ILO. International Labour Organisation of the United Nations.

Incineration. 1. Burning of solid, liquid or gaseous materials. 2. A treatment technology involving destruction of waste by controled burning at high temperature, e.g. burning sludge to remove the water and reduce the remaining residues to a safe, non-burnable ash that can be disposed of safely on land, in some waters or in underground locations.

INEM. International Environmental Management Association. Coordinates and supports national associations of environmentalist business management associations or business enterprises. Described in the European Community publication *Business and Environment*.

INTIB. Industrial and Technological Information Bank of UNIDO.

IPCC. Intergovernmental Panel on Climate Change.

IRPTC. International Register of Potentially Toxic Chemicals, at Geneva. A cooperative activity of UNEP/WHO/ILO. Maintains a global system for assessing environmental effects of chemicals. Topics include identification of knowledge gaps; chemical hazards; evaluation and control of chemicals in the environment; numerical data; production, use and characteristics of chemicals; laws and regulations affecting man, living species and natural resources.

Landfills. 1. Sanitary landfills are land disposal sites for non-hazardous solid wastes, where the waste is spread in layers, compacted to the smallest practical volume and cover material applied at the end of each operating day. 2. Secure chemical landfills are disposal sites for hazardous waste. They are selected and designed to minimize the chance of hazardous substances being released into the environment.

Leachate. A liquid produced when water collects contaminants as it trickles through wastes, agricultural pesticides or fertilizers. Leaching may occur in farming areas, feedlots or landfills and may result in hazardous substances entering surface water, groundwater or soil.

Media. Specific environments—air, water, soil—that are the subject of regulatory concern and activities.

Mercury. A heavy metal that can accumulate in the environment and is highly toxic if breathed or swallowed. See **Heavy metals**.

Minimization. Actions to avoid, reduce or in other ways diminish the hazards of wastes at their source. Recycling is, strictly speaking, not a minimization technique but is often included in such programmes for practical reasons.

Minamata. A fishing village in Japan. In the 1950s and 1960s the people who lived there were poisoned by mercury pumped into the bay by a local company. The mercury was absorbed by fish later eaten by the people. The mercury caused nervous disorder in adults and cerebral palsy in children.

Montreal Protocol. The Montreal Protocol on Substances that Deplete the Ozone Layer, adopted 16 September 1987, sets limits for the production and consumption of damaging CFCs and halons.

MVA. Manufacturing value added.

NGO. Non-governmental organization. Examples are Greenpeace, International Chamber of Commerce, International Environmental Management Association and many others.

NIMBY. Acronym for "not in my back yard." Political jargon to describe a situation in which the electorate might agree to, say, industrial dumping or incineration, as long as it does not take place near their homes.

Nitrate. A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and that can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and cows.

Non-point source. Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm-water run-off. The commonly used categories for non-point sources are agriculture, forestry, urban areas, mining, construction, dams and channels, land disposal and salt-water intrusion.

NO_X. Chemical formula that stands for all the oxides of nitrogen, mainly NO_2, but also N_2O, NO, N_2O_3, N_2O_4 and NO_3, which is unstable.

Nutrient. Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in waste water but is also applied to other essential and trace elements.

OECD. Organization for Economic Cooperation and Development. Twenty-four countries, all market economies, are members: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. It collects and analyzes information, including data on environmental degradation and spending on environmental protection.

Off-site facility. A hazardous waste treatment, storage or disposal area that is located away from the generating site.

Ozone (O_3). Found in two layers of the atmosphere, the stratosphere and the troposphere. In the stratosphere (the atmospheric layer beginning 7-10 miles above the earth's surface), ozone is a form of oxygen found naturally which provides a protective layer, shielding the earth from ultraviolet radiation's harmful health effects on humans and the environment. In the troposphere (the layer extending up 7-10 miles above the earth's surface), ozone is a chemical oxidant and a major component of photochemical smog. Ozone can seriously affect the human respiratory system and is one of the most prevalent and widespread pollutants. Ozone in the troposphere is produced through complex chemical reactions between nitrogen oxides, which are among the primary pollutants emitted by combustion sources, hydrocarbons, which are released into the atmosphere by the combustion, handling and processing of petroleum products, and sunlight.

Ozone depletion. Destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation harmful to life. This destruction of ozone is caused by certain chlorine- and/or bromine-containing compounds (chlorofluorocarbons or halons), which break down when they reach the stratosphere and catalyse the destruction of ozone molecules.

PCBs. A group of toxic, persistent chemicals (chemical name: polychlorinated biphenyls) used in transformers and capacitators for insulating purposes and in gas pipeline systems as a lubricant.

Phenols. Organic compounds that are by-products of petroleum refining, tanning and the manufacture of textiles, dyes and resins. Low concentrations cause taste and odour problems in water; higher concentrations can kill aquatic life and humans.

Phosphates. Certain chemical compounds containing phosphorus.

Phosphorus. An essential chemical food element that can contribute to the eutrophication of lakes and other water bodies. Increased phosphorus levels result from discharge of phosphorus-containing materials into surface waters.

Photochemical smog. Air pollutant formed by the action of sunlight on oxides of nitrogen and hydrocarbons.

Pollutant. Generally, any substance introduced into the environment that has the potential to adversely affect the water, soil or air. See **Residual**

Pollution. Generally, the presence of matter or energy whose nature, location or quantity produces undesired environmental effects.

PVC. A tough, environmentally indestructible plastic (chemical name: polyvinyl chloride) that releases hydrochloric acid when burned.

Recycling. The process of minimizing the generation of waste by recovering usable products that might otherwise become waste. Examples are the recycling of aluminium cans, waste paper and bottles.

REED. Referral Database on Energy and Environment.

Residual. A pollutant remaining in the environment after a natural or technological process has taken place, e.g. the sludge remaining after initial waste-water treatment or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

Risk assessment. The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific pollutants.

Scrubber. An air pollution control device that uses a spray of water or reactant or a dry process to trap pollutants in emissions.

Sink. In air pollution, the receiving area for material removed from the atmosphere, e.g. by virtue of photosynthesis plants are sinks for carbon dioxide.

Solvents. Liquids that dissolve other substances. Chemical solvents are used widely in industry. They are used by pharmaceutical makers to extract active substances; by electronics manufacturers to wash circuitboards; by paint-makers to aid drying. Most solvents can cause air and water pollution and can be a health hazard.

Sulphur dioxide (SO_2). A colourless, irritating pungent gas formed when sulphur burns in air, one of the main air pollutants that contribute to acid rain and smog. Comes from the combustion of the sulphur present in most fossil fuels.

Superfund. Levy on industry to pay for cleaning up the most contaminated industrial dumps and sites in the United States.

Suspended Particulate Matter (SPM). Fine liquid or solid particles such as dust, smoke, mist, fumes or smog, found in air or emissions.

Sustainable development. Development that meets present needs without compromising the ability of future generations to meet their own needs. Necessarily based on limited data due to our current inability to forecast accurately 50-100 years ahead.

Synergistic. Interaction between two or more forces such that their combined effect is greater than the sum of their individual effects.

Tradeable permits. Market mechanism for controlling pollution; it entails issuing permits to pollute up to fixed limits and grants the right to sell unused portions of the permits.

UNCED. United Nations Conference on Environment and Development; it took place at Rio de Janeiro in June 1992 and was convened by the General Assembly in its resolution 44/228.

UNDP. United Nations Development Programme.

UNEP. United Nations Environment Programme.

USEPA. United States Environmental Protection Agency. Established in 1970 by Presidential Executive Order, it brought together the parts of various government agencies involved with the control of pollution.

UV-B. Short wavelength ultraviolet radiation.

Valdez Principles. Ten standards of corporate responsibility, formulated by the Social Investment Forum in United States after the *Exxon Valdez* accident. Encourages sustainable development and good environmental practice by companies.

Waste. Unwanted materials left over from a manufacturing process and refuse from places of human or animal habitation.

Waste reduction audit. Highly cost-effective technique that follows material inputs into the production process and accounts for them quantitatively, in any form (solid, liquid, gaseous), to identify losses (wastes), which can then be reduced by changes in input materials, process technology, product design and recycling.

Waste minimization. The reduction of waste by changing materials, processes or on-site disposal arrangements in a way that is profitable for the enterprise and the environment. Also called waste reduction.

Water quality standards. Ambient standards for water bodies. The standards address the use of the water body and set water quality criteria that must be met to protect the designated use or uses.

WCED. World Commission on Environment and Development.

WHO. World Health Organization.

WICE. World Industry Council for the Environment, a division of the International Chamber of Commerce that raises environmental awareness on the part of industry in developing and developed countries.

WICEM II. Second World Industry Conference on Environmental Management, organized by the International Chamber of Commerce in 1991.

Reading Excerpts

The Road to Ecologically Sustainable Industrial Development

Excerpted from UNIDO, *Proceedings of the Conference on Ecologically Sustainable Industrial Development*, Copenhagen, Denmark, 14-18 October 1991 (PI/112), Working paper No. 1, chaps. 1 and IV.

Chapter I: Past Trends in Industrial Growth and Pollution

For the world as a whole, industrial output (taken as manufacturing value added) grew at an annual rate of 3.6 per cent during the last 20 years (see table 1), while population grew at 1.8 per cent. The manufacturing value added (MVA) of developed market economies grew at an annual rate of 3.1 per cent, while their population grew at 0.7 per cent. In the third world, noteworthy gains occurred in some regions, particularly East Asia and South-East Asia, which experienced annual growth of 9.1 per cent in industrial output compared with annual growth of 2.1 per cent in population.[1]

This growth in the industrial output of developing countries did not meet expectations, particularly in the 1980s. Overall, the share of these countries in global industrial output, in current prices, increased only modestly, from 9.3 per cent to 13.8 per cent from 1970 to 1980 (figure 1). Moreover, 10 countries accounted for over 60 per cent of the total MVA of all 116 developing countries, and 18 countries for nearly 80 per cent.

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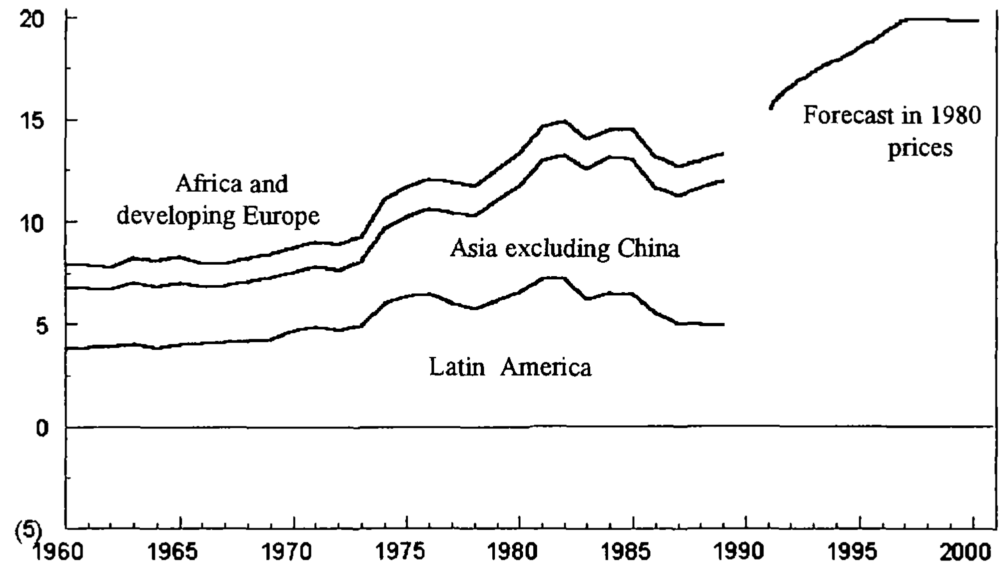
[1] UNIDO, *Handbook of Industrial Statistics 1988*, (UNIDO publication, Sales No. E/F.88.III.E.5).

Figure 1. Share of Developing Countries in World (excluding China) Manufacturing Production*



Current prices (1960-1989) and constant 1980 prices (1980-1992) (including forecasts to 2000)

*The Lima Declaration and Plan of Action on Industrial Development and Co-operation, adopted by the Second General Conference of UNIDO, held at Lima from 12-26 March 1975, called for their share to be increased to the maximum possible extent and as far as possible to at least 25 per cent of total world industrial production by the year 2000.

Events over the past 20 years are disturbing also in respect of environmental deterioration for all countries. Most startling are the threats to the biosphere, to which industrialization contributes a significant share.

One such threat is the concentration in the atmosphere of carbon dioxide (CO_2), a primary contributor to the greenhouse effect, which has increased by 10 per cent over the last 20 years (Figure 2).[2] As a result of increasing emissions of CO_2 and other greenhouse gases, the average global temperature will probably increase from 15.2° C in the 1980s to between 16.7 and 19.7° C by 2030.[3] Approximately two thirds of the CO_2 released into the atmosphere can be attributed to human activities, particularly fossil fuel combustion; and about one third of fossil fuel combustion is either directly or indirectly connected to industrial activity.

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[2] Other anthropogenic greenhouse gases are nitrous oxide from the chemical industry and the use of synthetic nitrogenous fertilizers; methane from rice cultivation, grazing animals, natural gas transmission leaks and coal mining; and synthetic chlorofluorocarbons (CFCs).

[3] Global Education Associates, "The global environment", *Breakthrough*, vol. 10, No. 4 (1989), p.4.

Table 1. Population, GDP, MVA and Their Growth Rates, 1970 to 2010 (Millions of persons and millions of 1980 US dollars)

Region*	1970			Growth rate 1970-1980			1980		
	Pop.	GDP	MVA	Pop.	GDP	MVA	Pop.	GDP	MVA
World	3 698	7 836	1 881	1.9	3.8	4.1	4 450	11 405	2 844
Developed									
DME	706	5 677	1 413	0.8	3.1	3.2	762	7 764	1 953
CPE Eastern Europe and USSR	331	651	255	0.9	5.1	6.6	361	1 080	494
Other developed	38	191	38	2.0	3.0	3.0	46	257	51
Developing									
North Africa	83	73	7	2.6	6.6	6.2	108	140	12
Tropical Africa	257	95	8	2.9	3.0	3.7	345	128	12
Latin America	285	418	96	2.4	5.8	6.1	362	747	177
Western Asia	99	237	17	3.0	5.8	7.0	133	424	35
Indian subcontinent	753	168	22	2.3	3.2	4.4	943	232	35
East and South-East Asia	262	150	25	2.3	7.7	10.9	329	325	75
CPE Asia	884	176		1.8	5.6		1 062	307	
Developing	2 623	1 317	176	2.2	5.6	6.8	3 282	2 304	345
Developed	1 075	6 520	1 706	0.8	3.3	3.8	1 169	9 101	2 499

* DME denotes developed market economies and CPE denotes centrally planned economies.

Region*	1980			Growth rate 1980-1990			1990		
	Pop.	GDP	MVA	Pop.	GDP	MVA	Pop.	GDP	MVA
World	4 450	11 405	2 844	1.7	2.9	3.2	5 289	15 178	3 921
Developed									
DME	762	7 764	1 953	0.6	2.7	3.1	805	10 174	2 669
CPE Eastern Europe and USSR	361	1 080	494	0.7	2.4	3.1	388	1 378	675
Other developed	46	257	51	1.9	2.6	1.4	56	332	59
Developing									
North Africa	108	140	12	2.8	2.6	5.3	142	182	21
Tropical Africa	345	128	12	3.0	1.6	2.1	467	150	14
Latin America	362	747	177	2.1	1.3	1.0	448	852	195
Western Asia	133	424	35	3.3	-0.1	5.3	186	421	60
Indian subcontinent	943	232	35	2.2	5.3	7.2	1 179	394	71
East and South-East Asia	329	325	75	1.9	6.0	7.4	399	593	157
CPE Asia	1 062	307		1.4	8.2		1 220	701	
Developing	3 282	2 304	345	2.1	3.6	4.1	4 040	3 293	518
Developed	1 169	9 101	2 499	0.7	2.7	3.1	1 249	11 885	3 402

* DME denotes developed market economies and CPE denotes centrally planned economies.

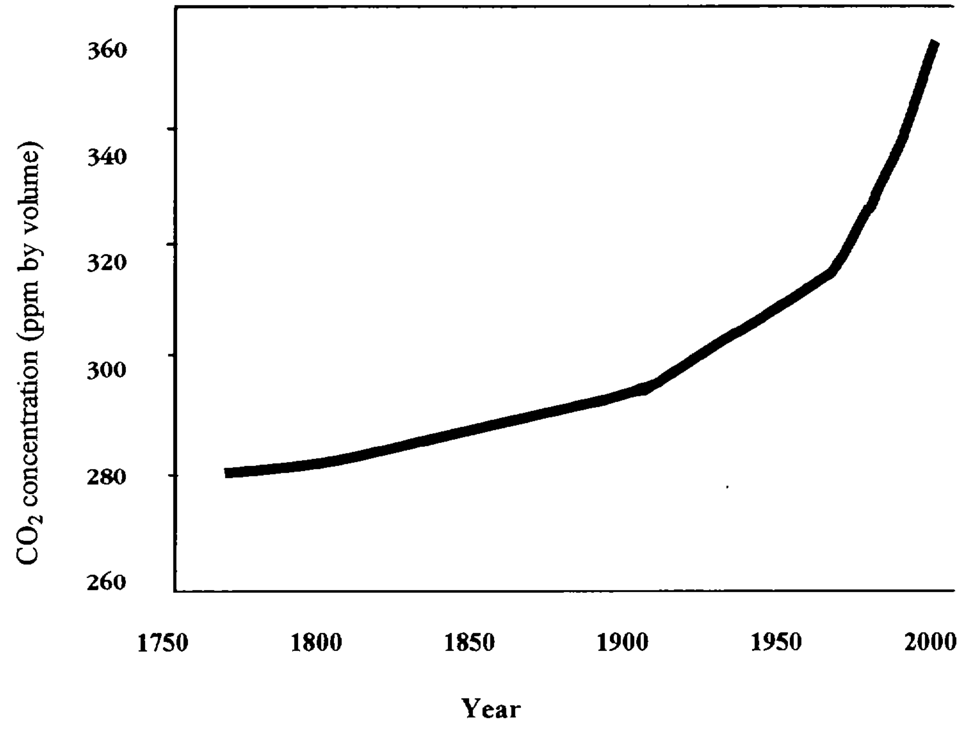
Region*	1990			Growth rate 1990-2000			2000		
	Pop.	GDP	MVA	Pop.	GDP	MVA	Pop.	GDP	MVA
World	5 289	15 178	3 921	1.7	3.4	3.5	6 260	21 387	5 563
Developed									
DME	805	10 174	2 669	0.4	3.0	3.4	838	13 734	3 749
CPE Eastern Europe and USSR	388	1 378	675	0.7	3.5	1.5	416	1 956	784
Other developed	56	332	59	1.6	3.2	4.7	65	457	95
Developing									
North Africa	142	182	21	2.3	3.5	5.6	180	258	36
Tropical Africa	467	150	14	3.3	4.0	5.5	647	223	25
Latin America	448	852	195	1.9	4.2	5.6	542	1 296	341
Western Asia	186	421	60	3.2	4.0	6.0	254	628	109
Indian subcontinent	1 179	394	71	2.0	5.0	6.1	1 439	650	132
East and South-East Asia	399	593	157	2.0	5.5	6.2	487	1 029	292
CPE Asia	1 220	701		1.3	5.0		1 392	1 155	
Developing	4 040	3 293	518	2.0	4.6	5.9	4 941	5 240	935
Developed	1 249	11 885	3 402	0.6	3.1	3.1	1 319	16 147	4 628

* DME denotes developed market economies and CPE denotes centrally planned economies.

Region*	**2000**			**Growth rate 2000-2010**			**2010**		
	Pop.	**GDP**	**MVA**	**Pop.**	**GDP**	**MVA**	**Pop.**	**GDP**	**MVA**
World	6 260	21 387	5 563	1.5	3.5	3.6	7 238	30 236	7 934
Developed									
DME	838	13 734	3 749	0.3	2.8	3.1	863	18 172	5 112
CPE Eastern Europe and USSR	416	1 956	784	0.5	4.0	2.0	438	2 918	957
Other developed	65	457	95	1.4	3.1	4.5	75	623	149
Developing									
North Africa	180	258	36	2.0	4.6	6.1	219	409	67
Tropical Africa	647	223	25	2.7	5.0	6.8	847	368	49
Latin America	542	1 296	341	1.5	5.0	6.0	630	2 137	622
Western Asia	254	628	109	2.8	4.5	7.3	336	985	225
Indian subcontinent	1 439	650	132	1.8	5.0	6.1	1 723	1 072	242
East and South-East Asia	487	1 029	292	1.8	4.7	5.6	583	1 646	511
CPE Asia	1 392	1 155		0.9	5.0	6.1	1 523	1 905	
Developing	4 941	5 240	935	1.7	4.9	3.0	5 862	8 523	1 716
Developed	1 319	16 147	4 628	0.4	3.0		1 376	21 713	6 218

* DME denotes developed market economies and CPE denotes centrally planned economies.

Figure 2. Global CO_2 Concentrations



Source: Heaton, G., R. Repetto, and R. Sobin, eds.,*Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century* (World Resources Institute, April 1991).

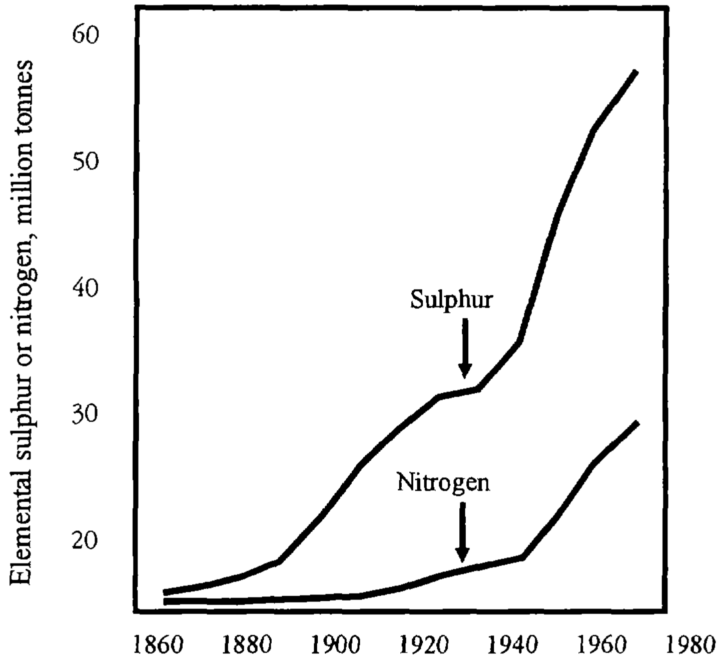
A second area of concern is the concentration in the atmosphere of chlorofluorcarbons (CFCs), which have increased dramatically (figure 3). CFCs are used in refrigerators and air-conditioners, in the blowing of plastic foam and as a solvent. They are the main cause of the "ozone hole", the name given to the decline in stratospheric ozone, which protects the surface of the earth from damaging ultraviolet radiation. Increased ultraviolet radiation promotes skin cancers and cataracts and depresses human immune systems; it also reduces crop yields, depletes marine fisheries, accelerates the deterioration of materials and increases smog. The higher concentration of CFCs also contributes to global warming.

Figure 3. Concentration of Trichlorofluoromethane (CFC 11)

Source: Intergovernmental Panel on Climate Change, *Climate Change: The IPCC Scientific Assessment* (World Meteorological Organization and United Nations Environment Programme, 1990).

A third area of concern is the increasing emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x), which increased by 40 per cent and 100 per cent, respectively, from 1960 to 1980 (figure 4). These pollutants are the main reasons for the growing acidity of the natural environment, especially freshwater lakes, rivers, forests and soils, and they contribute to the deterioration of the man-made environment, especially stone buildings and metallic infrastructure. These pollutants are produced mainly by the combustion of fossil fuels, primarily from power plants. It should be noted that the effects of acidification may have been masked until comparatively recently by the buffering effects of alkaline fly ash. However, the increasing use of smoke-control technology, especially electrostatic precipitators, may tend to accelerate the acid build-up by decreasing the buffering effect.

Figure 4. Global Emissions of Nitrogen and Sulphur Oxides from Fossil Fuel Consumption



Source: J. Dignon and S. Hameed,"Global emissions of nitrogen and sulfur oxides from 1860 to 1980", *Journal of the Air Pollution Control Association*, vol. 39, no. 2 (1989), p. 183.

A fourth area of concern is wastes, primarily toxic chemicals and heavy metals, which are dispersed locally and build up in soils or sediments. The most polluted areas are probably United States and European river basins, such as those of the Thames, the Rhine-Schelde, the Elbe, the Danube, the Vistula, the Po, the Hudson-Raritan, the Delaware, the Ohio and the lower Mississippi, which became industrialized in the last 100-150 years. There are no global data on such accumulations. There are, however, global estimates of annual atmospheric emissions of heavy metals (table 2). Anthropogenic emissions of lead, cadmium, vanadium, and zinc exceed emissions from natural sources by factors of 28, 6, and 3, respectively. Industrial contributions of arsenic, copper, mercury, nickel and antimony are as much as twice those from natural sources. In addition, atmospheric fallout, domestic and industrial wastewater discharges and urban runoff have caused significant inputs of trace metals into aquatic ecosystems and soils, threatening the biosphere as a whole, including regional seas and the oceans.

Industry is a major contributor to these environmental concerns.[4] It includes activities such as manufacturing, mining, utilities and construction. Of these sectors, manufacturing alone accounts for, on average, one third of total final energy consumption. More specifically, five manufacturing subsectors are known to be the most energy- and materials-intensive as well as the most pollution-intensive activities: iron and steel; nonferrous metals; nonmetallic minerals; chemicals; and pulp and paper.[5]

For a long time, industry in developed countries has been the major contributor to these problems of the biosphere, but the situation is changing with the rapid industrialization of developing countries. Whereas the developed countries have to some degree delinked energy and industrial output, developing countries have done just the reverse. In fact, the delinking phenomenon is partly due to structural shifts, namely the gradual relocation of resource-based (and energy-intensive) industries, such as steel, aluminium and petrochemicals, from the industrialized countries to the developing countries. Industrial final energy consumption in developed countries declined at an annual rate of 0.65 per cent in 1973-1985 and 1.93 per cent in 1980-1985, while industrial output increased at an annual rate of 1.50 per cent in 1973-1980 and 3.24 per cent in 1980-1985. In sharp contrast, industrial energy consumption in the developing countries as a whole, excluding China, grew at an annual rate of 6.32 per cent in 1973-1980 and 4.83 per cent in 1980-1983, while industrial output grew by 3.82 per cent and 0.03 per cent in the same periods. Similarly, four out of the five materials, energy and pollution-intensive manufacturing sectors listed above grew faster in developing countries than in developed countries during 1970-1988 and grew twice as fast in developing countries as in developed countries during 1980-1985.[6]

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[4] For the purpose of collecting data, industry is defined to include all operations falling into categories 2, 3 and 4 of the International Standard Industrial Classification (ISIC). Thus it includes mining, petroleum and gas extraction, electricity, waterworks and related activities. However, manufacturing (ISIC 3) is the largest and most important industrial sector, and it is in this sector that the work of UNIDO concentrates. It is also to this sector that the term "industry" mainly refers in all Working Papers.

[5] UNIDO, Industry and Development: Global Report 1990/1991 (United Nations publication, Sales No. E.90.III.E.12).

[6] UNIDO, Industry and Development: Global Report 1988/1989 (United Nations publication, Sales No. E.89.III.E.5), p. 106.

Table 2. Worldwide Atmospheric Emissions of Trace Metals (Thousand tonnes per year)

Element	Energy production	Smelting, refining and mining	Manufacturing processes	Commercial uses, waste incineration and transportation	Total anthropogenic contributions	Total contributions by natural activities
Antimony	1.3	1.5		0.7	3.5	2.6
Arsenic	2.2	12.4	2.0	2.3	19.0	12.0
Cadmium	0.8	5.4	0.6	0.8	7.6	1.4
Chromium	12.7		17.0	0.8	31.0	43.0
Copper	8.0	23.6	2.0	1.6	35.0	28.0
Lead	12.7	49.1	15.7	254.9	332.0	12.0
Manganese	12.1	3.2	14.7	8.3	38.0	317.0
Mercury	2.3	0.1		1.2	3.6	2.5
Nickel	42.0	4.8	4.5	0.4	52.0	3.0
Selenium	3.9	2.3		0.1	6.3	29.0
Thallium	1.1		4.0		5.1	5.1
Tin	3.3	1.1		0.8	5.1	10.0
Vanadium	84.0	0.1	0.733.4	1.2	86.0	28.0
Zinc	16.8	72.5	33.4	9.2	132.0	45.0

Source: Nriagu, J.O., "Global metal pollution: poisoning the biosphere?", Environment, Vol. 32, No. 7 (1990), pp. 7-32.

Chapter IV: Progress Towards Ecologically Sustainable Industrial Development

The question that now arises is, How well is industry doing in achieving ESID? It is a difficult question to answer because there is a lack of industry-specific data, but a reasonable assessment can be made using existing data and approximate measures.

UNIDO suggests two ways to measure progress towards protecting the biosphere. One is compliance with ambient environmental standards, the other is compliance with total loading standards.

Ambient Standards

Industry is only one of many contributors to the degradation of the environment. Agriculture, mining, energy, transport, services and households also contribute in varying degrees. Not enough data are available at the global level to assess the relative contribution of these various sources to ambient environmental deterioration. There is information, however, on the relative contribution of pollutant loadings into the environment.

Environmental deterioration associated with industrial development occurs at both the input and the output sides of production activities. Industrial production requires the input of a wide variety of natural resources, such as water, energy, minerals, forest products and other raw materials whose rapid depletion may cause environmental damage and ecological disruption. On the output side, the manufacturing process generates myriad wastes, including hazardous wastes, toxic chemicals and thermal wastes, that pollute the soil, the air and surface water and groundwater. On the output side, too, many manufactured end-products, such as pesticides, detergents, paints, plastics and combustion engines, add to the pollution.

In *Industry and Development: Global Report 1990/91*, UNIDO assessed the global degradation of the environment from both the input and output sides of production activities.[7] On the input side, it looked at the consumption of water, energy and mineral resources:

- **Water**. Industry uses much less water than agriculture, but it pollutes the water more. Although more than 80 per cent of the water used for cooling and cleaning is returned, the returned water is often contaminated by industrial effluents and thermal pollution;

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[7] UNIDO, *Industry and Development: Global Report 1990/91* (United Nations publication, Sales No. E.90.III.E.12).

- **Energy**. In the countries of the Organization for Economic Co-operation and Development (OECD), industry used more energy than any other sector in 1970-1987. Its share ranged from 40 per cent in 1970 to 33 per cent in 1987. The industrial share of energy consumption in developing countries varied from country to country, ranging from 63 per cent in China to 20 per cent in West Africa;

- **Mineral resources**. There seems to be no cause for concern about the exhaustion of mineral resources within the foreseeable future, although political disruptions can always lead to temporary shortages. More important in connection with mineral resources are the environmental problems posed by their production and industrial use.

On the output side, the *Global Report* analysed air pollution, water pollution, solid wastes, hazardous wastes and toxic chemicals:

- **Air pollution**. The manufacturing sector is not the sector that generates most air pollutants. Each major air pollutant has a different major source: electricity generation accounts for the bulk of anthropogenic emissions of SO_2; transport activities, for NO_x and CO; and motor vehicles, for hydrocarbons and lead. Industry, however, is a major source of particulate emissions in many countries;

- **Water pollution**. Industry is responsible for a fairly large share of waste-water discharges containing traditional pollutants. Estimation of the share is complicated by the fact that in many countries industry discharges its waste into municipal waste-water systems. Fragmentary data indicate that the share of industry in total waste-water discharges is roughly 20 per cent;

- **Solid wastes**. An inter-country comparison of solid waste generation is difficult owing to the different definitions for categories of wastes. A few country estimates are as follows: industry's share of solid waste generation accounts for 17 per cent of the total in the United States, 9 per cent in France and 60 per cent in Japan;

- **Hazardous wastes**. National data on hazardous wastes are scarce and incomplete. Even when available, they are not comparable because of the widely varying definitions and classification schemes for hazardous wastes adopted by different countries. Bearing these limitations in mind, the fragmentary data show that, with some minor exceptions, the largest portion of hazardous wastes is generated by industrial production. For instance, in the United States over 85 per cent of the hazardous waste is accounted for by the manufacturing sector; in Thailand, this share is over 95 per cent;

- **Toxic chemicals**. It is difficult to estimate the quantity of toxic chemical wastes produced in different countries each year, partly because the term "toxic" is defined differently in different countries. Some recent data from the United States seem, however, to permit the identification and quantification of the types and sources of toxic chemical wastes. The chemical industry accounted for 54 per cent of the total releases, followed by the paper products and primary metals subsectors.

In summary, while the available data allow a reasonable assessment for industrialized countries, the relative contribution of industry to overall environmental degradation in developing countries is little known. For OECD countries, the industrial sector in 1987 accounted for 15 per cent of the total water use, 25 per cent of NOx, 35 per cent of final energy use, over 40 per cent of SO_2 emissions, 50 per cent of greenhouse gas emissions, 60 per cent of the water pollution (biochemical oxygen demand), 75 per cent of non-hazardous inert waste and 90 per cent of toxic substances discharge to water. For developing countries, as well as the countries of Eastern Europe, the data on the relative contribution of industry to environmental deterioration are very fragmentary, as can be seen in a recent report from the Economic and Social Commission for Asia and the Pacific (ESCAP).[8] There is obviously significant variation, given the different levels of industrialization, between developed and developing countries as well as among developing countries. For example, industry's share of total final energy use, which use constitutes a major threat to the biosphere, was 34 per cent in Africa, 40 per cent in Latin America and around 55 per cent in Eastern Europe.[9]

Total Loadings

Meeting current ambient standards is insufficient to prevent global and regional environmental problems. These ambient standards were formulated to protect local populations and natural resources, and they focus on concentrations, or flows, of pollutants. Total loading standards for some pollutants reflect the fact that the cumulative stocks of these pollutants in the environment, as well as the flows into it, are significant and must be reduced. Except in the case of CFCs, the extent to which they must be reduced is an open question.

Global emissions of $C0_2$ from energy use, expressed on a total carbon basis, increased from 4.0 billion tonnes in 1970 to approximately 5.2 billion tonnes in 1985 (table 3). They are projected to reach 10.2 billion tonnes

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[8] Economic and Social Commission for Asia and the Pacific, *State of the Environment in Asia and the Pacific 1990* (ST/ESCAP/917).

[9] UNIDO, *Industry and Development: Global Report 1989/90* (United Nations publication, Sales No.E.89. III.E.5).

(the mid-point estimate) in the year 2025.[10] Industry's share of these emissions is estimated to have been 2.0 billion tonnes in 1985, assuming that industry uses slightly more than one third of the world's energy. In 1985, the industrialized countries emitted about 50 per cent of this total, the former Union of Soviet Socialist Republics (USSR) and the countries of Eastern Europe about 25 per cent and the developing countries about 25 per cent. In 2025, the distribution is projected to be 35 per cent, 25 per cent and 40 per cent owing to more rapid industrialization in developing countries and the positive linkage between energy consumption and industrial output. Currently, developing countries are experiencing the most rapid increase in CO_2, with average annual growth of 3.7 per cent compared to 1.2 per cent and 2.6 per cent for OECD countries and the USSR and Eastern European, respectively.

Global emissions of CFCs increased from 0.8 billion tonnes in 1970 to 1.5 billion tonnes in 1985 and are estimated to increase to 3.9 billion tonnes by 2025 (table 3). In 1985, the industrialized countries emitted about 70 per cent of the world's total, the former USSR and the countries of Eastern European about 15 per cent and developing countries (including China) about 15 per cent. In 2025, the industrialized countries are projected to emit about 40 per cent of the world's total, the former USSR and countries of Eastern Europe about 15 per cent and developing countries about 45 per cent.

Global emissions of SO_2 increased from 63 million tonnes in 1970 to 80.5 million tonnes in 1985 and are projected to increase to 235 million tonnes by 2020 (table 4). These emissions are primarily (85 per cent) attributable to fossil fuel combustion (coal and oil) and secondarily to petroleum refining, the smelting of sulphur-containing ores (copper, lead and zinc) and sulfuric acid production. Assuming that industry uses one third of the world's energy, it was either directly or indirectly (by purchases of electricity) responsible in 1985 for 30 million tonnes of SO_2 emitted into the atmosphere. In 1985, industrialized countries emitted about 40 per cent of the total emissions, the former USSR and countries of Eastern Europe for slightly more than 30 per cent. In 2020, the industrialized countries are projected to emit about 15 per cent of the world's total, the republics of the former Soviet Union and the countries of Eastern Europe about 15 per cent and developing countries about 70 per cent. Most of the increase in emissions by 2020 will be attributable to the increased use of coal in China.

Data on the accumulation of trace metals in soils and sediments over the past decades are limited, especially in developing countries.[11] In the past developed countries were the main culprits in the discharge of trace

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[10] Schwengels, Paul and Barry Solomon, "Energy technologies for reducing greenhouse gas emissions in developing countries and Eastern Europe", Environmentally Sound Technology Assessment (ESTA) (New York, Centre for Science and Technology for Development, United Nations, 1991).

metals, but the trend is reversing: "... the combination of natural resource endowments, the constraints imposed by population growth and economic development, and the lack of government regulations can only lead to an increase in the rates of toxic metal discharge in developing countries".[12]

Three activities are usually of greatest concern: the mining, smelting and refining of metals; the burning of fossil fuels for energy production; and the manufacturing processes, especially the production of metallic commercial products. A brief look at table 2 confirms that these activities are the main contributors of trace metals into the atmosphere. Manufacturing processes alone, ignoring energy use, are significant contributors of chromium, manganese, nickel, thallium and zinc.

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[11] The annual production of metals, both from virgin ores and from secondary sources, is known with reasonable accuracy. The annual consumption of non-ferrous metals has been roughly constant or even declining in the United States for the last 20 years. The fraction obtained each year from secondary sources has also remained roughly constant except in the case of lead, where the fraction derived from secondary sources has risen sharply owing to the ban on lead in gasoline. What these data mean is that between half and seven eights of the annual consumption of each of the heavy non-ferrous metals becomes dispersed and dissipated beyond economic recoverability. The situation in developing countries may be slightly better owing to greater incentives to conserve, but the range of uses is much the same, and for most dissipative uses, from paint to pesticides, recovery is simply not feasible.

[12] Nriagu, J.O., "Global metal pollution: poisoning the biosphere?" *Environment*, vol. 32, no. 7 (1990), pp. 7-32.

Table 3. Emissions of CO_2 and CFCs in 1985 and 2020

Category	Country or region	CO_2				CFCs			
		1985		2020		1985		2025	
		10^6 tonnes/yr as C	%	10^6 tonnes/yr as C	%	10^6 kg/yr	%	10^6 kg/yr	%
Industrialized countries	United States	1 398	50	1 699-2 110	35	441	70	548	40
	OECD Europe/Canada	795		1 096-1 397		417		765	
	OECD Pacific	302		411-603		199		306	
Centrally planned economies	Eastern Europe/USSR	1 398	25	1 754-2 822	25	232	15	567	15
Developing countries	Centrally planned Asia	521	25	1 014-2 000	40	29	15	212	45
	Middle East	110		493-712		13		90	
	Africa	192		192-795		65		458	
	Latin America	192		438-904		46		291	
	South-East Asia	302		493-1 370		88		618	
Total		5 210	100	7 590-12 713	100	1 530	100	3 855	100

Sources: United Nations Environment Programme, Environmental Data Report, second ed., 1989/90, prepared by GEMS Monitoring and Assessment Research Centre (Oxford, Blackwell, 1989). U.S./Japan Expert Group (1990); Task A Report (1990).

Table 4. Emissions of SO_2 in 1970, 1985 and 2020

Region	1970		1985		2020	
	Emissions (million tonnes/yr)	Share of world total (%)	Emissions (million tonnes/yr)	Share of world total (%)	Emissions (million tonnes/yr)	Share of world total (%)
Industrialized countries	23.0	37	31.0	40	35.0	15
Centrally planned economies	26.0	41	26.0	30	36.0	15
Developing countries	14.0	22	23.5	30	164.0	70
Total	63.0	100	80.5	100	235.0	100

Sources: Galloway, J.N., "Atmospheric acidification: projection for the future", Ambio, vol. 18, No. 3 (1989), pp. 161-166; Global Environment Monitoring System (GEMS); UNEP, Environmental Data Report, second ed., 1989/90 (Oxford, Blackwell, 1989).

Understanding Environmental Problems

Selected and adapted, with permission, from *Saving Our Planet: Challenges and Hopes* (UNEP, 1992), pp. 1-8, 9-15,25-40, and 75-83 with the exception of the section on acidification which was selected and adapted, with permission, from *Chemical Pollution: A Global Overview*, a joint publication of IRPTC and the Monitoring and Assessment Research Centre of GEMS, 1992, pp. 35-48.

Global Climate Change

An important descriptor of climate is temperature. Sunlight heats up the sea and land. The warmed surface of the earth then radiates heat back towards space. On its way out, some of this heat (infrared radiation) is absorbed by trace gases in the atmosphere, notably CO_2 and water vapour, and thereby keeps the earth's temperature suitable for life. Without this natural greenhouse effect of CO_2 and water vapour, the temperature at the earth's surface would be some 33°C cooler than it is today, i.e. below the freezing point. The natural concentration of CO_2 in the atmosphere is controlled by the interactions of the atmosphere, the oceans and the biosphere in what is known as the geochemical carbon cycle. Human activities can disturb this cycle by injecting carbon dioxide into the atmosphere. This leads to a net increase in carbon dioxide concentration in the atmosphere, which enhances the natural greenhouse effect.

It had been thought that CO_2 was the only greenhouse gas. However, research over the last two decades has identified other gases such as nitrous oxide, methane, chlorofluorocarbons and tropospheric ozone as potential greenhouse gases.

The atmospheric CO_2 concentration is now 353 parts per million by volume (ppmv), 25 per cent greater than the pre-industrial (1750-1800) value of about 280 ppmv, and it is currently rising at about 0.5 per cent per year owing to anthropogenic emissions. The latter are estimated to amount to about 5,700 million tonnes of carbon per year due to fossil fuel burning, plus 600-2,500 million tonnes of carbon per year due to deforestation. Between 40 and 60 per cent of the CO_2 emitted into the atmosphere remains there, at least for the short term; the rest is taken up by natural sinks, particularly the oceans but also forests. Future atmospheric CO_2 concentrations depend on the amounts of CO_2 released from fossil fuel burning, which will be determined by the amount and type of energy sources to be used; the CO_2 released from biotic sources, which is determined by the rate of future deforestation and changes of other vegetative cover; and the uptake of CO_2 by various natural sinks. The Intergovernmental Panel on Climate Change (IPCC) has estimated that if anthropogenic emissions of CO_2 could be kept at present-day rates, atmospheric CO_2 would increase to 460-560 ppmv by the year 2100 because of the long residence time of CO_2 in the atmosphere and the long lead-time for its removal by natural sinks.

Over the past 100 years, the atmospheric CO_2 concentration increased by about 25 per cent. A range of model calculations suggests that the corresponding equilibrium temperature rise should be 0.5°-1.0°C. If this is corrected for the effects of the thermal inertia of the oceans, which slows down climate change for a period of 10-20 years, the changing composition of the atmosphere should have produced a warming of 0.35°-0.7°C superimposed on the natural fluctuations of the atmosphere.

Detailed analysis of temperature records of the past 100 years indicates that the global mean temperature has risen by 0.3°-0.6°C. Much of the warming since 1900 has been concentrated in two periods, the first between about 1910 and 1940 and the other since 1975; the five warmest years on record were all in the 1980s. The size of the warming over the last century is broadly consistent with the predictions of climate models, but is also of the same magnitude as natural climate variability.

The main impacts of climate change are as follows:

- Sufficient evidence is now available to indicate that changes in climate would have an important effect on agriculture and livestock. Negative impacts could be felt at the regional level as a result of changes in weather (e.g. more frequent and more severe storms) and the arrival of pests associated with climate change, necessitating innovations in technology and agricultural management practices. There may be a severe decline in production in some regions (e.g. Brazil, the Sahel region of Africa, South-East Asia, the Asian region of the former Soviet Union and China), but there may be an increase in other regions because of a prolonged growing season.

- Natural terrestrial ecosystems could face significant consequences as a result of climate changes. Their evolution would lag ehind these climate shifts: they might survive in their location but flora and fauna could find themselves, in effect, in a different climatic regime. These regimes may be more or less hospitable and could increase the productivity of some species and decrease that of others.

- Relatively small changes in climate can cause large water resource problems in many areas, especially in semi-arid regions and in those humid areas where demand or pollution has led to water scarcity.

- Global warming will accelerate the rise in sea level, modify ocean circulation and change marine ecosystems, with considerable socio-economic consequences. The IPCC predicted that under the business-as-usual scenario, an average rise in the global mean sea level of about 6 cm per decade could occur over the next century. The predicted rate would mean a 20 cm rise in global mean sea level by 2030 and 65 cm by the end of the century.

Ozone Depletion

In contrast to the harmful ozone formed as a photochemical oxidant at ground level (tropospheric ozone), ozone in the stratosphere, between 25 and 40 km above the earth's surface, is the natural filter that absorbs and blocks the sun's short-wavelength ultraviolet (UV-B) radiation, which is harmful to life.

Ozone exists in equilibrium in the stratosphere, balanced between formation from molecular oxygen and destruction by ultraviolet radiation. The presence of reactive chemicals in the stratosphere, such as the oxides of hydrogen, nitrogen and chlorine, can accelerate the process of ozone destruction and therefore upset the natural balance, leading to a net reduction of the amount of ozone. These chemicals can participate in many ozone-destroying reactions before they are removed from the stratosphere.

In 1974, it was found that man-made CFCs, although inert in the lower atmosphere, can survive for many years and migrate into the stratosphere. There, they are destroyed by ultraviolet radiation, releasing atomic chlorine, which attacks the stratospheric ozone layer. This leads to another reaction that regenerates atomic chlorine, which in turn destroys more stratospheric ozone. This chain reaction can cause the destruction of as many as 100,000 molecules of ozone per single atom of chlorine.

CFCs are used as propellants and solvents in aerosol sprays; fluids in refrigeration and air-conditioning equipment; foam-blowing agents in plastic foam production; and solvents, mainly in the electronics industry. Studies in the 1980s showed that emissions of bromine can also lead to a significant reduction in stratospheric ozone. Bromofluorocarbons (halons 1211 and 1301) are widely used to extinguish fires, and ethylene dibromide and methyl bromide are used as fumigants.

The concentration of chlorine in the stratosphere is set mainly by anthropogenic sources of CFCs, carbon tetrachloride and methylchloroform. Methyl chloride is the only natural organo-chlorine compound found in the atmosphere. The concentration of chlorine in the atmosphere due to methyl chloride has remained unchanged since perhaps 1900. The major additions of chlorine to the atmosphere have occurred mainly since 1970 and have been attributed to anthropogenic sources. At present the total chlorine in the atmosphere due to organochlorine compounds is approaching 4.0 parts per billion by volume (ppbv), a 2.6-fold increase in only 20 years.

UV-B radiation is known to have a multitude of effects on humans, animals, plants and materials:

- Exposure to increased UV-B radiation can suppress the body's immune system, which might lead to an increase in the occurrence or severity of infectious diseases such as herpes, leishmaniasis and malaria and a possible decrease in the effectiveness of vaccination programmes. Enhanced levels of UV-B radiation can lead to increased damage to the eyes, especially cataracts, and to an increase in the incidence of non-melanoma skin cancer.

- Plants vary in their sensitivity to UV-B radiation. Some crop species, such as peanut and wheat, are fairly resistant, while others, such as lettuce, tomato, soybean and cotton, are sensitive. UV-B radiation alters the reproductive capacity of some plants and also the quality of harvestable products, seriously affecting food production in areas that already suffer acute shortages.

- Increased UV-B radiation has negative effects on aquatic organisms, especially small ones such as phytoplankton, zooplankton, larval crabs and shrimp, and juvenile fish. Because many of these small organisms are at the base of the marine food web, increased UV-B exposure may have a negative effect on the productivity of fisheries.

Acidification

Acidification, in an environment context, can be considered as a change towards more acidic conditions in one or more compartments of the biosphere or a reflection of the processes that bring this change about. This definition recognizes that, initially, acid deposition may be absorbed, even in sensitive areas, by the natural buffering capacity of the environment and that the onset of acid conditions in an environment may occur long after an increase in acid deposition.

The predominant anthropogenic source of acid-forming gases, primarily sulphur dioxide and nitrogen oxides, is fossil fuel combustion; additional sources include metal ore smelting, sulphuric acid manufacture and other industrial processes. Other sources of acid-forming gases that may assume greater significance in less industrialized regions include the burning of biomass for fuel, deforestation and grassland management. The treatment, decomposition and incineration of human excreta and other wastes can release significant quantities of NO_x into the atmosphere or directly into watercourses. Similarly, the application of nitrogen fertilizers may affect soil pH levels.

A 1986 survey of the pH of precipitation over western Europe showed that typical Atlantic background values of pH, above 5.0, drop to less than 4.4 over Scandinavia. Similarly, a 1985 survey of North American precipitation showed pH values above 5.0 in the west of the continent, dropping to less than 4.2 in the northeast. Other regions of known high levels of acid deposition include the Czech Republic, Germany, Hungary and Slovakia, where the pH of the rainfall is typically 3.9-4.5. Evidence is also now available from south-western China (pH<3.5) and from tropical areas such as south-eastern Brazil (pH<4.0) and Venezuela (pH<4.0) that acid rain is occurring in developing countries. It appears that if the average pH of a station is below 5.0 the possibility of anthropogenic sources of acid deposition should be suspected; below an average pH of 4.5, the possibility becomes a probability.

The gradual onset of anthropogenic acidification and the concurrence with the growth of air pollution generally, as well as the episodic occurrence of natural climatic events, often makes it difficult to ascribe observed effects to acidification alone. Nevertheless, there is at least circumstantial evidence that acid deposition is implicated in the following effects:

- Acid deposition is suspected as one of the causal factors in the reported decline of European and North American forests. In the 1980s, a striking increase in foliar damage to plants, particularly the forest trees in Europe, was reported. European forest damage surveys provide strong circumstantial evidence for pollution-related foliar damage. It has been suggested that the level of damage observed in coniferous forest trees can be correlated with air pollution loading.

- Most countries in Europe have lakes and rivers that are susceptible to further acidification. There are also many river and lakes systems in Africa, Asia and South America with low pH and buffering capacity, which makes them potentially susceptible to acid rain. It is important to realize that fish may die not as a result of average conditions in streams but during short-lived acid flushes brought on by heavy rains after a dry spell or by the melting of snow, when water of high acidity melts first and causes very low pH levels in melt-water run-off.

- The impact of acidification on human health is both direct and indirect. Direct effects have been reported when acid sulphate aerosols come into contact with sensitive mucus membrane surfaces of the respiratory tract and lungs. For example, the bronchial clearance function has been shown to decline in adolescent asthmatics. In tests on animals, high long-term exposure leads to changes in surface cells and a narrowing of the airways.

- All materials suffer degradation from natural weathering processes, but air pollution has accelerated degradation rates since the mid-nineteenth century. Acidic deposition causes corrosion and tarnishing of metals; erosion and soiling of surface stone, brick and concrete; and erosion, discolouration and peeling of paint. Limestone and marble, which were commonly used in historic buildings and monuments, are also highly susceptible to damage by gaseous SO_X. Irreversible damage has also been caused to stained glass windows in historic churches. In the past remedial measures sometimes compounded the damaging effects. For example, corrosion of the iron rods used to strengthen limestone blocks has produced severe cracking of monumental structures.

Toxic Chemicals and Hazardous Wastes

Worldwide, about 10 million chemical compounds have been synthesized in laboratories since the beginning of the present century. Approximately 1 per cent of these—100,000 organic and inorganic chemicals—are produced commercially (the *European Inventory of Existing Commercial Chemical Substances* lists 110,000 chemicals). Between 1,000 and 2,000 new chemicals appear each year. Some of these chemicals, including pesticides and fertilizers, are used directly, but most of them are "basic" or "intermediate" chemicals used for the manufacture of millions of end-products for human use. There is virtually no sector of human activity that does not make use of chemical products, many of which have indeed benefitted man and his environment.

In recent years, however, there has been growing concern worldwide about the harmful effects of chemicals on human health and the environment. The deleterious effects of pesticides, vinyl chloride and polychlorinated biphenyls (PCBs) have been well documented since the 1960s. Over the past two decades many other substances have captured public attention, e.g. dioxin, methyl isocyanate, lead, mercury, other heavy metals and chlorofluorocarbons.

All chemicals are toxic to some degree. The health risk from a chemical is primarily a function of toxicity and exposure. Only a few parts per billion of a potentially toxic compound like dioxin may be sufficient to cause a health hazard following brief exposure. In contrast, only high doses of other compounds like iron oxide or magnesium carbonate pose problems after extended exposure. An important development in the past two decades has been the shift from a focus on just the acute health effects of chemicals to a focus on their chronic effects as well. These chronic effects, which include birth defects, genetic and neurological disorders and cancer, are of particular concern to the public, and this makes regulatory decisions both more visible and more difficult.

Toxic chemicals are released into the environment directly as a result of human application (e.g. the use of pesticides, fertilizers and various solvents) and indirectly by waste streams from various human activities, such as mining, industrial processes, incineration and fuel combustion. The chemicals may be released in solid, liquid or gaseous form and the release may be to air, water or soil. The distribution and fate of chemicals in the environment is a highly complex process, governed by the physico-chemical properties of the chemicals and of the environment itself. Many chemicals do not remain confined to the vicinity of their sources of release and are transported locally, regionally or globally to cause widespread contamination of the environment. The use of pesticides in California, for example, led to fog contamination there; 16 pesticides and their alteration products have recently been found in fog far from the place where the pesticides were used. PCBs have been transported by the atmosphere from the places of their release in industrial countries to as far as the Arctic. Mainly because they eat contaminated fish and aquatic mammals, inhabitants of the Arctic are experiencing near-toxic levels of PCB exposure.

Other examples of such toxic substances that are distributed to distant places include DDT, mercury, lead, other metals and hexachlorocyclohexane. General concern about growing global chemical pollution is reflected in concern about the effects of chlorofluorocarbons and other chemicals on the ozone layer and of greenhouse gases on climate.

Wastes are substances or objects that are disposed of, intended to be disposed of, or required, by law, to be disposed of. Certain wastes produced by human activities are described as hazardous. Although the term has a different connotation in different countries, wastes containing metallic compounds, halogenated organic solvents, organohalogen compounds, acids, asbestos, organophosphorus compounds, organic cyanides, phenols or ethers as constituents are considered hazardous.

Most hazardous wastes are produced by industry, but it is now recognized that there are hundreds of thousands of small-quantity generators of hazardous wastes, each generating up to 1,000 kg of waste per month. These include households, medical facilities (their wastes are referred to as biomedical wastes), garages and auto-repair workshops, petrol stations and small-scale industries and businesses. In the United States, 115,000 such small-scale hazardous waste generators are now being regulated under the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendment.

It has been estimated that, worldwide, about 338 million tonnes of hazardous wastes are produced annually, of which 275 million tonnes, or 81 per cent, are produced in the United States alone. For comparison, hazardous waste generation in Singapore amounts to 28,000 tonnes per year, in Malaysia, 417,000 tonnes per year and in Thailand, 22,000 tonnes per year. It should be noted that these figures represent conservative estimates since many countries have no records of the amounts of wastes generated. This is particularly true for small-scale waste generators. The variable composition of the wastes adds to the problem (constituents that are considered hazardous in some countries may not be considered so in others).

In general, most hazardous wastes are chemicals. In the European countries that are members of OECD, the main hazardous wastes are solvents, waste paint, heavy metals, acids and oily wastes.

The traditional low-cost methods of hazardous waste disposal are landfill, storage in surface impoundments and deep-well injection. Thousands of landfill sites and surface impoundments used for dumping hazardous wastes have been found to be entirely unsatisfactory. Corrosive acids, persistent organics and toxic metals have accumulated in these sites for decades. For example, the largest site identified in the United States is the Clark Fork Mining Complex in western Montana, where wastes from copper and silver mining and smelting activities have accumulated for 125 years. It is considered the largest hazardous waste dump in the world. At the time such sites were established, little thought was given to their environmental impacts. When leaks occurred, threatening public health and contaminating groundwater and soil, policy makers took remedial actions in response to growing public concern and pressure.

By 1990, the United States Environment Protection Agency (USEPA) had identified 32,000 sites in its inventory of potential hazardous sites; about 1,200 of these need immediate remedial action. In Europe, some 4,000 unsatisfactory sites have been identified in the Netherlands, 3,200 sites in Denmark and 50,000 sites in western Germany. Although some industrialized countries have initiated steps to clean up the problem sites, the cost of remedial action has been found to be very high. Estimates indicate that about US$ 30 billion are needed for remedial operations in the former Federal Republic of Germany, US$ 6 billion in the Netherlands and US$ 100 billion in the United States.

Other unsatisfactory dumping of hazardous wastes has exposed people directly to hazardous chemicals. Perhaps the most notorious incident of all was the outbreak of disease in the town of Minamata on Kyushu Island, Japan, in the 1950s and 1960s. Discharges from a chemical factory into the sea led to the contamination of fish by mercury. When the local people ate fish, thousands of them suffered neurological disorders. As a result of this and a similar incident at Niigata on the east coast of Honshu, about 400 people died. Although the dumping of waste at sea is controlled under international and regional conventions, several countries are still using this route for the disposal of hazardous wastes. Between 10 and 15 per cent of hazardous wastes pro- duced in Europe are dumped at sea.

Atmospheric Pollution

Air pollution is defined for the purposes of this document as the presence in the outdoor or indoor atmosphere of one or more gaseous or particulate contaminants in quantities, characteristics or durations such as to be injurious to human, plant or animal life or to property or to unreasonably interfere with the comfortable enjoyment of life and property.

The combustion of fossil fuels results in the exothermic oxidation of carbon, hydrogen, sulphur and nitrogen. If complete combustion is achieved, CO_2, water vapour, SO_2, NO_x and volatile and non-volatile trace metals such as arsenic, cadmium, lead and mercury are the principal pollutants emitted. In practice, complete combustion does not occur and additional particulate and gaseous pollutants are produced. These include carbon monoxide and organic and elemental carbon particulates; polycyclic aromatic hydrocarbons may also be evolved, either absorbed on to particulate matter or as a gas. Further emissions may be produced by fuel additives such as tetraethyllead, tetramethyllead and various hydrocarbons.

Generally, pollutant emissions are determined by the method of combustion and the type of fuel used. Coal is the most polluting fuel per unit energy produced, based on current combustion technology. It provides 20-25 per cent of the total energy consumed in most regions. In China, however, 80 per cent of all primary energy is derived from coal, representing 22.6 per cent of the world's coal consumption. This presents unique pollution problems associated with SO_2 and particulate matter. Similar pollution problems were common in industrialized countries until the 1950s and 1960s, when clean air legislation was introduced. It is predicted that coal will once again play an increasingly important role in energy production. World trade in coal has increased by 40 per cent since 1980.

Atmospheric pollution is a major problem facing all the countries of the world. Various chemicals are emitted into the air from both natural and man-made sources. Emissions from natural sources include those from living and non-living sources (e.g. plants, radiological decomposition, forest fires, volcanic eruptions and emissions from soil and water). These emissions lead to a natural background concentration that varies according to the local source of emission and prevailing weather conditions. People have caused air pollution since they learned how to use fire, but man-made air pollution (anthropogenic air pollution) has increased rapidly since industrialization began.

Research over the past two decades has revealed that, in addition to the previously known common air pollutants (SO_x, NO_x, particulate matter, hydrocarbons and carbon monoxide), many volatile organic compounds and trace metals are emitted into the atmosphere by human activities. Although our knowledge of the nature, quantity, physico-chemical behaviour and effects of air pollutants has greatly increased in recent years, more needs to be learned about the fate and transformation of different pollutants and about their combined (synergistic) effects on human health and the environment.

Data from the Global Environmental Monitoring System (GEMS) air project from 1980 to 1984 indicate that of 54 major cities, 27 have acceptable levels of SO2 in the air, among them Auckland, Bucharest, Bangkok, Toronto and Munich, with SO2 concentrations below 40mg/m3

(WHO established a range of 40-60mg/m3 as a guideline for exposure to avoid increased risk of respiratory diseases). Eleven cities, among them New York, Hong Kong and London, have marginal air quality, with SO_2 concentrations between 40 and 60mg/m3. The remaining 16 cities, including Rio de Janeiro, Paris and Madrid, have unacceptable air quality, with SO_2 concentrations exceeding 60mg/m3.

Data for 41 cities indicate that 8, including Frankfurt, Copenhagen and Tokyo, have acceptable air quality with respect to suspended particulate matter (SPM), with concentrations below 60mg/m3 (the WHO range is 60-90mg/m3). Ten cities, including Toronto, Houston and Sydney, have borderline concentrations of suspended particulate matter, between 60 and 90mg/m3, and 23 cities, including Rio de Janeiro, Bangkok and Tehran, have SPM concentrations exceeding 90mg/m3. The extraordinary levels in some cities in developing countries can be partially explained by natural dust; other culprits include the black, particulate-laden smoke spewed out by vehicles fuelled on low quality diesel without even rudimentary pollution control. The GEMS assessment concluded that nearly 900 million people living in urban areas around the world are exposed to unhealthy levels of SO_2 and more than 1 billion people are exposed to excessive levels of particulates.

Air pollution affects human health, vegetation and various materials in the following ways:

- The notorious sulphurous smog that occurred in London in 1952 and 1962 and in New York in 1953, 1963 and 1966 clearly demonstrated the link between excessive air pollution and mortality and morbidity. Such acute air pollution episodes occur from time to time in some urban areas. In January 1985, an air pollution episode occurred throughout western Europe. Near Amsterdam, the 24- hour average concentrations of suspended particulate matter and SO_x were both in the range 200-250$\mu g/m^3$, much higher than the WHO guideline values. During the episode, several people were affected; pulmonary functions in children were 3-5 per cent lower than normal. This dysfunction persisted for about 16 days after the episode. Athens is known for frequent acute air pollution episodes. Even in the absence of such episodes, long-term exposure to air pollution can affect several susceptible groups (the elderly, children and those with respiratory and heart conditions).

- Air pollution can cause substantial damage to many materials. The most striking examples of such damage are illustrated by the effects of air pollutants (especially SO_x) on historical buildings and monuments. The Acropolis, the Coliseum and the Taj Mahal withstood the influence of the atmosphere for hundreds or even thousands of years without any great damage, yet in the past few decades their surfaces have suffered great damage because of increased air pollution.

- Indoor air pollution has a number of effects. The sick building syndrome can cause a substantial amount of disease and absenteeism from work or school. Recently, attention has focused on the possible health hazards of radon emissions in houses.

- Emissions from the burning of biomass fuels, especially in rural areas of developing countries, are a major source of indoor air pollution. The most important identified adverse effects are chronic obstructive pulmonary disease and naso-pharyngeal cancer.

Water Pollution

Marine Pollution

The two pathways by which most potential pollutants reach the oceans are the atmosphere and rivers. The atmospheric pathway accounts for more than 90 per cent of the lead, cadmium, copper, iron, zinc, arsenic, nickel, PCBs, DDT and hexachlorofluorohexane found in the open oceans water. River inputs are generally more important than those from the atmosphere in coastal zones, although in certain areas and for some substances (e.g. lead and hexachlorofluorohexane in the North Sea and nitrogen in the Mediterranean) atmospheric inputs are similar or even dominant.

Aside from physical degradation of the coastal and near- shore zones, pollution is the main problem affecting these zones. Most of the liquid wastes and a growing fraction of the solid wastes from man's activities on land are introduced into the oceans through the land/sea interface. Coastal areas receive direct discharges from rivers, surface run-off and drainage from the hinterland, domestic and industrial effluents through outfalls, and various contaminants from ships.

Most types of wastes, once introduced into the sea, cannot be removed. Their fate is determined by their chemical composition and by the physical transport processes (e.g. mixing, sea currents) of the recipient waters. The distance they can reach depends on these processes and on the rate of their decomposition, with the non-degradable wastes having the ability to travel for long distances.

Some wastes are easily decomposed into harmless substances, although their end-products, if excessively concentrated, may seriously disturb the ecosystem (e.g. eutrophication, which is due to an excess of nutrients). Other wastes, such as metals and persistent organic compounds, cannot be degraded; they usually remain adsorbed on bottom sediments near the sources of discharges.

Some marine organisms have a remarkable ability to accumulate such substances from sea water, even when the substances are present in extremely low concentrations. Others can convert some substances into more toxic ones; for example, the well-known conversion of inorganic mercury into methylmercury, which caused the outbreak of disease at Minamata in Japan in the 1950s and 1960s.

The principal problem for human health on a worldwide scale is the existence of pathogenic organisms discharged with domestic sewage into coastal waters. Bathing in sea water that receives such sewage and the consumption of contaminated fish and shellfish cause a variety of infections.

Epidemiological studies have provided unequivocal evidence that swimmers in sewage-polluted sea water have an above-normal incidence of gastric disorders. Studies have also indicated an increased incidence of non-gastric disorders, such as ear, respiratory and skin infections. The consumption of contaminated seafood is firmly linked with serious illness, including viral hepatitis and cholera.

Many compounds discharged into the sea tend to accumulate in various organisms. Halogenated hydrocarbons accumulate in fatty tissues, and the amount accumulated may increase through the food chain, so that high concentrations are found in the bodies of the top predators among birds, fish and mammals. Where the contamination has built up over decades, such as in enclosed bodies of water like the Baltic and the Wadden Sea, the reproductive capacity of marine mammals and birds has been affected.

Polychlorinated biphenyls (PCBs) accumulated in seafood can reach unacceptable levels. Tributyltin affects a wide range of invertebrates, and its use in marine paints was recently restricted in France, the United Kingdom of Great Britain and Northern Ireland, and several states in the United States of America.

Freshwater Pollution

Assuring an adequate supply is not the only water problem facing many countries: they also need to worry about water quality. Concerns about water quality have been growing since the 1960s. At first, attention centred on surface-water pollution from point sources (industrial plants and cities). More recently, however, groundwater pollution and non-point sources (agricultural lands, forests, roads etc.) have been found to be at least as serious problems.

The basic type of pollution is that caused by the discharge of untreated or inadequately treated waste water into rivers, lakes and reservoirs. With the growth of industry, industrial waste waters discharged into water bodies have created new pollution problems. One important water quality problem is the increasing eutrophication of rivers and lakes, caused mainly by the run-off of fertilizers from agricultural lands. The acidification of lakes by acidic deposition is common in some European countries and in North America. Wastes can also be carried to lakes and streams along indirect pathways, for example, when water leaches through contaminated soils and transports the contaminants to a lake or river.

Dumps of toxic chemical waste on land have become a serious source of groundwater and surface-water pollution. In areas of intensive animal farming or where large amounts of nitrate fertilizers are used, nitrates in groundwater often reach concentrations that exceed guidelines established by the World Health Organization (WHO). The problem has become a cause for concern in some European countries and in the United States and is growing in magnitude in some developing countries.

About 10 per cent of all the rivers monitored in the water project of the Global Environment Monitoring System (GEMS) may be described as polluted (they have a biochemical oxygen demand (BOD) of more than 6.5 mg/l). The two most important nutrients, nitrogen and phosphorus, are well above natural levels in the monitored waters. The median nitrate level in unpolluted rivers is 100μg/l. The European rivers monitored by GEMS show a median value of 4,500μg/l. In contrast, rivers monitored by the GEMS project outside Europe show a much lower median value, 250μg/l. The median phosphate level in rivers monitored in the project is 2.5 times the average for unpolluted rivers (10μg/l). Since 1970, regulatory measures have led to a marked decrease of lead in most rivers of countries that are members of the Organization for Economic Cooperation and Development (OECD). Trends for other metals and toxic substances are less encouraging, despite efforts to reduce discharges. Such sub- stances are often persistent, accumulate into bottom sediments and can be released over long periods of time once initially deposited. Levels of organochlorine pesticides recorded in some rivers in developing countries (e.g. Colombia, Malaysia and the United Republic of Tanzania) are higher than those recorded in European rivers.

The quality of fresh water depends not only on the quality of waste entering the water but also on the decontamination measures that have been put into effect. Although organic waste is biodegradable, it nonetheless presents a significant problem, especially in developing countries. Human excreta contain pathogenic micro-organisms, which are waterborne agents of cholera, typhoid fever and dysentery. Contaminated water has caused the outbreak of epidemics of these diseases in several developing countries.

Industrial waste may include heavy metals and many other toxic and persistent chemicals not readily degraded under natural conditions or removed in conventional sewage-treatment plants. Unless these wastes are adequately treated at the source or prevented from being discharged into watercourses, the fresh- water quality can be seriously impaired. The high content of nutrients in rivers and lakes has led to eutrophication. Apart from ecological and aesthetic damage, eutrophication brings increasing difficulties and costs for water treatment plants that have to produce safe, palatable drinking water. The acidification of freshwater lakes has affected aquatic life to various degrees.

In most developing countries, the pollution of rivers by municipal and industrial wastes is on the increase and decontamination efforts are often neglected. In these countries, industrialization has had a higher priority than the reduction of pollution. As a consequence, in some regions (East Asia, for example) the degradation of water resources is now considered the gravest environmental problem. In many of these countries, aquatic life has been affected. The deterioration of water quality is a growing threat to aquaculture, which provides a sizeable amount of fish for the population.

The Pakistan National Conservation Strategy

Excerpted, with permission, from *The Pakistan National Conservation Strategy* (Karachi, World Conservation Union, 1992), chap. 3.4. (Submitted as the national report to UNCED by the Government of Pakistan.)

Pollution

Most people think of environmental conservation in terms of the prevention of pollution—the control of discharges of unwanted, sometimes toxic wastes to the water, the air, or the land. This is only partially correct and reflects an urban bias; yet the importance of controlling pollution cannot be denied and is growing more urgent by the year.

Water Pollution

Water pollution has three main sources: bacterial and organic liquids and solids from urban and rural domestic sewage; toxic metals, organics, acids, and other less-toxic but still polluting substances from industrial discharges; and chemical pollution in the form of pesticide and fertilizer run-off from agricultural lands.

All three can contaminate both surface and groundwater supplies of water and render them unfit for other uses such as fisheries and recreation, or expensive to treat for industrial and municipal water supply uses. The costs of treatment places a heavy burden on municipal authorities and industries that must rely on polluted sources.

Domestic and Human Waste-Water Discharges

Solid and liquid excreta generated in human settlements along with kitchen and wash waste water are the major sources of water pollution in Pakistan and the cause of widespread water-borne diseases. The seriousness of the situation is clear from a World Health Organization study: diseases of a gastro-intestinal nature account for 25-30% of the cases seen at public hospitals and dispensaries in Pakistan. Approximately 60% of infant deaths are due to infectious and parasitic diseases, most of them water-borne. Losses to the national economy, not to mention the human suffering, caused by water-borne diseases are high. A study in India found that 73 million work-days a year were lost through such disease. The cost in terms of medical treatment and lost production was reported to be on the order of US$ 600 million per year.

As indicated, the source of most water-borne diseases is human excrement. Pakistan generates 34,370 wet tonnes of excreta per day, 12.5 million tonnes per year. Karachi alone discharges approximately 300 million gallons per day of sewage; Lahore, approximately 240 million gallons. The organic load discharged, measured in terms of biological oxygen demand, for all of Pakistan is 2,265 tonnes per day.

The breakdown by source is 26,370 tonnes excreta from rural areas a day and 8,000 tonnes from urban areas. An estimated 21,096 tonnes from the rural areas (80%) is deposited in fields. An estimated 4,160 tonnes of the urban excreta (52%) is disposed of into sewers, with the remainder being deposited on the roadside, into waterways, or incorporated in solid waste.

Major cities dispose of their largely untreated sewage into irrigation systems, where the waste water is reused, and into streams and rivers, without any consideration for the rivers' assimilative capacity. Consequently, not only does serious bacterial contamination result, threatening human health, but the organic load of the sewage seriously depletes the dissolved oxygen content of the receiving waters, causing unaesthetic conditions and making them unfit for fish. It has been reported that pollution of the River Ravi—into which Lahore discharges its untreated waste water—has meant 5,000 fewer tonnes of fish production per year.

Industrial Waste-Water Discharges

The major industries creating environmental hazards are the manufacture of chemicals (including pesticides), textiles, pharmaceuticals, cement, electrical and electronic equipment, glass and ceramics, and pulp and paper board; leather tanning; food processing; and petroleum refining. Pollutants associated with various industrial subsectors are shown in table 1.

No systematic or complete survey has been done of the sources, volumes, and characteristics of industrial pollution in Pakistan, although partial surveys, investigations of particular sources, and observations have shown the seriousness of industrial pollution in a number of locations. A preliminary study of hazardous chemical industries conducted in 1985 for the Environment and Urban Affairs Division surveyed 100 plants scattered throughout the country. Only three, two of which were branches of multi-national companies, treated their wastes to commonly accepted standards. The remainder did nothing except dispose of their wastes in the most convenient way.

For all practical purposes, industries do not control their waste-water effluents through process controls, waste recycling, or end-of-pipe treatment. In Kala Shah Kaku industrial area near Lahore, for example, the various chemical industries, tanneries, textile plants, steel re-rolling mills, and other operations discharge effluents containing hydrochloric acid and high levels of organic matter directly into streams and canals. Biological oxygen demand levels of 193 to 833 milligrams per litre and mercury levels of 5.6 milligrams per litre have been measured. (The proposed interim relaxed Government standards for these are 200 and 0.1, respectively.) These discharges have rendered the nullah (drainage course) water unfit for irrigation use and livestock consumption, and have caused an annual reduction in the fish catch of 400 tonnes, valued at Rs. 10 million.

In the vicinity of Karachi, industrial pollution discharges combined with mangrove destruction and overfishing have resulted in a sharp decrease in shrimp production, which translates into lower foreign exchange earnings. Toxic substances occurring in effluents from sample industries in Karachi are shown in table 2.

Two large industrial zones in Sindh Province—SITE (Sindh Industrial Trading Estate) and LITE (Landhi Industrial Trading Estate)—discharge large quantities of organic matter, heavy metals, oils and greases, and other materials into local rivers. In Korangi in Karachi, where LITE is located, 35 tonnes of suspended solids, 376 tonnes of dissolved solids, 2 tonnes of ammonia, and 1.4 tonnes of arsenic oxide, among other chemicals, are discharged into the city's already polluted harbour each day.

Leather tanning operations near Peshawar are polluting the Kabul River, threatening its use for domestic and irrigation purposes as well as its freshwater fishery. Over 235 industries in Faisalabad discharge high levels of solids, heavy metals, aromatic dyes, inorganic salts, and organic materials directly into the municipal sewers without any pretreatment, polluting nearby agricultural land.

Another area for concern is the contamination of shallow ground water in urban areas near industrial plants as industrial wastes are discharged directly into or onto the ground. Groundwater pollution is often permanent, in that hundreds or even thousands of years may be necessary for pollutants such as toxic metals from tanneries to be flushed out of a contaminated aquifer. Surface waters, on the other hand, can be rehabilitated if pollutant loadings are reduced or eliminated.

Agricultural Run-off

The use of fertilizers has grown 7.1% annually during the Sixth Five-Year Plan. Annual expenditure on pesticides currently amounts to Rs. 3.2 billion nationally. In 1986, 1.1 million tonnes of nitrogen and 93,000 tonnes of phosphate fertilizer were produced locally, and another 700,000 tonnes of fertilizer were imported. Pesticide imports have similarly grown rapidly, increasing from 7,083 tonnes in 1980/81 to 20,647 tonnes in 1986/87—a growth rate of 190% over the six-year period.

Table 1. Selected Pollutants Associated with Industry

Industrial Subsector	**Potential Pollutants***
Chemicals	Sulphuric and nitric acids, ammonia, fluorocarbons
Pesticides	Organohalogens, organophosphates, other toxic organics, arsenic
Textiles	Hydrochloric, sulphuric acids, high BOD (organic content), dye, various organic chemicals and detergents
Pharmaceuticals	Ammonia, acids, zinc
Leather tanning	Heavy metals (chromium, cadmium, etc.), various organic chemicals, acids, high BOD
Food processing	Ammonia, sulphur dioxide
Cement	Alkalines, limestone dust
Electrical/electronics	Fluorocarbons, heavy metals (including cadmium, nickel, selenium)
Glass/ceramics	Arsenic, fluorine
Petroleum refining	Phenols, sulphides, oily residues, ammonia
Pulp and paperboard	Mercaptans (organic sulphides) high BOD and organic solids, mercury

* Quantities and characteristics dependent on type of manufacturing process and whether waste treatment exists.

Source: Derived from Ahmed, Dr. Junaid, *NCS Sector Paper on Industries.*

Indiscriminate use of agricultural chemicals, mainly fertilizers and various pesticides including insecticides, fungicides, and herbicides, is contributing to chemical pollution of the environment. Agricultural run-off from fields where these have been used incorrectly or inappropriately can raise the levels of these substances in waterways.

The effects include excess nutrient loadings from fertilizer run-off and subsequent uncontrolled algal growth in waterways, and pesticide contamination of waters, resulting in fish kills. Dead fish, apparently due to pesticides, have been reported on the banks of the Kabul River in certain seasons. Pesticides are of particular concern because of their bioaccumulation in fish and animal tissue and in the soil, and because of their persistence in the environment.

Other risks include contamination of shallow wells used for drinking-water supplies for villages and cities, and pesticide residues on cereal and vegetable crops where care has not been taken in their application. Such residues may be harmful to humans. At least one case of poisoning resulting in a number of deaths, involving the pesticide endrin in foodstuffs, has been reported in Pakistan.

Increasing use of nitrogen fertilizers may also lead to excess nitrate levels in groundwater wells. High nitrate levels in drinking water are converted to more toxic nitrites in the stomach of adults and infants, and are known to cause blood disorders in infants. No studies to date have assessed groundwater contamination in Pakistan from pesticide or fertilizer use in agriculture.

Air Pollution

The classic source of air pollution is the factory smoke stack. Such stationary, point-source emissions are highly visible and represent a significant threat to those living nearby. By volume, however, they represent less of a threat to the overall health of Pakistanis than do the multiple mobile sources of the automobile and other vehicles. Nevertheless, the combined emissions of air pollutants from industry, power generation, transportation, domestic activities (particularly energy use), agriculture, and commercial institutions are growing rapidly. (See table 4).

Table 2 Toxic Substance Concentrations in Effluents of Sample Industries, Karachi

Type of Industry	Copper	Cadmium	Zinc (mg/litre)	Nickel	Lead
Suggested standard*	1.00	0.10	5.00	1.00	0.50
Food processing	0.43	0.03	0.24	0.27	0.23
Oil mill	0.03	0.03	2.19	0.65	0.48
Beverage	0.09	0.04	2.06	0.41	0.04
Textile	0.02	0.05	5.30	0.51	—
Tannery	0.30	0.15	7.00	1.14	1.80
Chemical-alkali	0.14	0.03	0.22	1.18	0.66
Paint manufacture	0.07	0.94	0.48	0.20	3.88
Shipyard	0.28	0.10	1342.50	0.74	11.75
Cement	0.33	0.33	2.66	1.00	0.79

*Based on EEC report to EUAD

Source: *NCS Agriculture Sector Paper* by Dr. G.R. Sandhu.

Industry and power generation are becoming major sources of carbon dioxide and sulphur dioxide emissions. The rapid increase in thermal power generating capacity currently under way will result in substantial increase in emissions of these two gases and of nitrogen oxide from the burning of oil and coal in new generating stations. Pakistan's low thermal-value, high-sulphur coal reserves will cause a rapid increase in these emissions as they come into production to feed the thermal generating stations.

Similarly, use of natural gas, coal, and oil as fuels by industry is expected to cause a substantial increase in air pollution. The expected effects of these emissions, unless they are controlled at the source, include deterioration of soil quality in the vicinity of factories, potential damage to crops (particularly from sulphur dioxide and nitrogen oxides), and possibly human health effects. Many studies in a number of countries have quantitatively linked air pollution with respiratory disease, including lung cancer.

Vehicle Emissions and Urban Air Pollution

As table 3 indicates, the truly dangerous pollutants to human health—those that can cause bronchial irritation, hasten asthma attacks, and irritate the eyes—arise primarily from non-stationary sources in urban areas. Motor vehicle emissions in Lahore account for approximately 90% of the total annual emissions of hydrocarbons, aldehydes, and carbon monoxide, and for smaller but still the largest proportion of the emissions of sulphur dioxide and nitrogen oxides.

Table 3 Annual Emissions of Air Pollutants Lahore, 1985

Source	**Particulates**		**SO_2**		**CO**		**Hydrocarbons**		**NO_2**		**Aldehydes**	
	tonnes	**%**	**tonnes**	**%**	**tonnes**	**%**	**tonnes**	**%**	**tonnes**	**%**	**tonnes**	**%**
Motor vehicles	2,014	26	1,377	49	123,054	96	29,536	91	14,565	73	209	89
Railway	171	2	756	27	657	—	447	1	1,878	9	26	11
Natural gas	54	1	5	—	193	—	51	—	1,553	8	—	—
Wood, coal, solid waste	1,119	14	302	11	4,622	4	1,569	5	3,424	9	—	—
Industrial unit	4,406	57	358	13	285	—	1,010	3	162	1	—	—
Total emissions	7,764		2,798		128,811		32,613		21,582		235	

Source: Tariq, Dr. Nawaz and Waris Ali,*NCS Sector Paper on Municipal Discharges*..

Table 4 Estimated Air Pollutants from Various Economic Sectors

(thousand tonnes)

Sector	1977/78			1987/88			1997/98		
	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x
Industry	12,308	19	n/a	26,680	423	n/a	53,429	982	n/a
Transport	7,068	52	n/a	10,254	57	n/a	18,987	105	n/a
Power	3,640	4	3	11,216	95	n/a	53,062	996	76
Domestic	16,601	5	n/a	24,054	16	n/a	3,998	40	n/a
Agriculture	845	5	n/a	4,490	28	n/a	6,368	40	n/a
Commercial	1,726	11	n/a	2,587	13	n/a	4,261	25	n/a

(n/a=not applicable)
Source: *NCS Sector Paper on Energy.*

Metropolitan reliance on buses and light commercial vehicles also has various air pollution consequences. Old vehicles stay on the roads because of the absence of emission regulations, lack of enforcement of motor vehicle fitness regulations, and the owners' lack of capital to purchase replacements. Thus the average Pakistani vehicle emits 20 times as much hydrocarbons, 25 times as much carbon monoxide, and 3.6 times as much nitrous oxides in grams per kilometre as the average vehicle in the United States. As such, air pollution along busy roads and narrow streets of the main cities is an order of magnitude greater than would be predicted from the number of vehicles on the road.

The pollutants recorded are the standard emissions monitored throughout the world. Sulphur dioxide, a precursor of acid rain, is an irritant to the eyes, nose, and throat as well as to the lungs. It is also phytotoxic, damaging plants. Aldehydes are particularly noteworthy for their obnoxious smell.

Carbon monoxide is considered to be the most toxic common urban air pollutant, since it reduces the oxygen carrying capacity of the blood. Carbon monoxide levels in the range of 8-30 parts per million (ppm) and 6-40 ppm have been recorded for Lahore and Karachi respectively.

Exposure for an eight-hour period at these levels is known to cause temporary impairment of nervous system functions, including eyesight sharpness.

Hydrocarbons are an important source of particulate air pollution in Pakistan's major cities. These substances are the precursors of photochemical smog, in conditions where exposure to sunlight changes the material into an eye and lung irritant. Smog is also known to inhibit plant growth.

Nitrogen dioxide is the component of the family of nitrogen oxides that has the potential for the greatest adverse effects on human health and hence is the chemical form of nitrogen oxides usually measured. In laboratory tests, nitrogen oxide levels of 100 ppm cause illness if breathed for a short time. Levels of 700 ppm are fatal if breathed for 30 minutes. The standard recommended by the World Bank for nitrogen dioxide is 0.05 ppm.

The most dangerous of vehicle-related emission, lead, does not appear in table 3 because urban lead emission levels have been measured only sporadically in Pakistan. In Karachi, ambient lead levels have been measured at between 0.024 and 0.13 micrograms per cubic metre. Estimated lead released from emissions to the air in Pakistan is 520 tonnes.

Lead is added to gasoline to increase the octane rating and to reduce engine knock. When lead is ingested by young and growing children, it is deposited in the brain and has been shown to cause a reduction in intelligence quotient. Lead from auto emissions is a particular hazard for inner-city residents living, working, or playing along heavily travelled urban roads. It is for this reason that all industrial nations have moved towards lead-free gasolines. In Britain, a reduction in the lead content of gasoline from 0.06% to 0.015% led to a halving of blood lead levels among affected groups.

Uncontrolled open burning of garbage is another source of urban air pollution. Such burning, which typically takes place at relatively low temperatures, has been found in the West to be a major source of dioxins, an extremely toxic product. Open dumping and treatment by weathering will eventually produce a harmless product, but before that happens the dump will be a malodorous home for rats and flies, and, via leachates, another source of groundwater contamination.

Industrial Emissions

Little information exists on the nature of industrial air emissions in Pakistan; neither comprehensive nor spot surveys have been reported. But observations in the vicinity of a number of industrial zones have shown the effects of these pollutants. In Kala Shah Kaku industrial area, gaseous emissions are believed to be responsible for adverse effects on downwind crops. The Punjab Environmental Protection Agency has recently begun preliminary air pollution surveys with the assistance of the Institute for Public Health Engineering and Research at the University of Engineering and Technology (Lahore) and the Pakistan Council for Scientific and Industrial Research.

Air pollution is primarily an urban problem, where the density of industry and vehicles is sufficient to overcome the ability of the air to disperse the pollutants or dilute them quickly enough. In rural areas, air quality is not normally a problem except in the vicinity of particularly obnoxious and large discharges of pollutants.

For example, most cement plants in Pakistan have not installed equipment to control dust emissions, and pose a nuisance and a potential health hazard for surrounding residents. Large fuel-burning sources, such as thermal generating stations and industries that burn coal for steam boilers, could create localized problems from deposition of particular ash matter and sulphur compounds, especially if the coal used has a high sulphur content, as does much of Pakistan's indigenous coal supplies. Peri-urban brick-making kilns are currently the largest user of coal and emit quantities of ash and sulphur. But their effects are usually localized, due to the relatively small amount of emissions they generate.

Land Pollution

Pakistan generates 47,920 tonnes of solid waste per day—19,190 tonnes from urban areas and 28,730 tonnes from rural areas. This amounts to 17.5 million tonnes per year. In cities such as Lahore and Karachi, waste disposal typically accounts for 20-25% of municipal expenditures. Even so, only about 55% of these two urban areas, typically the wealthier sections, benefit from municipal collections. The composition of the waste includes a compostable content of 73% for Lahore (56% for Karachi) and a paper content of 5-6%.

Solid domestic waste is typically dumped onto low-lying land in Pakistan, and not even with the benefit of modern sanitary landfill methods. The result is unsightly and unsanitary conditions at and around dump sites, the use of land that could be turned to more productive purposes, and the loss of potentially valuable recyclable materials. The very elements that cause the problem, the organic matter content, give it a potential value as compost if it is encapsulated in soil and the organic matter is reduced to an enriched sterile fertilizer. Recycling the organic content of solid wastes has begun with a 500 tonne/day composting plant operating in Karachi. Others are planned for Lahore, Islamabad, and other cities. Sanitary landfills are also under consideration for Lahore and Islamabad.

Of considerable concern is the likelihood that quantities of toxic industrial wastes have been dumped in municipal disposal areas or are being dumped directly onto lands adjacent to factories with no record of their location, quantity, or toxic composition. The experience in many countries has shown that such 'toxic real estate' has grave social and economic implications for the future: serious health problems among local residents, large liabilities for cleanup incurred by the industries, lowered property values, and considerable public expense for identification and rehabilitation of contaminated sites.

Coastal Pollution

Pakistan has two ports (Karachi and Port Qasim) and four fish harbours either operational or under construction (Karachi, Pasni, Gwadar, and Korangi). Karachi port and harbour are the most used areas, and it is here that the greatest pollution is seen, both from vessels (illegally pumping out bilges and refuse), and from the port's oil terminal. An estimated 90,000 tonnes per year of oily discharges are pumped out within port limits. No oily ship waste reception or treatment facility exists within the port. Dredging operations, necessary to keep the approach channels open, also have a major impact.

The shipping lanes in the Arabian Sea are some of the busiest in the world, and it is fortunate that Pakistan has not experienced a spill greater than that of the 'Akbar', an oil barge that sank and discharged 700 tonnes of crude in 1984. Pakistan has no capacity to cope with an oil spill, minor or major, or with any other kind of shipping accident with environmental consequences.

Recently, another potential hazard has also come to light: the possibility of toxic waste dumping either at sea or, through the subterfuge of wrongly labelled containers on ships, on land. The port authorities are untrained and ill-equipped to recognize and deal with such cases.

About 45% of Pakistan's industry (by value added) is located in Karachi. All its effluents plus the domestic sewage from a city of more than 8 million people and all agricultural run-off from the hinterland and in the Indus River find their way, untreated, into the sea. No comprehensive, systematic assessment of industrial or domestic/municipal pollution in the coastal zone of Pakistan has been done. Some studies indicate that eutrophication caused by pollution from sewage (or other organic biodegradables such as fish processing wastes), though increasing overall biomass in the form of algal blooms, has reduced economically important marine fauna. Water-borne disease vectors and the interaction of sewage with other materials also have serious implications for human health, particularly for villages on the coast.

The three main coastal industries with the largest volumes of effluents are the steel mill, power plants, and refineries. But the many smaller industrial units have more significant polluting effects on the marine environment.

Surveys of industrial pollution, by virtue of being localized and based on a limited number of water and sediment samples, cannot represent accurately the degree or extent of water pollution or the problem of materials leaching into soil and groundwater resources. The synergistic and cumulative effects of interactions among different inorganic chemical compounds and between these compounds and organic matter remain to be investigated. For example, the effluent from the Karachi Shipyard is recorded as having a pH level of 4 with 110 milligrams per litre of zinc in suspension. The synergistic effects of this level of zinc in acid effluents is likely to be far more dangerous to the coastal environment than is recognized in current reports. The continuing piecemeal study of pollutants and lack of consideration of interactions among different ones represents a major weakness in current assessments.

Other negative impacts on the coast include that of thermal pollution, increased turbidity and siltation due to dredging, oil spills, tarballs, plastics, and toxic effluents, including heavy metals. Field studies of heavy metal concentrations in coastal sediments and fish indicate levels typical of coastal waters off an industrial city. However, certain 'hot spots' of chromium and mercury indicate that caution is now required in effluent disposal. Baseline surveys have yet to be undertaken to assess natural radioactivity levels along the coast, so as to assess the impact of the KANUPP nuclear power plant.

If present trends continue, with no checks being instituted, it is expected that the present zone of oxygen-deficient bottom conditions in Karachi harbour will extend to cover most of that area and its backwaters, except the channels where tidal flushing is effective in dispersing pollution loads. These conditions will slowly spread into the creeks, with serious consequences to marine bottom-dwelling species and benthic fauna. The resulting deterioration in water quality will adversely affect pelagic flora and fauna, the extent of eutrophication will increase, and phytoplankton blooms and red tides will become regular features. The bioaccumulation of toxic substances in marine fauna will increase and heavy metal pollution will spread seawards, eventually approaching toxicity levels within commercially important fish stock, with potentially disastrous implications to the fishing economy.

Further information may be obtained from:

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Learning Unit 3

DEFINING ECOLOGICALLY SUSTAINABLE INDUSTRIAL DEVELOPMENT

UNIDO
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

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Additional Course Material

Video: *Greenbucks*, produced by the Television Trust for the Environment

Introduction

Industrial development can be sustained only if it preserves the balance of nature. Otherwise, as we saw in Learning Unit 2, the gradual eroding of the environment will eventually undermine an economy's ability to grow. Learning Unit 3 presents the basic principles of ecologically sustainable industrial development (ESID) and summarizes recent United Nations and UNIDO activities to promote sustainable development.

Objectives

The specific learning objectives of this unit are as follows:

- To define and explain the concept of ecologically sustainable industrial development (ESID).
- To establish the criteria for ESID as a practical programme for both developed and developing countries.
- To summarize the ESID activities of UNIDO.
- To review industry's contributions to the ESID dialogue at the Second World Industry Conference on Environmental Management (WICEM II) in 1991 and the Industry Forum that preceded UNCED.
- To review the results of UNCED.
- To outline the contents of the Rio Declaration on Environment and Development and Agenda 21.

Key Learning Points

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1 Ecologically sustainable industrial development (ESID) is an approach to industrial development that will allow us to reconcile the demands of population growth, the desire for continued industrial development and the need to preserve the environment.

2 The Conference on Ecologically Sustainable Industrial Development, held at Copenhagen in October 1991, defined ESID as "those patterns of industrialization that enhance economic and social benefits for present and future generations without impairing basic ecological processes".

3 The three criteria to achieve ESID are as follows:

- Protection of eco-capacity,
- Efficient use of human, material and energy resources,
- Equity in sharing the environmental burdens as well as the outputs of industrialization.

4 Reduction in the pollution intensity of industry through Cleaner Production is the only immediate way for industrial development to meet the ESID criteria.

5 The Conference on ESID in 1991 recommended several initiatives that industry and Governments could take to promote Cleaner Production.

6 ICC organized WICEM II in 1991. WICEM II produced the *Business Charter for Sustainable Development* and led to the organization of the Industry Forum on Environment and Development, which was held at Rio de Janeiro in 1992, just before UNCED.

7 UNCED adopted the Rio Declaration on Environment and Development and developed Agenda 21 as the world agenda for environmentally sustainable development in the twenty-first century. Chapter 30 of Agenda 21 calls for the promotion of Cleaner Production, i.e. the reduction of pollution intensity.

8 The critical problem is to convert the ESID rhetoric into operational reality by incorporating ESID into industrial development projects.

Suggested Study Procedure

1 Work through the test at the beginning of the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.

2 Work through the *Study Materials*, including the *Reading Excerpts* and video. Prepare answers to the questions and check your answers against those suggested.

3 Read the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

4 Complete the exercises in the *Review*.

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Study Materials

Ecologically Sustainable Industrial Development: Principles

The challenge of reconciling the demands of population growth, the desire for continued industrial development and the need to preserve our environment can be met only by an approach that fosters development and at the same time sustains the environment.

UNIDO has taken the general United Nations call for sustainable development, contained in, for example, General Assembly resolution 42/187, and translated it into practical terms that relate to industrial development. This UNIDO calls ecologically sustainable industrial development, or ESID.

ESID is a new approach to industrial development that allows industry to contribute economic and social benefits for present generations without compromising the ability of future generations to meet their own needs and without impairing basic ecological processes.

To achieve ESID, industrial development must meet three criteria:

- Eco-capacity, the capacity of ecosystems to continue to function despite pollution.
- Efficiency, the most efficient conversion of human, material and energy resources into industrial outputs.
- Equity, the equitable distribution of environmental burdens as well as of the outputs of industrialization across nations, across segments of society and across generations.

Next Steps

1 **Read the excerpt from "The road to ecologically sustainable development", included at the end of this Learning Unit.**

2 **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

1 Give a definition of ecologically sustainable industrial development and name the three main criteria of ESID.

2 Which kind of equity is meant in the ESID context?

3 Give some examples of intractable environmental problems that cannot be corrected for future generations.

Answers

1. Ecologically sustainable industrial development is defined as those patterns of industrialization that enhance economic and social benefits for present and future generations without impairing basic ecological processes. The three main criteria are eco-capacity, efficiency and equity.

2. Equity that refers to the equitable distribution of environmental burdens as well as the outputs of industrialization across nations, across segments of society and across generations.

3. There is no way to remove greenhouse gases from the atmosphere. Furthermore, there is no way to replace genetic information that is lost when species disappear forever.

Next Steps

1 Look over the questions below so that you have some idea of what you want to learn from the video.

2 Watch the video *Greenbucks*.

3 Test your comprehension of the video by answering the questions below. Compare your answers with those suggested.

Questions

1 According to Maurice Strong, Secretary-General of UNCED, what was the purpose of the Earth Summit?

2 What was the mandate of the Business Council for Sustainable Development?

3 How does Asea Brown Boveri measure progress towards sustainable development?

4 What would be required to achieve 100 per cent recycling of cars?

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5 What steps have been taken to make a "sustainable" T-shirt?

6 What do developing countries need to achieve ESID?

7 What problem is Danfoss encountering in producing CFC-free compressors?

Answers

1. *The purpose of the Earth Summit was to establish a fundamental change in our economic behaviour and life. An important participant in the process is industry.*
2. *The brief of the Business Council for Sustainable Development was to formulate the role of business in achieving sustainable development.*
3. *Asea Brown Boveri measures its progress towards sustainable development by developing new, cleaner technology and by selling it.*
4. *Production of a 100 per cent recyclable car would require redesign of the car.*
5. *The steps taken to manufacture a sustainable T-shirt are eliminating the use of formaldehyde in the making of the cloth, using dyes that are free of heavy metals and the organic growing of cotton.*
6. *To achieve ESID, industries in developing countries need transfer of cleaner technology, access to capital to purchase this technology, government financial assistance and, most importantly, a change in attitude.*
7. *Danfoss is finding that refrigerator manufacturers are not redesigning their products to accommodate the CFC-free compressors.*

UNIDO Conference on Ecologically Sustainable Industrial Development

To secure the views of member States on the issue of sustainable industrial development, UNIDO convened the Conference on Ecologically Sustainable Industrial Development at Copenhagen, from 14 to 18 October 1991.

At the Conference, the member States agreed that the reduction of pollution intensity across all media (air, water and land) within industry, through Cleaner Production (see Learning Unit 4), was the key to achieving ESID.

The member States recommended several initiatives for industry, Governments and international cooperation:

- *Industry*: adopt pollution prevention, integrate environmental awareness and responsibility at all levels of management, assume a cradle-to-grave approach to product and project design and develop and transfer environmentally sound technologies.
- *Governments*: review the environmental impact of current and planned policies, strengthen procedures for reviewing industrial projects with potentially significant environmental effects, design policies based on the "polluter pays" principle and encourage ESID through research, training and information exchanges.
- *International cooperation*: mobilize financial resources to achieve ESID, promote the transfer of Cleaner Production technologies and seek international cooperation in linkages between trade and the environment.

The member States also recommended several directions for UNIDO to take in helping developing countries achieve ESID, including the provision of technical support, assistance in identifying financial resources and the strenghtening of ESID-related databases and information centres.

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Next Steps

1 **Read "Blueprint for clean industry", included in the *Reading Excerpts* at the end of this Learning Unit.**

2 **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

1 What did the member States of UNIDO recognize to be the key to achieving ESID?

2 Explain the "polluter pays" principle.

3 What are the main tasks of international cooperation as a vehicle for achieving ESID?

Answers

1. The reduction in pollution intensity through Cleaner Production.

2. Polluters should pay for the measures necessary to repair any environmental damage they create.

3. To mobilize financial resources, to promote the transfer of Cleaner Production technologies and to promote linkages between trade and the environment.

WICEM II and the Industry Forum

To secure the views of the business community on sustainable industrial development and to contribute to UNCED, ICC, in cooperation with UNEP and UNCED, organized the Second World Industry Conference on Environmental Management (WICEM II) at Rotterdam from 10 to 12 April 1991.

Over 750 leaders from industry, Governments and NGOs met at Rotterdam following regional preparatory meetings at New Delhi, Budapest, Cairo and Rio de Janeiro. They reviewed the progress made in environmental management since WICEM I, in 1984 (Versailles), and discussed the challenges for world business in the context of the UNCED, which was to be held in 1992.

The delegates to WICEM II agreed to support the Business Charter for Sustainable Development, thereby committing themselves to improving their environmental performance and to working towards achieving sustainable development.

The Industry Forum on Environment and Development was organized by ICC and held at Rio de Janeiro a few days before UNCED. Over 500 corporate executives and government officials met to exchange views on the implementation of sustainable development.

The 350-page book, published by ICC, *From Ideas to Action*, was announced at UNCED. It contains over 150 examples of how industry has implemented the Business Charter.

Next Steps

1. **Read the *Business Charter for Sustainable Development*, included in the *Reading Excerpts* at the end of this Learning Unit.**

2. **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

1 Summarize industry's activities prior to UNCED.

2 What force does the Business Charter have?

3 What was the Industry Forum?

Answers

1. Organized WICEM II to review environmental progress and prepare for UNCED, adopted the Business Charter for Sustainable Development and organized the Industry Forum on Environment and Development at Rio de Janeiro a few days before UNCED.

2. The Business Charter is a non-binding agreement, but it represents a commitment on the part of those businesses that have adopted it.

3. A meeting of business executives and government officials at Rio de Janeiro a few days before UNCED.

United Nations Conference on Environment and Development

The United Nations Conference on Environment and Development (UNCED) was held at Rio de Janeiro from 3 to 14 June 1992 on the twentieth anniversary of the United Nations Conference on the Human Environment, held at Stockholm. It brought together over one hundred heads of State or Government in the most ambitious attempt to date to merge the hitherto often conflicting demands of environmental protection and economic development into a programme to achieve global sustainable development of the sort outlined in the 1987 report of the World Commission on Environment and Development, known as the Brundtland Report.

The main objective of UNCED was to propose an alternative path for global development into the next century.

An intensive two-year preparatory process preceded UNCED. It aimed to identify and incorporate the concerns of national Governments and regional groupings, the United Nations bi- and multilateral organizations, interest groups such as business and industry, NGOs and private citizens. As far as possible, specific roles for each of these interest groups were included in the proposed follow-up activities.

At UNCED, Governments agreed on several non-binding documents, including the Rio Declaration on Environment and Development (the “Rio Declaration”) and Agenda 21. The Rio Declaration sets forth 27 principles for sustainable development.

Agenda 21 is a global action programme designed to implement the Rio Declaration. It is set forth in a document of more than 500 pages and includes over 100 programmes in 40 chapters. Agenda 21 is divided into four sections:

- Social and economic dimensions, including poverty alleviation, consumption patterns, demographics, health and human settlements.

- Conservation and management of resources for development, including oceans and fresh water, agriculture, atmosphere, all kinds of wastes, biotechnology and biological diversity.

- Strengthening the role of major groups, including women, farmers, indigenous people, children and business and industry.

- Means of implementation, including financial mechanisms, transfer of technology, information, capacity building, legal instruments and institutional mechanisms.

Chapter 30 of Agenda 21 summarizes the role of business and industry in achieving sustainable development. It emphasizes Cleaner Production and cites the Conference on Ecologically Sustainable Industrial Development in this regard.

In December 1992, the General Assembly noted with satisfaction the report of UNCED (General Assembly resolution 47/190) and endorsed the recommendations on international institutional arrangements to follow up UNCED, particularly these on the establishment of a high-level Commission on Sustainable Development (General Assembly resolution 47/191). It requested that the Commission be set up as a functional commission of the Economic and Social Council. The Commission would be responsible for overseeing the implementation of Agenda 21. The United Nations system would also work closely with the Com- mission through its new Inter-Agency Committee on Sustainable Development.

Next Steps

1 **Scan the following material from the report on UNCED, included in the *Reading Excerpts* at the end of this Learning Unit:**

- **Rio Declaration on Environment and Development**
- **Agenda 21: Contents**
- **"Strengthening the role of business and industry"**

2 **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

1 What was the main objective of UNCED?

2 What are the objectives of promoting Cleaner Production as set forth in chapter 30 of Agenda 21, "Strengthening the role of business and industry"?

3 What will be the work of the Commission for Sustainable Development? What organization is it part of?

Answers

1. *The main objective of UNCED was to propose an alternative path for global development into the next century.*
2. *To increase the efficiency of resource utilization and to reduce the quantity of waste discharge per unit of output.*
3. *The Commission on Sustainable Development is to oversee the implementation of Agenda 21. It is part of the United Nations Economic and Social Council.*

The Response of UNIDO to UNCED

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At the operational level, UNIDO will do its part to promote sustainable development through ESID in the context of Agenda 21. At the policy level, UNIDO will work through the Inter-Agency Committee on Sustainable Development to ensure that industry-related issues are properly addressed and that all the means of implementation referred to in section IV of Agenda 21 are fully utilized.

UNIDO adopted a formal response to Agenda 21 in November 1992. This response outlined UNIDO activities that correspond to the objectives of specific chapters of Agenda 21.

Next Steps

1 **Read section II of "Response of UNIDO to Agenda 21", included in the *Reading Excerpts* at the end of this Learning Unit.**

2 **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

1 Suggest two actions that UNIDO could incorporate into its technical assistance activities in support of chapter 9, "Protection of the atmosphere", of Agenda 21.

2 Suggest two actions that UNIDO could incorporate into its technical cooperation activities in support of chapters 17 and 18 of Agenda 21, which deal with the protection of water resources.

3 Suggest two actions that UNIDO could incorporate into its technical assistance activities in support of chapters 19, 20 and 21 of Agenda 21, which deal with the environmentally sound management of toxic chemicals, hazardous wastes and solid wastes.

4 Suggest two actions that UNIDO could incorporate into its technical assistance activities in support of chapter 30 of Agenda 21, which deals with the strengthening the role of business and industry.

5 Suggest two actions that UNIDO could incorporate into its technical assistance activities in support of chapter 34 of Agenda 21, which deals with the transfer of environmentally safe and sound technology, cooperation and capacity building.

Answer

1. *To work with alternative clean fuels (cleaner coal and oil, emission control), greater efficiency in combusting processes, energy conservation and alternative clean energy sources (solar, hydropower, hydrogen).*
2. *To improve efficiency by reducing the quantity of water used, the quantity of waste water produced and the extent of water-borne pollutants.*
3. *To work with cleaner technologies, to minimize waste at its source, to develop alternatives for reusing or recycling waste and to require safety in the production of chemicals.*
4. *To adopt pollution prevention measures through product and process improvements, to adopt a cradle-to-grave approach to product design and production and to secure the commitment of top management to environmentally sound management.*
5. *To adopt technologies that do not use chemicals that damage the ozone layer and to adopt technologies that are less dependent on fossil fuels.*

Additional Suggested Reading

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This concludes the study section of Learning Unit 3. For additional information on ecologically sustainable industrial development, you may refer to the following sources.

Daly, Herman E., "Sustainable development: from concept and theory to operational principles" GAIA, vol. I No. 6, (November/December 1992), pp. 333-338.

Daly, Herman E., and Kenneth N. Townsend eds., *Valuing the Earth: Economics, Ecology, Ethics* (Cambridge, Massachusetts, MIT Press, 1993).

Pearce, David W., and Jeremy J. Warford, *World Without End: Economics, Environment, and Sustainable Development* (New York, Oxford University Press, 1993).

Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century, (Washington, D.C., World Resources Institute, 1990).

UNIDO, "Barriers facing the achievement of ecologically sustainable industrial development", *Proceedings of the Conference on Ecologically Sustainable Industrial Development* (PI/112), Working Paper No. II.

United Nations, *Agenda 21: Programme of Action for Sustainable Development; Rio Declaration on Environment and Development; Statement of Forest Principles* (United Nations publication, Sales No. E.93.I.11).

Case Studies

Case Study 1: ESID Approaches in Pakistan

Next Steps

1 Review Case Study 2 from Learning Unit 2 as well as the table that you prepared for that case study. Read *The Pakistan National Conservation Strategy*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Prepare a table like that outlined below suggesting approaches that Pakistan might take to bring its industry more into harmony with the environment. Or, if you have enough information, prepare one for your own country.

3 Of the solutions that you have suggested for each problem, which do you think will be most effective? Most economical? Most in harmony with the principles of ESID?

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Pollution problem	Industries involved	Possible solutions

Next Steps

1 **Study the case below, provided by R. G. A. Boland, AGL International, Previssins-Moens, France. Then answer the questions that follow, if possible in a small group.**

2 **Compare your answers with those suggested.**

Case Study 2: Financial Organizations and the Environment

A senior French banker was asked how his bank deals with environmental issues and audits. He responded with the following practical advice:

"Environment is a very serious problem, but it is not a problem for the bank! It is a problem for Government and for industry. You see in France, we have very strict laws about environmental impacts, but there is no legal requirement for environmental audit. Thus when we help our clients to finance major industrial developments, they have to get environmental approval from the Government. So you see, for the bank, there is no financial risk! And in any case we just don't have the time or the staff to deal with such technical/scientific matters".

Questions

1 What are the assumptions and values underlying this advice?

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2 Do you agree with the banker? Why?

3 How could environmental issues be relevant to banking and financial organizations?

Answers

1. *False assumptions, such as that the environment is a scientific rather than a management problem, that the Government is mainly responsible, that there is no public relations benefit for the bank, that the European Community will not act, that public/political/business attitudes towards the environment will not change soon and that there is no financial risk for the bank if environmental standards are not met.*
2. *You should disagree. Banks have changed radically since 1989. Environmental compliance audits are becoming a normal business activity. The Business Charter was accepted by major companies in 60 countries at WICEM II (April 1991), including the major banks.*
3. *Banks have secondary responsibility if they finance disastrous projects, and the public relations effects could be important. In 1992 at UNCED, the new responsibility of financial institutions to refuse to finance environmentally damaging projects was clearly established as a critical factor for achieving Agenda 21.*

Review

Test

The following test will help you review the material in Learning Unit 3.

1 Sustainable development means meeting the needs of the present without

a. Compromising the needs of the future
b. Creating pollution problems for those over 60 years of age
c. Increasing population
d. Creating greenhouse effects

2 To achieve ESID, we need all of the following except

a. Eco-capacity
b. High GNP per capita
c. Efficiency
d. Equity

3 The critical load of industrial pollutants beyond which the quality of life and the proper management of natural assets are affected is called

a. Clean production limit
b. Effluent standard
c. Eco-capacity
d. Ambient environmental standard

4 A strategy for protecting the biosphere should

a. Set standards for annual emissions and wastes
b. Try to stabilize and reduce total loadings of pollutants
c. Focus on economic growth
d. Focus on reducing the number of industrial areas

5 Waste minimization is an objective of environmental

a. Eco-capacity
b. Equity
c. Economic analysis
d. Efficiency

6 The concept of a fair opportunity to share in the benefits of industrialization refers to

a. Efficiency
b. Eco-capacity
c. Dreams
d. Equity

7 Which option for achieving ESID has a more immediate chance of success in both developed and developing countries?

a. More rigorous enforcement of environmental standards
b. Cleaner Production
c. Conservation of renewable resources
d. Conservation of non-renewable resources

8 What is the key to achieving ESID?

a. Transfer of clean technology
b. Government financial subsidies
c. Reduction of pollution intensity
d. Commitment to the Business Charter of ICC

9 ESID is justified mainly by

a. Limited capacity for absorbing wastes from human activities
b. Shortage of natural resources
c. The need for new business ethics
d. UNCED

10 The Conference on ESID at Copenhagen worked out initiatives for all of the following except

a. Industry
b. Environmental organizations
c. Governments
d. International cooperation

11 Agenda 21, chapter 30, "Strengthening the role of business and industry", calls for

a. Support of the Valdez Principles
b. Shipment of hazardous wastes to developing countries
c. Annual environmental reporting
d. Preparation of emergency response plans

12 Agenda 21, chapter 8, "Integrating environment and development in decision-making", calls for

a. Increased government subsidies for pollution control
b. Economic impact analyses of environmental regulations
c. Use of market incentives
d. Integrated multimedia pollutant discharge permits

13 The Rio Declaration is

a. A call for reform of the United Nations system
b. Principles of sustainable development
c. A commitment to address climate change issues
d. Industry's response to sustainable development issues

14 Agenda 21 is

a. A global action plan to implement the Rio Declaration
b. A call for a new international order
c. A tropical forest action plan
d. A UNDP initiative for capacity building

15 The Business Charter for Sustainable Development is

a. An environmental agreement among transnational corporations
b. A business agreement to conduct environmental audits
c. A call for fair terms in international trade
d. A business commitment to improve their environmental performance

Answers

1-5 abcbd

6-10 dbcab

11-15 ccbad

Some Ideas to Think About

The following are some problems that you might face as a UNIDO representative. Take some time to think about them. If possible, work in a small group and try to achieve consensus.

1 In a UNIDO project a large commercial laboratory has been carrying out safety tests on new chemical products for various companies for over 10 years. Many of the products, including pesticides and potentially toxic drugs, have been registered and authorized for widespread use on the basis of these tests. A series of adverse reports of environmental damage finally led to the admission by the laboratory that it had falsified many of the results because it believed many of the tests were unnecessary and that some products were absolutely safe. The records have been destroyed. Does this problem have anything to do with the potential for ESID in some developing countries?

2 Can an underpopulated country tolerate higher levels of air pollution than a densely populated country?

3 In developing countries, do environmental concerns entail a cost for business without much benefit?

4 In 1991, some years after the Bhopal incident, the Government of India issued a warrant for the arrest of the Chief Executive Officer of Union Carbide on the charge of "absconding" from the judicial process after the case for damages. His extradition from the United States to face criminal charges in India is being requested. Does this have anything to do with ESID?

Reading Excerpts

The Road to Ecologically Sustainable Industrial Development

Excerpted from UNIDO, *Proceedings of the Conference on Ecologically Sustainable Industrial Development, Copenhagen, Denmark, 14-18 October 1991,* (PI/112), Working paper No. 1, chaps. II and III.

Chapter II: Definition of Ecologically Sustainable Industrial Development

There has been a good deal of debate on the meaning of the term "sustainable development". The World Commission on Environment and Development of the United Nations offered several definitions of sustainable development. The one that is most often repeated is that sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs".

Any definition ought to address three issues:

- The explicit contribution of ecological processes to living standards;
- The access by future generations to as effective a resource base as that enjoyed by the present generation, if living standards are not to decline over time;
- The resource base, which must include a mix of man-made and natural capital.

The last issue, the appropriate mix of man-made and natural capital that needs to be preserved for future generations, is at the centre of the sustainability debate. The components of this capital are four: man-made capital; non-renewable resources; renewable resources; and common property resources (air, water and soil). Often thought of as cost-free, common property resources, in particular those of the biosphere, are at greatest risk from industrial activities, because both the production processes and the products themselves generate residuals that enter the water, air, and soil.

There is considerable disagreement about the extent to which industrialization can sacrifice environmental assets—particularly common property resources—and still result in sustainable development.[1] There are those, primarily traditional economists, who see sustainable development only in terms of growing wealth which allows for substitution between man-made and natural capital (the weak definition). Their concern is that the overall aggregate of man-made and natural capital should not decline from one generation to the next. On the other hand, there are those who see sustainable development under the constraint of non-declining natural wealth, which does not allow for substitution between man-made and natural capital (the strong definition). Their concern is that a similar natural endowment should be available from one generation to the next. Those advocating the strong definition challenge the substitutability argument, as applied to natural environmental capital. . They point out that there is no plausible way to recreate the ozone layer of the stratosphere or to remove greenhouse gases from the atmosphere. Nor is there any plausible technological solution to the problems of increasing environmental acidification and/or toxification. Finally, there is no way to replace genetic information that is lost when species disappear forever.

On the basis of the growing scientific evidence in support of the strong definition of sustainable development, UNIDO proposes a definition of ecologically sustainable industrial development (ESID) that tends to preserve natural capital and allows a low degree of substitutability by man-made capital. ESID is defined as those patterns of industrialization that enhance economic and social benefits for present and future generations without impairing basic ecological processes.

This definition of sustainability does not admit major man-made changes to climate, human interference with the carbon cycle, anthropogenically induced deforestation of the tropics, accumulation of toxic heavy metals and non-biodegradable halogenated organics in soils and sediments or sharp reductions in biodiversity. It follows, therefore, that any significant degradation of ecological processes by industrialization, as well as by other human activities, is *ipso facto* unsustainable over long periods.

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[1] For an elaboration of this argument, see Pearce, D., N. Markandya and E. Barbier, *Blueprint for a Green Economy* (London, Earthscan Publications, 1990), Chap. 2.

Chapter III: Criteria for Ecologically Sustainable Industrial Development

UNIDO proposes three criteria that a particular pattern of industrialization must satisfy if it is to be deemed ecologically sustainable:

- It must protect the biosphere;
- It must make the most efficient use of man-made and natural capital;
- It must promote equity.

Protection of the Biosphere

The Concept of Eco-Capacity

The concept of eco-capacity has two aspects. On the one hand, it refers to the capacity of an ecosystem to be resilient, that is to maintain its patterns of behaviour in the face of external disturbance. On the other, it refers to the capacity of the system to remain stable, that is to maintain its equilibrium in response to normal fluctuations in the environment. It is the first aspect of the concept that is of interest here.

Protecting the biosphere from industry-related activities is a fundamental criterion for sustainable development. It is also a very difficult one to measure because it is multidimensional. It includes stabilizing the biosphere in the face of the threats from greenhouse gases and ozone-depleting substances, maintaining the carrying capacity of natural resource systems (forest, fisheries and agricultural land) and protecting the absorptive (assimilative) capacity of air, water, and soil from emissions and waste discharges.

Complicating the analysis is the continuing expansion of our scientific knowledge and the uncertainty surrounding that knowledge at a time when decisions must be made. One has only to look at the environmental concerns cited at the beginning of this paper. For example, CFCs came into commercial use in the 1930's. They were heralded as a significant environmental improvement because the common refrigerants at the time—ammonia, methyl chloride and SO_2—were not suitable as home refrigerants owing to their noxious and toxic properties. In the 1940's, CFCs were used as aerosols for insecticides such as dichlorodiphenyltrichloroethane (DDT) and later they were used widely as solvents by the microelectronics industry. Only in the early 1970's did scientific studies, which were confirmed by direct observations in the 1980's, demonstrate that these long-lived substances damaged the stratospheric ozone layer.

Another example of expanding knowledge turns up in connection with the regulation of SO_2 in the United States. In 1971, the United States Environmental Protection Agency set the ambient standards for this pollutant on the basis of considerable scientific data that had been assembled in the 1960's; these standards have since been adopted by many nations. At the time, the Environmental Protection Agency considered the standards adequate to protect not only human health but also natural ecosystems. Now, in the 1990's, it is calling for a total loading standard, that is, a further 50 per cent reduction in SO_2 emissions, over and above that required by the annual ambient standard, because of concern about the effects of acid deposition on natural ecosystems.

Strategies for Protection

There are two main strategies for protecting the biosphere. The first, which is less restrictive, is to keep annual emissions and wastes from industrial activity within the limits of ambient environmental standards. Ambient standards set acceptable concentrations of the various pollutants in the environment. They are based on the effects of pollutants on human health and on flora and fauna and often vary, particularly for water quality, where they depend on the use of the receiving body of water (e.g. more stringent standards are required for rivers that are sources of drinking water). Standards are difficult to establish because of inadequate scientific information, particularly about the effects of minuscule concentrations of toxic chemicals. In addition, they are difficult to implement because complex modelling is required to relate industrial discharges to overall ambient concentrations. At the national and international levels, ambient standards exist for common pollutants such as particulate matter and SO_2 and for several toxic pollutants, such as heavy metals and selected organic compounds.

Environmental managers have adopted an alternative in response to the shortcomings of ambient standards. This alternative, discharge standards, emerged in the 1970's in response to the difficulties of relating emissions to ambient concentrations. Discharge standards are expressed in terms of the concentration of a pollutant in the effluent stream or in terms of the allowable quantity of pollutant discharge per unit of raw material or product output. These standards, which have evolved over the past 20 years, are usually determined on the basis of available technology and economic considerations. While they eliminate the problem of relating emissions to ambient concentrations, they can reduce pollutant discharges to a greater or lesser extent than is needed for environmental protection.

The second major strategy for protecting the biosphere, now emerging in light of global and regional environment problems, is to stabilize and eventually reduce total loadings of pollutants of global and regional concern. This more restrictive strategy recognizes the limitations of science in determining acceptable concentrations for pollutants that have irreversible effects.[2] The pollutants at issue are those associated with global and

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[2] For example, the United States invested more than $500 million over a 10-year period in research to determine the amount of SO_2 reduction that would be necessary to protect aquatic and terrestrial ecosystems. In the end, the report could not

regional air pollution problems, primarily global warming, ozone depletion and acid deposition, and those causing the deterioration of aquatic ecosystems, primarily toxic heavy metals and chlorinated hydrocarbons. The aim of the total loading standards is to reduce pollutant loadings to the environment to a level below that required by ambient standards. A clear expression of support for total loading standards at the regional level is the Bergen Ministerial Declaration on Sustainable Development in the ECE Region, which calls for significant reductions in CO_2, SO_2 and NO_x emissions and for the replacement of hazardous chemicals and their safe disposal. At the national level, one endorsement of the loading standard for the pollutants of concern is the national environmental policy adopted by the Government of the Netherlands.

The meeting of total loading standards is a more costly and long-term strategy but also a more important one because it would impose more stringent discharge limitations than ambient standards. Total loading standards call for very low levels of pollutant discharge so as to protect the ozone layer, the climate-stabilizing system and key cycles—carbon/oxygen, nitrogen, phosphorous and sulfur. It is essential to recognize that continuous reduction of emissions, per unit of output is not sufficient to achieve ESID. Emissions must be reduced in absolute terms, for the industrial system as a whole. In the long run this implies (a) the massive substitution of renewable (e.g. solar or biomass) energy for fossil fuels, especially coal and (b) the closing of the materials and product cycles through optimal processes and optimal products, as discussed in Working Paper III, which discusses the role of industry in achieving ESID.

Efficiency

Even if the overriding concern of sustainable development is the preservation of the natural environment, this should be done in an efficient manner. Thus, if there are alternatives for maintaining eco-capacity, the idea would obviously be to choose those that minimize input (of energy, for example) per output produced or that maximize output per input needed. This follows from the fact that the notion of development is central to ESID, and development, in turn, implies rising living standards, at least in the broad sense. As attested by economic history, economic development by means of industrialization (the transformation of raw materials into products) has long been the path to higher standards of living. Hence industrialization policies have to be consistent with achieving the most efficient conversion of raw materials into outputs.

Equity

There is one further criterion that needs to be applied, namely the promotion of equity. The issue of equity takes a number of forms. The first

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refute the political decision to reduce SO_2 emissions by 50 percent nor could it suggest another target.

is the equitable distribution of environmental burdens as well as outputs. The solution of this issue may have important repercussions for their preservation of the environment. If the costs of meeting environmental standards are considered to be too high, sizable segments of the population, many of the already poor, will suffer the consequences of this decision, i.e., a degraded environment, and this will make them poorer. The cycle spirals downwards because poverty per se breeds some of the worst forms of environmental degradation, i.e. deforestation, over-exploitation of marine resources, unsanitary living conditions etc., as discussed later.

On a global scale, the issue of equity arises in another way. One argument is that industrialized countries, which have benefited the most from the exploitation of natural resources and the waste assimilative capacity in the biosphere, now have a moral obligation to permit the developing countries to follow similar growth patterns. This argument implies that industrialized countries should pay the excess costs incurred by the developing countries to protect the environment. However, this moral argument is not necessarily accepted by those who would have to pay the excess costs. A more effective argument might well be based on interlocking mutual security and economic interests. This was the argument that justified the Marshall Plan after the Second World War. At present, a number of West European countries have found it cost-effective, i.e. in their own interests, to assist Poland and the other Eastern European countries to reduce air pollution. Such arguments can be applied on a global, as well as regional scale.

A third aspect of the equity issue is intergenerational equity. The present generation is clearly paying for the degradation of natural resources, such as deforestation, overgrazing and erosion, caused by earlier generations. Future generations will, however, have to pay not only the costs of current environmental degradation of the same kind (only accelerated) but also the costs of accumulations of atmospheric gases and toxic heavy metals and the loss of tropical rain forests and biological diversity. One implication of this understanding is that the needs of future generations should be taken into account even if this places an additional strain on political institutions, which are normally geared to achieving short-term targets and not to satisfying future generations.[3]

Two further aspects of the equity issue are especially relevant to industry. First, all countries need to participate in the shift to cleaner

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[3] Indeed, there is a deep underlying ethical divide on the issue of intergenerational equity. On one side are those who argue that discounting, which is how society currently evaluates the future costs and benefits of present actions, is ethically justified because future generations will be the gainers. While current generations may use up the earth's natural resources, they endow their descendants with greater scientific knowledge and more powerful technologies, not to mention invested capital, than their ancestors left them. On the other side are those who see man as part of nature with no special rights over other species. Somewhere in between is Thomas Jefferson's view that the environment is a common property of all generations, held by the living in usufruct for the unborn. These two positions correspond to very different choices of a discount rate: very high in the first case and very low (or zero) in the second.

production processes, which are at the core of ESID. Industrialization in developing countries has the potential to go forward with much smaller energy and raw material inputs than developed countries needed at similar stages of industrialization. Cleaner production processes could maximize this potential. Secondly, unless employment opportunities are created for marginalized populations, they will continue to resort to environmentally unsound farming, grazing and fishing, giving rise to environmental disasters such as desertification, deforestation and the depletion of top-soils. One study estimates that deforestation in developing countries accounts for 23 per cent of global CO_2 emissions and says that it shows little sign of diminishing.

It is difficult to lay out a path that would consistently satisfy all three criteria. There will have to be trade-offs between them, and these will be based on value judgments. For instance, a certain investment strategy might create more jobs, but it would not necessarily lead to the most economically efficient production, which is often based on capital-intensive, clean technologies. Similarly, there might be trade-offs between economic efficiency and protection of eco-capacity. Pollution reduction measures, particularly those that reduce conventional pollutants, might not be the most economically efficient investments because they would divert capital from more productive investments. Trade-offs between efficiency and eco-capacity for pollutants that threaten basic life support systems are a lesser problem. At any rate, the criteria will have to be weighted, and this can only be done through the political process. Whatever the outcome of such a process, it is essential that the importance of the criteria is understood by the affected public.

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Blueprint for Clean Industry

UNIDO, *Blueprint for Clean Industry: Conclusions and Recommendations of the ESID Conference* (PI/111).

General Considerations

The Ministers noted with concern that, although successes had occurred in the 1970's, the gap between developed and developing countries in terms of per capita income and per capita industrial output narrowed slightly between 1970 and 1990. Industrialization, the well-trodden path to the achievement of higher standards of living and expanded economic development, remained a distant goal for many developing countries.

The Ministers noted that threats to the environment were a common concern. They stated that all countries should take effective action to protect and enhance the environment in accordance with their responsibilities and respective capacities. In this regard, the Ministers confirmed that in developing strategies to secure agreement on, and commitments by, Governments on major environmental issues, it has been recognized that:

- Because the greater part of current emission of pollution into the environment originates in developed countries, these countries bear the main responsibility for combating such pollution;
- International cooperation between all countries, and in particular between developed and developing countries, is essential to acquiring and using relevant scientific information and environmentally sound technologies. Industrialized countries with significant experience in pollution prevention, Cleaner Production methods and pollution control technologies are encouraged to promote industrial pollution prevention and management worldwide. Economic well-being is essential for achieving sustainable development and minimizing the degradation of the environment concomitant with such growth. Ministers called on Governments and industry to cooperate at the local, national and regional levels in using existing and, where necessary, establishing new mechanisms that promote pollution prevention, waste minimization, Cleaner Production, energy efficiency and rational use of natural resources and in making these techniques and technologies available, particularly to developing countries. This would entail the mobilization of financial resources and enhanced technical cooperation in particular with developing countries, at the bilateral and multilateral levels. However, it was also recognized that new and additional financial resources will have to be channelled to

developing countries in order to ensure their full participation in global efforts for environmental protection.

Ministers recognized that economic, social and environmental elements of the decision-making process should be fully integrated, and that there was a fundamental mutual dependence between economic growth and environmental protection. Ministers noted that sustained economic growth and effective environmental protection are closely interlinked and should not be looked upon as competitive policy objectives.

The continuing deterioration of the global environment is closely related to the unsustainable pattern of production and consumption in particular in industrialized countries. In developing countries, environmental degradation is closely related to poverty and underdevelopment, as well as demographic patterns and pressures. Promotion of economic and social development is therefore essential for the protection of the environment.

The Ministers noted with concern the financial and technological constraints facing the developing countries in realizing the desired ecologically sustainable industrial development.

The Conference was held at the time when economic reforms to strengthen the private sector and harness market forces in support of economic development were being carried out in a number of countries. The need was recognized for economic instruments to supplement public regulations. Ministers stressed that market-oriented instruments could play an increasing role in achieving ESID, in particular by internalizing environment considerations. Assistance should be provided upon request, by donors and international organizations, to countries that needed to develop such instruments and to administer them.

The Ministers called for new approaches to industrialization that would allow industry to contribute to economic and social benefits for present generations without compromising the ability of future generations to meet their own needs, and without impairing basic ecological processes. These new approaches do not imply in any way encroachment upon national sovereignty. States have, in accordance with the Charter of the United Nations and the applicable principles of international law, the sovereign right to exploit their own resources pursuant to their environmental policies. This also reaffirms their responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States. Those new approaches would enhance economic development over time through the efficient and rational management of both renewable and non-renewable resources while aiming at minimizing waste. They would differ from country to country, depending on the resource endowments, the stage of development and other economic and social characteristics as well as the assimilative capacity of the ecosystem.

The Ministers agreed that the reduction of pollution intensity across all media within industry, through Cleaner Production, was the key to achieving ESID. Thus, the development of technology to promote Cleaner Production should be enhanced. The objective of Cleaner Production, with its focus on source reduction, waste minimization, energy efficiency and low-waste and non-waste technology, is to prevent or minimize, in the most cost-efficient manner, the short- and long-term risks to humans and the environment. Cleaner Production would require a management approach that, ***inter alia***:

- Assigned priority to the efficient use of resources, materials substitution and product reformulation, process modification and equipment redesign to lower waste technologies, and recycling and reuse as the primary options for pollution prevention and increased profitability;
- Utilized safe and environmentally sound processes, technologies and substances combined with efficient operating procedures;
- Assigned clear responsibility and incentives for pollution prevention and control, in the context of a regulatory framework that establishes achievable environmental goals and that provides industry with flexibility in the choice of response actions.

Ministers recognized the importance of providing women with knowledge on ESID, as well as access to the necessary measures to promote it.

The Ministers agreed to support action to overcome barriers to the achievement of ESID. Among those barriers are the difficulties of implementing policies both in the North and the South that would bring about a transition to ESID. Industry everywhere needed to re-examine its attitudes on pollution prevention, Cleaner Production and environmentally friendly products.

Industry Initiatives in Achieving ESID

The Ministers recognized that industry and industrial institutions had to play a central role in the transition to ESID. While Governments can assist, regulate and control that transition, it is essential that industry acts in accordance with the principles implied by ESID. The relevant organizations and institutions should promote managerial practices and technologies based on the principles of sustainability.

The Ministers agreed that, in order to achieve ESID, industry initiatives should include the following objectives:

- Adoption of pollution prevention, the approach that prevents pollution at the source in products and manufacturing processes rather than removing it after it has been created;

- Integration of environmental awareness and responsibility at all management levels, taking into account careful analysis of relative risks, introduction of waste minimization and environmental compliance auditing, establishment of emergency, risk and safety management systems, as well as training programmes;
- Adherence to environmental codes of conduct, including voluntary ones, for industrial investment and production;
- Increase of R and D activities with emphasis on Cleaner Production technologies, giving priority to technologies that offer potential for improved efficiency and reduced pollution; and provide training facilities to developing countries for this purpose;
- Consideration, where feasible, of the use of substitute materials and product reformulations, process modifications and equipment redesigns, renewable sources of energy and raw materials, recycling and reuse of waste and scrap materials;
- Assumption of a "cradle-to-grave" assessment approach to industrial products and projects;
- Application of cleaner industrial production processes and more rational use of natural resources;
- Development, transfer and adaptation of environmentally sound technologies, know-how and skills to meet the needs of other countries, in particular developing countries, and mobilization of financial resources and provision of human resources for this purpose;
- Encouragement of industry to provide information on environmentally sound management and energy conservation.

The foregoing objectives could be facilitated by regular exchanges of experiences in the context of long-term programmes developed by industry.

The Ministers recognized that the Economic and Social Council, at its second regular session of 1991, had addressed ways to encourage and mobilize industrial enterprises, including transnational corporations, to cooperate in efforts to protect and enhance the environment in all countries. In that regard, the Council adopted resolution E/1991/55, requesting, *inter alia*, the preparation of action-oriented and practicable recommendations for consideration by the Commission on Transnational Corporations and by the Preparatory Committee of the United Nations Conference on Environment and Development.

The Ministers recognized that many transnational companies and investors involved in international joint ventures or in the export of manufacturing processes implement ESID and apply general standards of environmental responsibility to their foreign operations which are fully consistent with those used in their home countries and in compliance with the laws and regulations of host countries. These standards should not be applied on a discriminatory basis. Ministers encouraged all companies to adopt this policy and subscribe to a rational and precautionary approach to anticipating and preventing the causes of serious or irreversible environmental degradation consistent with scientific and technical understanding and the economical use of resources.

The Ministers encouraged non-governmental organizations representing all the parties involved in the industrial process, including industrial federations, trade unions, and consumers and environmental groups, to carry out and participate in activities relevant to ESID.

UNIDO undertook five case studies for the preparation of the Conference to illustrate the scope for ESID. These case studies covered pulp and paper, leather industry, alumina industry, plastics and plastics waste recycling, and phosphate fertilizers. The studies presented a number of problems related to unsustainable production processes and suggested measures to solve them. Ministers emphasized the importance of ensuring close cooperation between industry, Governments and international organizations in solving those problems.

Government Initiatives in Achieving ESID

The Ministers agreed that Governments could:

- Review the environmental impact of current and planned policies, regulations and institutional infrastructure that affect industry and environment with a view to contributing to the transition to ESID through appropriate policies and measures;
- Review the environmental impact of current and planned policies and build in the environmental concerns as an integrated part in such policies and strategies;
- Design suitable methods and tools for quantification and valuation of natural and environmental resources used by industry;
- Establish new or strengthen existing procedures for reviewing industrial projects with potentially significant environmental effects. Similar procedures should be applied for reviewing risks associated with products. The evaluation and assessment procedures should be based on a cradle-to-grave approach and continue during and after completion of projects. The evaluation and assessment procedures should be supported by internationally recognized ecological guidelines and indicators where these exist;
- Apply, with due consideration for the economic and social conditions in specific countries, a balanced mix of regulatory and economic instruments, including the internalization of externalities in price calculations, to reach the objectives of industrial development and environmental protection;

- Design policies based on the "polluter pays" principle, bearing in mind the need to internalize the cost of environment protection in price calculations, and to apply a precautionary approach and the principle of economic efficiency when undertaking or promoting investments. Inclusion of the cost for pollution abatement in entrepreneurial calculations would thus be a useful approach governing the use of economic instruments and help to achieve a better allocation of resources in the pursuit of environmentally sustainable industrial development;
- Implement schemes for increasing public awareness, particularly in the younger generation, of the necessity for ESID and the responsibility of individual enterprises, managers, engineers, workers and other members of staff in that respect;
- Give active encouragement to ESID through research, development, acquisition and transfer of techniques and technologies, as well as efficient utilization of existing relevant technologies in the public and private sectors, and through public and private partnerships while ensuring occupational health and safety;
- Promote technical and managerial training and education that incorporate ESID in both informal and formal sectors;
- Create an adequate institutional framework to stimulate environmental policies such as regulations, standardization, monitoring and control of the industrial environment;
- Promote ESID through environmental education and the participation by the general public and non-governmental organizations, such as industrial federations, employees associations, community-based groups, consumers, women's, environmental and developmental organizations;
- Support exchanges of information and experience on ESID among all countries in particular between industrialized and developing countries;
- Provide access, on preferential conditions, to financing sources to small and medium-scale enterprises in support of ESID oriented restructuring and modernization;
- Incorporate the principal elements of their policy in programmes that extend over several years. These programmes should be made public.

International Cooperation in Achieving ESID

The Ministers called upon Governments to enhance international cooperation in mobilizing financial resources for achieving ESID. The mobilization of financial resources is of vital importance to ESID, as well as to alleviating environmental problems in general. International sources of financing, particularly the development assistance programmes of developed countries, play a key role in this respect.

Noting that the transfer of techniques and technologies is one of the keys to the adaptation and absorption of pollution prevention techniques and the Cleaner Production processes by industrial firms, the Ministers agreed to encourage international cooperation in the transfer of those techniques, technologies and processes, and the requisite information, skills and know-how from industrialized to other countries, in particular developing countries, as well as the means necessary to develop infrastructure and policies to support them. The Ministers recalled United Nations General Assembly resolution 44/228, section I, paragraph 15 (m), which decided that UNCED should have as an objective the examining of effective modalities for favourable access to, and transfer of, environ- mentally sound technologies, in particular to the developing countries, including on concessional and preferential terms. The Ministers look forward to the results of that examination.

The Ministers invited Governments to seek international cooperation in addressing concerns about linkages between the environment and trade in manufactured goods. While the pursuit of the objectives of trade liberalization and environmental protection are in principle compatible, some trade practices may give rise to certain environmental concerns, and some environmental actions may adversely affect international trade flows. The Ministers also noted that improved access to markets in general— through reduction and possible elimination of tariffs and elimination of non-tariff barriers to trade—would improve the possibilities of all coun- tries, particularly of developing countries, to finance the introduction of ESID-related technologies, and could have important foreign exchange implications.

Noting that financial and technological constraints are among the key obstacles facing many countries, in particular developing countries, in achieving ESID, the Ministers acknowledged that the industrialized countries should create a climate conducive to enabling those countries to have access to appropriate ESID techniques and technologies and to financial resources on concessional and non-concessional terms, as appropriate.

Ministers called for the need to coordinate efforts between UNIDO and all other United Nations institutions and organizations that deal with environmental issues, in order to be more efficient and effective, and avoid duplication in the pursuit of ESID.

Ministers recognized the critical situation prevailing in least developed countries and called for special measures in favour of those countries in support of their ESID policies and programmes.

Future Activities of UNIDO

Ministers recognized that ESID can both reduce environmental problems and enhance industrial efficiency, and invited the fourth session of the General Conference of UNIDO to express its support for UNIDO to continue working on the best options to achieve ESID, in order to present them as a valuable contribution to be taken into account at the Fourth Preparatory Committee of the United Nations Conference on Environment and Development, which took place in March 1992, and for submission at the UNCED conference held in June 1992.

Ministers invited UNIDO to submit proposals incorporating the views expressed at the meeting in Copenhagen, and to make concrete sugges- tions to harmonize its activities, in the short, medium and long term, with the concept of ESID. These suggestions should be submitted for con- sideration to the policy-making bodies of the Organization, taking into account the mandates, recommendations and guidelines of UNCED. In order to improve UNIDO's capabilities to implement the conclusions and recommendations of the ESID Conference, the Ministers further call upon Member countries to continue to make resources available for sustainable industrial development through the UNIDO Environment Programme.

Action by UNIDO, within available regular budget resources and additional voluntary contributions, if any, could make a significant contribution to the implementation of ESID. Because environmental management often involves complex issues and requires specialized skills, UNIDO would need to work in cooperation with other organs, organizations and programmes of the United Nations system to ensure the broadest possible effort. In particular, UNIDO should work closely with the United Nations Environment Programme, especially with its Industry and Environment Office, in such activities as information exchange and training.

UNIDO should lend its support, on a coordinated basis, to the activities of other organizations active in this field, in particular United Nations regional commissions, in implementing ESID at the regional level. Further, UNIDO should promote the establishment and support of the necessary institutional framework and should work in close cooperation with national institutions in implementing ESID.

The following were some major directions for possible UNIDO action in achieving ESID:

- Assisting developing countries, upon request, in building the technical and scientific institutional capacity to develop, absorb and diffuse pollution prevention techniques and cleaner production processes essential to making the transition to ESID. This could be done by:

  - Demonstrating the financial and economic advantages and environmental benefits of ESID by working cooperatively with industry and other technical experts, and with Governments, to undertake a programme of site-specific, country case studies;
  - Providing technical support for the design, establishment, operation, evaluation and monitoring of pollution prevention techniques and cleaner production processes and technologies;
  - Assisting demonstration and training centres at new or existing industrial facilities, and providing support to centres of excellence;
- Assisting developing countries in the implementation of international environmental conventions and protocols related to industrial activities by:
  - Providing technical assistance to those countries to identify and implement the actions needed;
  - Helping those countries to locate expertise and funding for projects that contribute to the implementation of those conventions and protocols;
- Assisting developing countries in determining the environmental soundness of industrial technologies by:
  - Preparing guidelines on environmentally sound industrial practice for selected sectors;
  - Promoting, in selected sectors, technical procedures to evaluate and to test processes. products and services;
  - Providing assistance for the development of assessment techniques for the identification and measurement of environmental impact;
- Assisting developing countries in integrating environmental considerations into their industrial strategies and policies by:
  - Identifying sectoral and subsectoral priorities for environmentally sound industrial activities;
  - Specifying the techniques available to rehabilitate existing industries so that they could operate in an ecologically sustainable manner, assessing the costs of such a transition and estimating a time frame for achieving it;
- Assisting developing countries in identifying appropriate, including new, financial resources, where possible on concessional terms, that would enable them to take necessary steps to achieve ESID;

- Assisting other countries, upon request, in achieving ESID in accordance with the provisions of the UNIDO Constitution and relevant decisions of the General Conference and Industrial Development Board;
- Strengthening its existing database and its capacity to coordinate the dissemination of technical and policy information on ESID, ***inter alia***, by cooperating with the United Nations Environment Programme in its work on the International Cleaner Production Clearinghouse (ICPIC).

In implementing its programmes and projects UNIDO should establish and/or strengthen internal procedures for appraisal and approval of activities that ensure compatibility with the concept of ESID.

The Business Charter for Sustainable Development: Principles for Environmental Management

Excerpted, with permission, from International Chamber of Commerce, *The Business Charter for Sustainable Development*, Publication 210/356 A (Paris, 1990).

Introduction

Sustainable development involves meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Economic growth provides the conditions in which protection of the environment can best be achieved, and environmental protection, in balance with other human goals, is necessary to achieve growth that is sustainable.

In turn, versatile, dynamic, responsive and profitable businesses are required as the driving force for sustainable economic development and for providing managerial, technical and financial resources to contribute to the resolution of environmental challenges. Market economies, characterised by entrepreneurial initiatives, are essential to achieving this.

Business thus shares the view that there should be a common goal, not a conflict, between economic development and environmental protection, both now and for future generations.

Making market forces work in this way to protect and improve the quality of the environment—with the help of performance-based standards and judicious use of economic instruments in a harmonious regulatory framework—is one of the greatest challenges that the world faces in the next decade.

The 1987 report of the World Commission on Environment and Development, "Our Common Future", expresses the same challenge and calls on the cooperation of business in tackling it. To this end, business leaders have launched actions in their individual enterprises as well as through sectoral and cross-sectoral associations.

In order that more businesses join this effort and that their environmental performance continues to improve, the International Chamber of Commerce hereby calls upon enterprises and their associations to use the following Principles as a basis for pursuing, such improvement and to express publicly their support for them.

Individual programmes developed to implement these Principles will reflect the wide diversity among enterprises in size and function. The objective is that the widest range of enterprises commit themselves to improving their environmental performance in accordance with these Principles, to having in place management practices to effect such improvement, to measuring their progress, and to reporting this progress as appropriate internally and externally.

Principles

Corporate Priority

To recognise environmental management as among the highest corporate priorities and as a key determinant to sustainable development; to establish policies, programmes and practices for conducting operations in an environmentally sound manner.

Integrated Management

To integrate these policies, programmes and practices fully into each business as an essential element of management in all its functions.

Process of Improvement

To continue to improve corporate policies: programmes and environmental performance, taking into account: technical developments, scientific understanding, consumer needs and community expectations, with legal regulations as a starting point; and to apply the same environmental criteria internationally.

Employee Education

To educate, train and motivate employees to conduct their activities in an environmentally responsible manner.

Prior Assessment

To assess environmental impacts before starting a new activity or project and before decommissioning a facility or leaving a site.

Products and Services

To develop and provide products or services that have no undue environmental impact and are safe in their intended use, that are efficient

Note: The term environment as used in this document also refers to environmentally related aspects of health, safety and product stewardship.

in their consumption of energy and natural resources, and that can be recycled, reused, or disposed of safely.

Customer Advice

To advise, and where relevant educate customers, distributors and the public in the safe use, transportation, storage and disposal of products provided; and to apply similar considerations to the provision of services.

Facilities and Operations

To develop, design and operate facilities and conduct activities taking into consideration the efficient use of energy and materials, the sustainable use of renewable resources, the minimisation of adverse environmental impact and waste generation, and the safe and responsible disposal of residual wastes.

Research

To conduct or support research on the environmental impacts of raw materials, products, processes, emissions and wastes associated with the enterprise and on the means of minimizing such adverse impacts.

Precautionary Approach

To modify the manufacture, marketing or use of products or services or the conduct of activities, consistent with scientific and technical understanding, to prevent serious or irreversible environmental degradation.

Contractors and Suppliers

To promote the adoption of these principles by contractors acting on behalf of the enterprise, encouraging and, where appropriate, requiring improvements in their practices to make them consistent with those of the enterprise; and to encourage the wider adoption of these principles by suppliers.

Emergency Preparedness

To develop and maintain, where significant hazards exist, emergency preparedness plans in conjunction with the emergency services, relevant authorities and the local community, recognizing potential transboundary impacts.

Transfer of Technology

To contribute to the transfer of environmentally sound technology and management methods throughout the industrial and public sectors.

Contributing to the Common Effort

To contribute to the development of public policy and to business, governmental and intergovernmental programmes and educational initiatives that will enhance environmental awareness and protection.

Openness to Concerns

To foster openness and dialogue with employees and the public, anticipating and responding to their concerns about the potential hazards and impacts of operations, products, wastes or services, including those of transboundary or global significance.

Compliance and Reporting

To measure environmental performance; to conduct regular environmental audits and assessments of compliance with company requirements, legal requirements and these principles; and periodically to provide appropriate information to the Board of Directors, shareholders, employees, the authorities and the public.

Support for the Charter

The ICC is undertaking an extensive campaign to encourage member companies and others to express their support for the Charter. It has also invited certain international organizations to provide supportive messages.

A list of these companies, and the messages received from international organizations are given in separate leaflets which are normally circulated together with the Charter. They may also be obtained from ICC Headquarters or ICC National Committees in nearly 60 countries.

Business Charter for Sustainable Development, ICC Document n° 210/356/A, published in its official English version by the International Chamber of Commerce, Paris, copyright © International Chamber of Commerce (ICC), available from ICC Publishing S.A., 38 Cours Albert 1er, 75008 Paris, France.

Rio Declaration on Environment and Development

Excerpted, with permission, from *Report of the United Nations Conference on Environment and Development*, vol. I (United Nations publication, Sales No. E. 93. I. 8), resolution 1, annex I.

The United Nations Conference on Environment and Development,

Having met at Rio de Janeiro from 3 to 14 June 1992,

Reaffirming the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972[1], and seeking to build upon it,

With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people,

Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system,

Recognizing the integral and interdependent nature of the Earth, our home,

Proclaims that:

Principle 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or

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[1] *Report of the United Nations Conference on the Human Environment*, Stockholm, 5-16 June 1972 (United Nations publication, Sales No. E.73.II.A.14 and corrigendum), chap. I.

control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Principle 6

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 7

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

When the term "Governments" is used, it will be deemed to include the European Economic Community within its areas of competence. Throughout Agenda 21 the term "environmentally sound" means "environmentally safe and sound", in particular when applied to the terms "energy sources", "energy supplies", "energy systems" and "technology" or "technologies".

Principle 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9

States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

Principle 12

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Principle 13

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Principle 19

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23

The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25

Peace, development and environmental protection are interdependent and indivisible.

Principle 26

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27

States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

Agenda 21: Contents

Based on *Report of the United Nations Conference on Environment and Development*, vol. I (United Nations publication, Sales No. E. 93. I. 8), resolution 1, annex II.

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1. **Preamble**

2. **International Cooperation to Accelerate Sustainable Development in Developing Countries and Related Domestic Policies**

   - Promoting sustainable development through trade
   - Making trade and environment mutually supportive
   - Providing adequate financial resources to developing countries

3. **Combating Poverty**

   - Enabling the poor to achieve sustainable livelihoods

4. **Changing Consumption Patterns**

   - Focusing on unsustainable patterns of production and consumption
   - Developing national policies and strategies to encourage changes in unsustainable consumption patterns

5. **Demographic Dynamics and Sustainability**

   - Developing and disseminating knowledge concerning the links between demographic trends and factors and sustainable development
   - Formulating integrated national policies for environment and development, taking into account demographic trends and factors
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6. **Protecting and Promoting Human Health**

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7. Promoting Sustainable Human Settlement Development

- Providing adequate shelter for all
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- Promoting sustainable land-use planning and management
- Promoting the integrated provision of environmental infrastructure: water, sanitation, drainage and solid waste management
- Promoting sustainable energy and transport systems in human settlements
- Promoting human settlement planning and management in disaster prone areas
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8. Integrating Environment and Development in Decision-Making

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- Providing an effective legal and regulatory framework
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- Establishing systems for integrated environmental and economic accounting

9. Protection of the Atmosphere

- Addressing the uncertainties: improving the scientific basis for decision-making
  - Promoting sustainable development
  - Energy development, efficiency and consumption
  - Transportation
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10. Integrated Approach to the Planning and Management of Land Resources

- Integrated approach to the planning and management of land resources

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- Land-resource planning, information and education for agriculture
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- Conservation of biological diversity

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- Strengthening the role of farmers

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- Transfer of environmentally sound technology, cooperation and capacity-building

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Strengthening the Role of Business and Industry

Excerpted, with permission, from *Report of the United Nations Conference on Environment and Development*, vol. I (United Nations publication, Sales No. E. 93. I. 8), resolution 1, annex II, chap. 30 of Agenda 21.

Introduction

Business and industry, including transnational corporations, play a crucial role in the social and economic development of a country. A stable policy regime enables and encourages business and industry to operate responsibly and efficiently and to implement longer-term policies. Increasing prosperity, a major goal of the development process, is contributed primarily by the activities of business and industry. Business enterprises, large and small, formal and informal, provide major trading, employment and livelihood opportunities. Business opportunities available to women are contributing towards their professional development, strengthening their economic role and transforming social systems. Business and industry, including transnational corporations, and their representative organizations should be full participants in the implementation and evaluation of activities related to Agenda 21.

Through more efficient production processes, preventive strategies, Cleaner Production technologies and procedures throughout the product life cycle, hence minimizing or avoiding wastes, the policies and operations of business and industry, including transnational corporations, can play a major role in reducing impacts on resource use and the environment. Technological innovations, development, applications, transfer and the more comprehensive aspects of partnership and cooperation are to a very large extent within the province of business and industry.

Business and industry, including transnational corporations, should recognize environmental management as among the highest corporate priorities and as a key determinant to sustainable development. Some enlightened leaders of enterprises are already implementing "responsible care" and product stewardship policies and programmes, fostering openness and dialogue with employees and the public and carrying out environmental audits and assessments of compliance. These leaders in business and industry, including transnational corporations, are increasingly taking voluntary initiatives, promoting and implementing self-regulations and greater responsibilities in ensuring their activities have minimal impacts on human health and the environment. The regulatory regimes introduced in many countries and the growing consciousness of consumers and the general public and enlightened leaders of business and industry, including transnational corporations, have all contributed to this. A positive contribution of business and industry, including transnational corporations, to sustainable development can increasingly be achieved by using economic instruments such as free market mechanisms in which the prices of goods and services should increasingly reflect the environmental costs of their input, production, use, recycling and disposal subject to country-specific conditions.

The improvement of production systems through technologies and processes that utilize resources more efficiently and at the same time produce less wastes—achieving more with less—is an important pathway towards sustainability for business and industry. Similarly, facilitating and encouraging inventiveness, competitiveness and voluntary initiatives are necessary for stimulating more varied, efficient and effective options. To address these major requirements and strengthen further the role of business and industry, including transnational corporations, the following two programmes are proposed.

Programme Areas

Promoting Cleaner Production

Basis for Action

There is increasing recognition that production, technology and management that use resources inefficiently form residues that are not reused, discharge wastes that have adverse impacts on human health and the environment and manufacture products that when used have further impacts and are difficult to recycle, need to be replaced with technologies, good engineering and management practices and know-how that would minimize waste throughout the product life cycle. The concept of Cleaner Production implies striving for optimal efficiencies at every stage of the product life cycle. A result would be the improvement of the overall competitiveness of the enterprise. The need for a transition towards Cleaner Production policies was recognized at the UNIDO-organized ministerial-level Conference on Ecologically Sustainable Industrial Development, held at Copenhagen in October 1991.

Objectives

Governments, business and industry, including transnational corporations, should aim to increase the efficiency of resource utilization, including increasing the reuse and recycling of residues, and to reduce the quantity of waste discharge per unit of economic output.

Activities

Governments, business and industry, including transnational corporations, should strengthen partnerships to implement the principles and criteria for sustainable development.

Governments should identify and implement an appropriate mix of economic instruments and normative measures such as laws, legislations and standards, in consultation with business and industry, including transnational corporations, that will promote the use of cleaner production, with special consideration for small and medium-size enterprises. Voluntary private initiatives should also be encouraged.

Governments, business and industry, including transnational corporations, academia and international organizations, should work towards the development and implementation of concepts and methodologies for the internalization of environmental costs into accounting and pricing mechanisms.

Business and industry, including transnational corporations, should be encouraged:

- To report annually on their environmental records, as well as on their use of energy and natural resources;
- To adopt and report on the implementation of codes of conduct promoting the best environmental practice, such as the Business Charter on Sustainable Development of the International Chamber of Commerce (ICC) and the chemical industry's responsible care initiative.

Governments should promote technological and know-how cooperation between enterprises, encompassing identification, assessment, research and development, management marketing and application of Cleaner Production.

Industry should incorporate Cleaner Production policies in its operations and investments, taking also into account its influence on suppliers and consumers.

Industry and business associations should cooperate with workers and trade unions to continuously improve the knowledge and skills for implementing sustainable development operations.

Industry and business associations should encourage individual companies to undertake programmes for improved environmental awareness and responsibility at all levels to make these enterprises dedicated to the task of improving environmental performance based on internationally accepted management practices.

International organizations should increase education, training and awareness activities relating to Cleaner Production, in collaboration with industry, academia and relevant national and local authorities.

International and non-governmental organizations, including trade and scientific associations, should strengthen cleaner production information dissemination by expanding existing databases, such as the UNEP International Cleaner Production Clearing House (ICPIC), the UNIDO Industrial and Technological Information Bank (INTIB) and the ICC International Environment Bureau (IEB), and should forge networking of national and international information systems.

Promoting Responsible Entrepreneurship

Basis for Action

Entrepreneurship is one of the most important driving forces for innovations, increasing market efficiencies and responding to challenges and opportunities. Small and medium-size entrepreneurs, in particular, play a very important role in the social and economic development of a country. Often, they are the major means for rural development, increasing off-farm employment and providing the transitional means for improving the livelihoods of women. Responsible entrepreneurship can play a major role in improving the efficiency of resource use, reducing risks and hazards, minimizing wastes and safeguarding environmental qualities.

Objectives

The following objectives are proposed:

- To encourage the concept of stewardship in the management and utilization of natural resources by entrepreneurs;
- To increase the number of entrepreneurs engaged in enterprises that subscribe to and implement sustainable development policies.

Activities

Governments should encourage the establishment and operations of sustainably managed enterprises. The mix would include regulatory measures, economic incentives and streamlining of administrative procedures to assure maximum efficiency in dealing with applications for approval in order to facilitate investment decisions, advice and assistance with information, infrastructural support and stewardship responsibilities.

Governments should encourage, in cooperation with the private sector, the establishment of venture capital funds for sustainable development projects and programmes.

In collaboration with business, industry, academia and international organizations, Governments should support training in the environmental aspects of enterprise management. Attention should also be directed towards apprenticeship schemes for youth.

Business and industry, including transnational corporations, should be encouraged to establish worldwide corporate policies on sustainable development, arrange for environmentally sound technologies to be available to affiliates owned substantially by their parent company in developing countries without extra external charges, encourage overseas affiliates to modify procedures in order to reflect local ecological conditions and share experiences with local authorities, national Governments and international organizations.

Large business and industry, including transnational corporations, should consider establishing partnership schemes with small and medium-sized enterprises to help facilitate the exchange of experience in managerial skills, market development and technological know-how, where appropriate, with the assistance of international organizations.

Business and industry should establish national councils for sustainable development and help promote entrepreneurship in the formal and informal sectors. The inclusion of women entrepreneurs should be facilitated.

Business and industry, including transnational corporations, should increase research and development of environmentally sound technologies and environmental management systems, in collaboration with academia and the scientific/engineering establishments, drawing upon indigenous knowledge, where appropriate.

Business and industry, including transnational corporations, should ensure responsible and ethical management of products and processes from the point of view of health, safety and environmental aspects. Towards this end, business and industry should increase self-regulation, guided by appropriate codes, charters and initiatives integrated into all elements of business planning and decision-making, and fostering openness and dialogue with employees and the public.

Multilateral and bilateral financial aid institutions should continue to encourage and support small and medium-scale entrepreneurs engaged in sustainable development activities.

United Nations organizations and agencies should improve mechanisms for business and industry inputs, policy and strategy formulation processes, to ensure that environmental aspects are strengthened in foreign investment.

International organizations should increase support for research and development on improving the technological and managerial requirements for sustainable development, in particular for small and medium-sized enterprises in developing countries.

Means of Implementation

Financing and Cost Evaluation

The activities included under this programme area are mostly changes in the orientation of existing activities and additional costs are not expected to be significant. The cost of activities by Governments and international organizations are already included in other programme areas.

UNIDO Environment Programme: Response of UNIDO to Agenda 21

Excerpted from "UNIDO environment programme: Response of UNIDO to Agenda 21: Report by the Director-General" (IDB.10/32).

Agenda 21 and the Activities of UNIDO

The scope of Agenda 21 calls for a careful re-examination of the roles and responsibilities of the agencies in the United Nations system. Steps are already being taken to establish principles for defining those roles. Pending the outcome of the system-wide deliberations, UNIDO considers that it can play a key role in the implementation of certain programme areas and chapters of Agenda 21. The relevant chapters elaborated below are divided into two categories.

The first category shows those programme areas that are accorded high priority within UNIDO, based on the Organization's specific strengths as developed over the past 25 years. UNIDO regards these programme areas as the Organization's primary concerns, as they are based on a clear delineation of its role and on an efficient division of labour within the United Nations system.

The second category includes those programme areas where UNIDO can play a key complementary role contributing to the implementation of system-wide efforts relating to Agenda 21 by making optimum use of the expertise and experience available throughout the specialized agencies. Future directions for UNIDO activities are further elaborated in the updated UNIDO environment programme, taking full account of Agenda 21.

Category 1

Integrating Environment and Development in Decision-Making (chap. 8)

The UNIDO strategic management approach is based on a process of consultations and cooperation between the Government and the private sector for the development of flexible and demand-driven technical and financial support programmes that enhance productivity and secure sustainable growth. Furthermore, the policy studies, System of Consultations and technology acquisition and negotiation programmes are all instruments geared to effecting a proper integration of environment into the decision- and policy-making process.

Protection of the Atmosphere (chap. 9)

UNIDO addresses this issue in three ways: by developing alternative clean fuel programmes (cleaner coal and oil, mission control); by stimulating greater efficiency in combustion processes and energy conservation; by supporting alternative clean energy sources (solar, hydropower, hydrogen). Both environmental and energy considerations are being increasingly integrated into UNIDO activities, stressing the development of sustainable energy systems.

Protection of Water Resources; The Oceans (chap. 17); Fresh Water Resources (chap. 18)

An integrated approach to water management can ill afford to ignore industry, and the efficient use of water was thus emphasized at the ESID Conference. Over the years, UNIDO has been endeavouring to minimize the impact of industrial activities on the aquatic environment. Its objective is to improve industrial efficiency by reducing the quantity of water used, the waste water produced, and the extent of water-borne pollutants. Complementing such efforts, manuals, guidelines and technological information on the management of waste water will be prepared and disseminated.

Environmentally Sound Management of Biotechnology (chap. 16)

UNIDO has recognized the enormous potential that biotechnology offers both industrial development and environmental protection and is currently enhancing the biotechnological capacity of some developing countries so as to enable them to take advantage of that potential. Appropriate mechanisms and centres, such as the International Centre for Genetic Engineering and Biotechnology (ICGEB), have been set up.

Efforts have and will continue to concentrate on studies and capacity building, enabling countries to identify and capitalize on opportunities in biotechnology, based on their own comparative advantages, as well as on direct technical assistance in applying biotechnology to industrial activities in health care, chemical production and environmental protection; and to promote biosafety through inter-agency collaboration aimed at developing a biosafety information network and advisory service.

Environmentally Sound Management of Toxic Chemicals; Hazardous Wastes and Solid Wastes (chaps. 19, 20, 21)

Solid and hazardous industrial waste can be reduced through improved process efficiency. This involves promoting cleaner technologies, minimizing waste at source, developing alternatives for erstwhile waste and promoting recycling.

In UNIDO priority is given to safety in chemical production, especially with regard to hazardous operations and toxic chemicals. This approach covers operational, occupational and environmental safety in chemical production, and contributes to the sound management of toxic chemicals, thus complementing the work initiated by the World Health Organization (WHO) in collaboration with UNEP and the International Labour Organisation (ILO) of the International Programme on Chemical Safety (IPCS). UNIDO is currently negotiating to join IPCS.

Global Action for Women Towards Sustainable and Equitable Development (chap. 24)

The integration of women in industrial development is a cross-sectoral issue. The approaches employed by UNIDO include: promotion of gender-sensitive programme/project design; studies and research programmes to monitor the impact on women of new technologies and industrial restructuring; examination of issues related to health, safety and working conditions of women workers; development and dissemination of appropriate energy-saving and environmentally sound technologies for rural women; maintenance of quantitative and qualitative databases on women in industry; and provision of policy support to governments and industry in creating a sustainable and enabling environment for the participation of women in industry; organization of training workshops to promote women entrepreneurs in selected industrial branches with specific emphasis on environmentally sound and energy-saving technologies.

Strengthening the Role of Business and Industry (chap. 30)

UNIDO will analyse increasingly the role of business and industry with a view to advocating either the short- or long-term profitability of environmental protection through the use of clean or energy-efficient technology and energy conservation in industry. UNIDO will build on its prior experience of pollution prevention through product and process improvement, including plant modernization and rehabilitation. Business and industry in developing countries will be assisted in the adoption of processes and procedures that reduce demand on resources by industry and generate less industrial waste, ***inter alia*** by devoting particular attention to environmental considerations in the operation and development of small and medium-scale industries. Through demonstration activities such as Cleaner Production centres, UNIDO will foster the reduction of industrial waste in the production process. The investment promotion activities of UNIDO will play a major role in providing enterprises in developing countries with the means to approach sources of financing required for diversification of their products and services into environment-related areas.

Environmentally Sound Technology, Cooperation and Capacity-Building (chap. 34)

Inherent in all efforts to promote sustainable industrial development is the need to select appropriate technologies based on social, technical, economic and environmental criteria and to develop the absorptive capacity for these technologies. Support is also provided in the negotiation of technology transfer contracts in order to ensure that the transfer mechanism matches the needs and capabilities of the recipient. The efforts of UNIDO to assist developing countries in effective technology transfer will strengthen the ability of those countries to meet the obligations of international agreements relating to environmental protection, as outlined in the recommendations of ESID. For example, the transfer of appropriate technology reduces dependence upon technologies using chemicals damaging to the ozone layer; it is thus in accordance with the aims of the Montreal Protocol on Substances that Deplete the Ozone Layer. Similarly, appropriate technologies can minimize the quantities of hazardous wastes produced by industry, which supports the principles of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

Information for Decision-Making (chap. 40)

Adequate decision-making for industry is directly related to the adequacy of information available. UNIDO is working at three interrelated levels to provide information to developing countries: collection and dissemination of industry-related environmental information to developing countries through a referral/clearing-house system; data and information collection, analysis and modelling as a basis for policy formulation and decision-making; inclusion through the UNIDO feasibility study programme of environmental considerations in the calculation of the costs and benefits of potential investments. The Organization's activities also take on a further dimension in enhancing public awareness, with the public information programme advocating sustainable industrial development through the print and audio-visual media, among other approaches, and by promoting closer and continued linkages between UNIDO and developing-country counterparts, donors, the media and the public at large.

National Mechanisms and International Cooperation for Capacity-Building in Developing Countries (chap. 37)

Capacity-building permeates the many different layers of the Organization's response to Agenda 21. Its support to national capacity building concentrates on three fundamental aspects of sustainable industrial development: enhancing national capacities to incorporate environmental considerations into industrialization policy and strategies; enhancing capacities to disseminate and analyse technological information; improving capacities to analyse and exercise choices among technological options. Closely linked to technology cooperation, UNIDO's experience forms a substantial base upon which to continue, in cooperation with Governments, the United Nations system, NGOs and the private sector, to strengthen and amplify those activities.

Category 2

Combating Deforestation (chap. 11)

On the basis of its experience and ongoing activities, UNIDO supports the concepts of Agenda 21 related to deforestation by promoting the value of forestry products, maximizing the return on forestry products and publicizing the use of secondary wood species, agricultural residues and non-wood products. The programmes include using agricultural residues such as cotton-stalk wastes for charcoal manufacture, non-wood fibres such as bagasse for paper manufacture, recycling waste paper and increasing the efficiency of pulp and paper mills.

Combating Poverty (chap. 3); Promoting Sustainable Agriculture and Rural Development (chap. 14)

The organization's promotion of safer and more environment-friendly agro-chemicals such as pesticides and fertilizers and their formulations, should contribute to industry's role in the development of sustainable agriculture. It will also complement integrated pest management as well as add to the International Code of Conduct on the Distribution and Use of Pesticides. Furthermore, the assistance provided by UNIDO to such areas as low-cost housing, use of agricultural residues for energy, construction materials and pulp and paper will lend the necessary impetus to rural development.

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The Pakistan National Conservation Strategy

Excerpted, with permission, from *The Pakistan National Conservation Strategy* (Karachi, World Conservation Union, 1992) Chap 8.2. (Submitted as the national report to UNCED by the Government of Pakistan).

Industrial Development

Industry is central to the economies of modern societies and an indispensable motor of growth. It is essential to widen the development base and meet the growing needs of Pakistan. Industry extracts materials from the natural resource base and inserts both products and pollution into the environment. It has the power to enhance or degrade the environment; it invariably does both. Whether industry provides more environmental benefits than advantages depends on how it is established and maintained, and whether sustainable and least polluting alternatives are systematically examined and adopted at each stage of planning, development, and operations.

As background to sustainable industry policies, these rough rules of thumb are helpful. Typically, the cost of pollution abatement (end-of-pipe) equipment ranges from 3-5% of the capital cost of the plant. 'Retrofitting' can be two to three times as expensive. And restoring devastated ecosystems is typically 100 to a 1,000 times more costly.

Explicit consideration of environmental objectives at the project conception stage can frequently deliver the same or better product through an environmentally benign process without increase in capital outlay; re-use, waste trading, and recycling may actually reduce unit operation costs. Unlike end-of-pipe abatement, which sometimes merely moves pollution loads from one medium or place to another, anticipatory planning can have system-wide efficacy.

Since opportunities are reduced and abatement costs rise after plant and infrastructure are in place, the options for sustainable industry must be considered separately for existing and new industries.

Existing Industry

At Independence, Pakistan had no industrial base, yet it is now a leader in textiles in South Asia. In a development paradigm that was not sensitive to environmental considerations, the Government offered financial incentives to produce and export goods and to create jobs. In a harsh financial climate with few lending institutions in place, the entrepreneurs who responded to this call were strapped for cash, could not afford state-of-the-art machinery, and bought secondhand 1940s and 1950s plants from Europe that were pollution-prone. The entrepreneurs delivered what they were asked to—jobs and foreign exchange. In the 1960s, the industrial sector had a model growth rate, commended by the World Bank. Looking back, it is now clear that a growth path based on pollution was wrong, but it was deemed right at the time. Therefore it would not be fair to penalize private industry now for practices aided and abetted by Government policies in the past.

In the 1970s, many major industries were nationalized, such as steel, chemicals, and automobiles. In common with public-sector enterprises, these units were given multiple objectives: job creation and regional balance in addition to maintaining quality, profits, and growth, but seldom sustainability or environmental care. Owing to close political supervision, fewer became well-run enterprises generating their own investment requirements. In the early 1980s, a Federal Government strapped for cash and facing considerable external and internal debt decided to halt expansion in public-sector industries. As a result, some factories have now closed, while many others are barely kept going until divestiture. Most plants are poorly operated and maintained, resulting in abnormal levels of effluents and emissions per unit of production. In the past, only a small minority of public enterprises installed pollution control equipment, and there is little hope that they will now proceed on their own to retrofit their machinery.

Policies for existing industry should therefore recognize both the need to forgive private industry for environmental costs incurred in the past, while requiring them to internalize current and future environmental costs, and the no-growth, financially stagnant situation of public enterprise.

The logical measures regarding existing industry are therefore to identify the most worrying pollutants (i.e., the biggest volume discharges, the toxics of most concern, and persistent chemicals) and to establish realistic standards based on interim guidelines from the Environment and Urban Affairs Division (EUAD) to reduce the identified major pollutants (organics, solids, and selected toxics according to the industry). Implementing the reduction of these pollutants would have to be phased in, i.e., using relaxed standards to 1993 (the current Five-Year Plan) and more stringent ones after then based on Best Practicable Control Technology (BPCT), with deferment available up to 1994-95 in cases of demonstrated financial and/or technical hardship.

New Industry

The bulk of industrialization in Pakistan lies ahead. At the 7% average rate of growth in the 1980s, industry will double in 10 years and double again by 2010. Together with the ordinary retirement of industrial units at 1% per annum, this implies that 80% of Pakistani industry in 2010 will be less than two decades old, and that the nation therefore has a unique opportunity to plan these facilities with sustainability as an explicit objective.

This opportunity comes on the heels of a return to the free market in the 1980s. To quote the Ministry of Industries:

> "The industrial sector has been deregulated and as such the sponsors are free to set up initiatives anywhere in the country except in those areas which have been declared as negative areas for purpose of location.
>
> In these circumstances, environment control has become difficult (in the) industrial sector, except in a few cases which require prior approval of Government.. Thus only the right incentives...could be helpful to persuade the prospective investors to take measures (to control) en- vironmental damage. Some of the Provincial Governments have laid down a condition under which if there is no proper arrangement for effluent treatment and disposal, they can refuse to provide approval for a new or expanded industrial undertaking which is in contravention of the public interest, ecology or any other law or regulations which are in force. However, the Provincial Governments have the key role to play in control of industrial pollution."

In light of this situation, a number of measures are proposed here for new industry. First, the Government should create a set of incentives related to location and siting, benign improved processes, and recycling industries, and should apply to BPCT standards from the start. A negative and positive list of industry types to be screened (in an initial environmental estimate) and subjected to environmental impact assessments should be developed as a joint effort of the Ministry of Industry (MOI) and EUAD.

Assessments and incentives should be applied initially to water pollution; air pollution controls may be introduced on a case-by-case basis by the provincial environment protection agencies (EPAs) or by municipal development authorities.

The implementation system that should be developed must coordinate the responsibilities of MOI for setting guidelines for incentives through the Industrial Policy, of EUAD for negotiating appropriate standards for various industrial classes with MOI and with industry representatives, of provincial EPAs for establishing monitoring and enforcement networks, of local environmental science expertise for providing environmental evidence, and of industry itself.

Three Approaches to Sustainable Industrial Development

Bearing in mind these variations in content and application for existing versus new industry, three broad approaches to achieving sustainable industrial development can be followed: regulations, incentives, and location of facilities.

The three approaches can be attempted singly, but each has its drawbacks. The regulatory approach is limited by the managerial capability of Government's enforcement agencies, the incentive approach by its financial capacity, and the locations approach by the market logic of minimizing transport costs and lack of control over subsequent decisions on location. Since these limitations differ, the best results are likely from a judicious combination of the three approaches.

Regulations

Realistic, strong regulations has been shown in every industrialized country of the world to be the basis for controlling industrial pollution. It has met with mixed results in newly industrializing countries.

The approach is already incipient in the form of the Pakistan Environmental Protection Ordinance of 1983. Unfortunately, it is not yet fully operational owing to the lack of supporting legislation. Obviously such rules and regulations are one of the initial steps to be taken to implement the Ordinance fully.

The next step in the regulatory approach is to create a full-time professional secretariat for the Pakistan Environmental Protection Council to facilitate its regular meetings and implementation of its decisions. The Council should consider and approve the rules and regulations under the 1983 ordinance to effectuate the Pakistan Environmental Protection Agency.

The substantive effluent and emission standards and mechanisms to ensure compliance need to be approved (e.g., environmental addenda to PC 1 form) and then systems need to be established to decide priorities for action. For example, since the most hazardous discharges from Pakistani industry are not atmospheric but water-borne, the priority concern of the provincial EPAs should be to control discharges to water or water courses.

Such an approach and systematic steps will be necessary but not sufficient. The deterrent approach alone is not enough, as skill is required to encourage industry but to prevent it from generating pollution.

Incentives

Benign and environmentally appropriate industries should be granted the same advantages as the most favoured industry currently

Criteria for Environmentally Benign Industry

- A beneficial and sustainable use of resources.
- Innocuous or bio-degradable discharge or waste products, or preferably both.
- The ability to trace the pathway to bio-degradability and then internalize or eliminate any negative externalities (the Polluter Pays Principle).
- A use of waste produced by some other industry, thus contributing to the solution of pollution problems rather than adding to them; some form of credit balance might be required in this case.
- Provision of a market for environmentally beneficial practices, or enabling them to be adopted.
- The use of cogeneration, where the steam required for an industrial process is used to generate electrical power for the national grid.
- A contribution to conserve energy.
- The production of products or systems that treat wastes or enable recycling to take place, such as waste-water treatment plants or water recycling plants.
- The substitution of an environmentally considerate process for an environmentally degrading approach.

receives. Certain industries that are considered vital for improved export performance or some other economic reason are granted special consideration to enable rapid development. At the moment, favoured and designated industries have the readiest access to financing (the cheapest financing is dominated by government lending agencies), have the easiest access to import licenses, may be exempt from import duties for critical parts, and may receive special consideration on income taxes.

With so many of the essentials of industrial development being influenced by the government, environmentally beneficial industries are unlikely to develop strongly in competition with most favored industries unless a level playing field, with equity of treatment, is provided. Almost certainly the petro-chemical industries currently favoured by government assistance carry with them real hazards of pollution and contamination, particularly in the absence of an effective environmental law. Such industries represent a substantial contingent liability on the health and prosperity of tomorrow's generations. They thus impose costs on the community that should be internalized.

Environmentally benign industries such as fish farming, game ranching, farm forestry, or the use of the waste products of one industry as the raw material for another are not automatically given priority in the current industrial development policy. This is not to suggest that special subsidies need to be provided to environmentally benign industries. They should be, and are, capable of competing on an equal footing. But when limited funding and managerial capability is siphoned off by the incentives provided to favoured industries, it is difficult for the environmentally beneficial to prosper as they should. The principle should be one where environmentally benign or beneficial industries or industrial practices should be eligible for the same consideration accorded to industrial groups identified as essential to the development of the Pakistan economy, and for the same reason.

To be selected as an environmentally beneficial industry, eligible for most favoured industry treatment, and industry would have to meet several criteria. (See box on p.79.) The first three of these should be considered the minimum requirements for all industries. Essentially they represent the minimums built into the Environmental Protection Ordinance, and merely ensure that industries are non-polluting or pollute within clearly defined limits. To qualify as environmentally benign, an industry would have to meet these first three requirements plus one other from the remainder of the list.

Numerous examples of relevant industries can be cited. An industry that consumes 10 tonnes of sulphur per day that originated from stack wastes (rather than raw elemental sulphur) while discharging 1,000 kilograms, for instance, should be considered an environmentally beneficial industry. So would a company that collected and converted consumable waste products, from grain mills to slaughterhouses and other food-processing industries, into livestock feed. A pulp-mill might be established as a market for farm forestry products, and it could be a thermo-mechanical mill, rather than a sulphite one, so that its water consumption and waste discharges would be minimized.

Examples of industries that contribute to energy conservation include those that produce insulation materials, compressed sun-baked bricks, or energy-efficient stoves and tandoor ovens. Those that would qualify under the final criteria include the identification and packaging of biological components of Integrated Pest Management; the inoculation of plants to induce greater production of nitrogen; the development or rearing of plants, bacteria, or algae for the treatment of sullied water; the development or propagation of plant species to assist in biological treatments; or the development of plants adapted to arid conditions that would be palatable to stock and would not be considered a weed in more humid conditions.

Industrial Siting

The national industrial policy also gives a number of incentives to favoured locations, such as customs duty exemptions on machinery, tax holidays, and subsidized electricity. However, these zones have been designated on the basis of regional economic balance, not on their inherent capacities to absorb and treat industrial wastes.

Ecosystems have vastly different assimilative capacities. While the theoretically best solution is that no ecosystems should be polluted, practical requirements suggest the use of these quality differences in nature, provided this can be done without undermining the national drive to establish standards and enforcement mechanisms.

After the installation of focused regulatory and incentive approaches, uniform standards for emissions of particulates, gases, and liquid pollutants for particular industrial categories should be established and enforced nationally to avoid provinces competing for industries by applying less stringent standards.

In the case of certain industries, however, it may be inordinately difficult either to compel attainment of certain minimum standards of environmental discharges or to provide most favoured industry status for environmentally benign processes. The arguments could be that the effective application of regulations would handicap industry too much and make it non-competitive, while the provision of subsidies would be too costly and inequitable, and would not provide sufficient reward to induce the major offenders to clean up their processes. Such 'heavy' industry must be located at sites where their discharges will cause the least damage to the environment and people.

This approach involves the location of industry on sites where biomass productivity is very low—on sandy, stony, or rock deserts or areas of very low productivity for other reasons. Some 12.2 million hectares of land in Pakistan falls in the Class I and II category of good or very good agricultural soils; another 75 million hectares not in those categories are not as critical for the food base of the country. Among these poorer or non-agricultural soils, it should be possible to find suitable alternative sites for industry that does not whittle away at an agricultural base that in 20 years must feed 200 million people.

The water-table below sites for heavy industry should be non-potable or, if potable, so deep (more than 500 feet) that chances of contamination are negligible. Watercourses for at least 30 kilometres downstream should be unutilized or unutilizable so that untreated waste-water discharges are not reused for stock watering, drinking, or irrigation before they have had a chance to be thoroughly cleansed.

Every province has areas that meet these criteria to a greater or lesser extent. Industries need not be sited on Class I and II agricultural land, on top of sweet groundwater, or near or upstream of users of water or groundwater. It is an act of criminal irresponsibility to neither control industrial wastes nor locate industry where its effluents will do the least harm to the fewest people. Either one or the other, though preferably both, should be chosen to minimize the harmful effects of industrial effluents and emissions.

Provincial governments, which are responsible for industrial siting approvals (no objection certificates), already guide heavy industry away from population centres. They should also develop explicit instruments to guide industry away from prime agricultural land. By the same token, they should continue to develop industrial estates away from such areas, and should provide the collective treatment facilities. The discharges from industrial parks or zones must comply with the standards set for all industry, to avoid complaints of unfair competition; low costs for dirty plants on 'hardened' sites provide a disincentive to high-quality environmental and economic performance among competitors elsewhere in the country.

Setting industry up away from urban centres may lead to the work-force invading adjacent land and settlements springing up; this happened at Bhopal and was a factor in the high mortality and injury there. Hence, rigorous residential development controls have to be imposed. Large industries may be encouraged to set up 'industrial settlements' where the work-force is provided with adequate housing and services as part of the benefits package. This would require a considerable investment by the industry, but would pay off in the long run by creation of a stable, dedicated, well-trained labour force.

Transnational Corporations

One special enterprise category needs to be mentioned separately: Pakistani branches of transnational corporations. The parent companies may range widely in size, but have in common an experience of complying with environmental requirements elsewhere. Their record in Pakistan, though better than indigenous firms, is still much below their performance in their home countries. It is clearly undesirable for such companies to be allowed to treat the environment of Pakistan with less respect than that of their home countries. If lower environmental standards are accepted for the sake of cost-cutting, the costs to the company of environmental control are externalized and the citizens of Pakistan pay the price, either today or tomorrow.

It may be easier to persuade transnationals to adopt environmental controls since they are used to doing this elsewhere, and they could provide an example of compliance with environmental standards for all companies. Getting their cooperation also provides an opportunity for the transfer of environmental technologies, and for the import of standardized pollution control packages.

Summary of Industry Policies and Measures

Policy:

- Develop and enforce effective pollution controls.

Measures:

- Set in place an industry-wide system for collection of national and regional statistics on location, type, and amount of effluents and hazardous wastes, plus a survey of existing waste treatment equipment and degree of use.
- Establish government regulations and standards in consultation with industry.
- Implement a phased programme of pollution controls by EUAD and by provincial EPAs.
- Implement in-plant and end-of-pipe environmental safeguards within industry, along with the preparation of waste management plans for the reduction, collection, reuse, or treatment and disposal of industrial wastes.
- Incorporate a programme to establish and disseminate 'environmentally safe product' standards by the proposed Quality Control Authority as part of its product standards setting function.
- Disseminate improved industrial engineering design practices for internal process and environmental control standards (e.g., promoting efficient use of coolant water, process heat).
- Reorient balancing, modernization and replacement incentives for old industry to encourage modernization that reduces pollution (as in Indonesia's 'industrial restructuring' programme).

Policy

- Promote clean industrial processes and recycling.

Measures:

- Disseminate information on the economics of recovery with case studies of sucess.
- Encourage waste trading networks.
- Develop institutions for acquisition and transfer of environmentally benign technologies.
- Insist that branches of transnational corporations in Pakistan meet or do better than the environmental standards shared in their home countries.
- Provide special incentives, like tax holidays, for recycling industries.

Summary of Industry Policies and Measures (cont.)

Policy:

- Establish incentives for environmentally beneficial or benign industries.

Measures:

- Apply the current incentives of the national industrial policy to environmentally beneficial industries.
- Grant specific fiscal and trade incentives for defined categories of environmentally sustainable industry.
- Develop a package of financial incentives to offset the cost of environmental control equipment.

Policy:

- Develop a policy to site industry in areas of lower environmental sensitivity.

Measures:

- Establish regional and local land use plans and controls.
- Continue controls on the location of industry in urban areas.
- Promote rural industrialization.
- Guide industry away from prime agricultural land and areas of sweet groundwater.
- Control residential development close to hazardous industry.

Policy:

- Build awareness within industry.

Measures:

- Give out annual awards for environmentally clean industry.
- Disseminate the sustainable development concept by lectures, video shows, etc.
- Promote pollution control systems as potential opportunites for further industry, cost savings, and so on.

Further information may be obtained from:

Environment and Energy Branch, UNIDO
Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49

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Learning Unit 4

CLEANER PRODUCTION

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

Additional Course Materials

Reading: *Cleaner Production Worldwide*, a UNEP booklet

Video: *Pollution Prevention: Swedish Experiences*, a film by TEM, an environmental research organization at the University of Lund

Introduction

In Learning Unit 4 we describe what Cleaner Production means, explain its role in achieving ESID and discuss how it can be achieved. Cleaner Production is important to industrial development because it offers the potential to reduce pollutants and to increase industrial productivity.

Objectives

The specific learning objectives of this unit are as follows:

- To understand the concept of Cleaner Production as essential for achieving ESID.
- To review the many activities that can achieve Cleaner Production.
- To learn what many enterprises already have achieved by implementing Cleaner Production.
- To be aware of the barriers to introducing Cleaner Production to industry.

Key Learning Points

1 Industry first tried to deal with pollution by using the natural environment to dilute the impact of pollutants. Subsequently, it became clear that some action had to be taken to minimize the impact of pollutants on the environment. This led to the use of pollution control (end-of-pipe) technology. These methods are expensive and, often, they are not fully effective.

2 Cleaner Production avoids industrial pollution by reducing waste generation at every stage of the production process in

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order to minimize or eliminate waste before any potential pollutants are created.

3 The terms pollution prevention, source reduction and waste minimization are often used to mean the same thing as Cleaner Production.

4 Cleaner Production can be achieved in a number of ways, such as good housekeeping and operating procedures, materials substitution, technology changes, on-site recycling and product redesign or any combination of these actions.

5 Cleaner Production is more cost-effective than pollution control. By minimizing or preventing waste generation, the costs of waste treatment and disposal are reduced. Furthermore, the systematic avoidance of waste and pollutants reduces process losses and increases process efficiency and product quality.

6 The environmental advantage of Cleaner Production is that it solves the waste problem at its source. Conventional end-of-pipe treatment often only moves the pollutants from one environmental medium to another, e.g. the scrubbing of air emissions generates liquid waste streams.

7 Cleaner Production is often not accepted because of human factors rather than technical problems. The traditional end-of-pipe approach is well known and accepted by industry and engineers. Existing government policies and regulations often favor end-of-pipe solutions, which are administratively easier to impose. There is a lack of com- munication between those in charge of production processes and those who manage the wastes that are generated. There is often a lack of easily accessible information. Managers and workers who know that the factory is inefficient and wasteful are not rewarded for suggesting improvements.

8 Although Cleaner Production techniques are preferable, some end-of-pipe treatment still may be necessary when it is impossible, at least for now, to eliminate completely the production of wastes.

9 Because Cleaner Production attacks the problem at several organizational levels at once, the introduction of an industry/ plant-level Cleaner Production programme requires the

commitment of top management and a systematic approach to waste reduction in all aspects of the production process.

10 Future industrial development based on Cleaner Production would bring industrial activity closer to meeting the ESID criteria because it would both reduce pollutant discharges and increase the efficiency of raw material and energy utilization.

Suggested Study Procedure

1 Look through the test at the beginning of the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.

2 Work through the *Study Materials*, including the *Reading Excerpts*, the brochure and the video.

3 Prepare answers to the questions posed for the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

4 Complete the exercises in the *Review*.

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Study Materials

The following sections are designed to help you become familiar with Cleaner Production, to explain how Cleaner Production fits in with other approaches dealing with pollution, to outline the advantages of Cleaner Production, to acquaint you with many of the principal methods for achieving Cleaner Production and to discuss the barriers to implementing Cleaner Production in developing countries.

Background

The approach to pollution control has evolved through three stages over the last 50 years:

- Dilution
- Treatment
- Avoidance/Cleaner Production.

Many countries are still at the dilution and/or treatment stage.

The dilution approach involves the discharge of pollutants directly into the environment. It relies on the assimilative capacity of the water, air and soil to dilute or neutralize the impacts. This approach can work if the amount of waste is small compared to the volume of the receiving environment.

The treatment stage, traditionally called end-of-pipe treatment, has been used at the end of the production process to collect pollutants and then to separate or neutralize them in various ways, usually in specially built treatment installations. Treatment often merely separates the pollutants from the waste stream, but they still have to be disposed of somewhere.

Dilution and treatment, and even recycling, are not long-run solutions. Natural systems have a limited assimilative capacity to dilute wastes (see Learning Unit 2). In areas where there is a heavy concentration of industry, this capacity is easily exceeded. Wastes can impair human health, reduce the productivity of fisheries and agriculture and damage man-made materials. The level of treatment is often limited because only so much of production costs can be allocated for pollution control, which is a non-productive investment. Recycling often suffers from poor or unpredictable markets for its products. Both treatment and recycling generate further residues themselves, some of which may be worse than the original waste product.

The costs of the end-of-pipe treatment approach are creating a barrier to further industrial development. The United States spent US$ 100 billion and the countries of the European Community spent more than US$ 30 billion on pollution control in 1992. There is little direct financial return to the industries that incur this expenditure.

The composition of the pollution is becoming more complex. Thousands of new chemicals are introduced into the market each year to add to those already there. Some of them find their way into emissions and wastes. Also, the potential toxicity of these chemicals means that safety regulations are required to protect workers and users. The costs of complying with these regulations must be borne by chemicals producers and users.

Strengthened environmental regulations are putting pressure on industry to increase its environmental performance. It is often difficult, however, to modify existing plants at a reasonable cost.

Cleaner Production, the preventive way, is a better approach to avoiding and minimizing environmental problems. Avoiding pollution by preventive methods often solves the problem rather than treating the symptoms. As a consequence of Cleaner Production, there are often cost savings and better quality products.

Next Steps

1 Read "The road to ecologically sustainable industrial development", included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the material by answering the questions below. Compare your answers with those suggested.

Questions

1 What are the three stages in the evolution of pollution control approaches?

2 Give two examples of how dilution still is used.

3 What are two weaknesses of end-of-pipe treatment?

4 Explain how a Cleaner Production approach was used to reduce dioxin discharges from pulp and paper mills.

Answers

1. Dilution, treatment and Cleaner Production.

2. Letting untreated effluent flow into a river and installing higher smoke stacks.

3. It does not reduce waste production hence it does not increase production efficiency. It is often more expensive than Cleaner Production. Often, it only transfers the pollution from one medium to another, e.g. from the air to the soil.

4. Sufficient reduction of dioxin discharge from pulp and paper mills by treatment of waste water is not possible. Thus, the industry had to change its bleaching process and significantly reduce chlorine use.

Cleaner Production

Cleaner Production is defined by UNEP as the continuous application of an integrated preventive environmental strategy to processes and products to reduce risks to humans and the environment.

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- For production processes, Cleaner Production includes conserving raw materials and energy, eliminating toxic processing materials and reducing the quantity and toxicity of all emissions and wastes before they leave a production process.

- For products, the approach focuses on the reduction of environmental impacts along the entire life cycle of a product, from raw material extraction to the ultimate disposal of the product, by appropriate product design.

Cleaner Production is good for the environment because it reduces pollution from industry. There are also some direct benefits to the companies that follow this approach, such as:

- Cost-saving through reduced wastage of raw materials and energy.

- Improved operating efficiency of the plant.

- Better product quality and consistency because the plant operation is more predictable.

- Recovery of some wasted materials.

Cleaner Production requires:

- Applying know-how.

- Improving technology.

- Changing attitudes.

The Cleaner Production approach to industrial environmental management requires a hierarchical approach to pollutant management practices. The order of preference in decision-making on design and operation is as follows:

- Prevention of generation of wastes.
- Recycling.
- Treatment.
- Safe disposal.

Only when prevention techniques have been fully adopted should recycling options be used. Only when wastes are recycled as far as possible should treatment of the residues be considered. To use off-site recycling or end-of-pipe technologies before prevention has been maximized is not Cleaner Production.

Cleaner Production does not always require new technologies and equipment. Some examples of practical Cleaner Production techniques include:

Good housekeeping and operating procedures:

- Tighten valves and check pipes to reduce leaks. Turn off water when not needed.
- Minimize dragout when objects are removed from processing baths.
- Optimize operating parameters of the plant.
- Reduce storage and transfer losses by revising procedures.
- Improve materials handling to reduce the incidence of spillage.

Material substitution:

- Replace solvents with water.
- Replace acid pickling of steel with peroxide treatment.
- Replace chlorine bleaching with oxygen bleaching.

Technology changes:

- Batch instead of continuous processing.

- Mechanical instead of solvent cleaning.
- Powder painting instead of wet painting.
- Automatic instead of manual chemical feed.
- Dry heating instead of heat treatment baths for metal finishing.

On-site recycling:

- Internal recycling of rinse waters.
- More efficient washing or cleaning using counter-current principles.
- Steam condensate recovery and recyling.

Product redesign:

- Remove toxic substances from product components.
- Concentrate product to reduce packaging.
- Increase durability and improve repairability.
- Use materials that can be recycled.

In the PRISMA project, the Government of the Netherlands selected 10 of the most efficient companies in the electroplating, food and drugs, transportation, metalworking and chemicals industries. An initial assessment of Cleaner Production possibilities yielded 164 options, distributed as follows: improved housekeeping (28%), material substitution (22%), technology changes (39%), on-site recycling (10%) and product redesign (1%).

Because it often leads to cost savings and improved operating efficiencies, Cleaner Production enables business and other organizations to pursue their economic goals while improving the environment at the same time.

The implementation of Cleaner Production involves changes in human thinking and attitudes about production and the environment.

Next Steps

1 Read "Deciding on pollution prevention" from the *Facility Pollution Prevention Guide*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What is Cleaner Production?

2 What is the difference between Cleaner Production and traditional environmental protection approaches?

3 What are some of the environmental benefits of Cleaner Production?

4 What are some of the benefits to companies of Cleaner Production?

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5 **What are the three source reduction measures involving process changes mentioned in the *Facility Pollution Prevention Guide*?**

6 **Why is off-site recycling not considered a Cleaner Production process?**

Answers

1. *Cleaner Production is the continuous application of an integrated preventive environmental strategy to processes and products to reduce risks to humans and the environment.*
2. *Cleaner Production looks for pollution prevention opportunities, such as product and process changes and on-site recycling and recovery, before turning to pollution abatement measures.*
3. *It eliminates toxic processing material, conserves energy and raw material and reduces the discharge of pollutants into the environment.*
4. *Company benefits include increased efficiency and financial returns.*
5. *Improved operating practices, technology changes, input material changes.*
6. *Off-site recycling requires transportation and there is often residual waste from the recycling process.*

Cleaner Production Pays

Cleaner Production is cost-effective. It can increase process efficiency and improve product quality.

The payback period is the amount of time it takes the savings to pay back the amount invested in Cleaner Production. Some savings, e.g. housekeeping and changed procedures, can be made immediately; some require study and investment. Even when investment costs are high, the payback period can be short.

End-of-pipe treatment is an add-on cost and does not give a payback.

Many Cleaner Production techniques yield substantial savings in production costs. (See the *Reading Excerpts* and the video.)

Savings can come from reduced raw material and labor costs, lower energy consumption, less expensive maintenance, reduced waste management costs, improved worker safety and lower product liability.

In the PRISMA project, the 42 Cleaner Production options for small and medium companies were determined: 20 of them (49%) produced cost-savings, 19 (45%) were cost-neutral and 3 (7%) increased production costs. The cost-saving options had an average payback period of less than one year.

Thus, even though Cleaner Production does not always lead to cost-savings, it is the most cost-effective way to reduce pollution.

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Next Steps

1 Read the brochure *Cleaner Production Worldwide,* included in the training kit, and "The effects of cleaner production on unit costs," included in the *Reading Excerpts* that accompany this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 Explain how Cleaner Production leads to savings.

2 Does Cleaner Production always have a payback?

3 How did Cleaner Production save money for the photographic firm PCA International?

Answers

1. Savings in raw materials and energy, decreased waste management costs, improved product quality, enhanced productivity, decreased down time, decreased long-term liability for the clean-up of wastes.

2. No, but in most cases it does, and it is always the most cost-effective way to reduce pollution.

3. Replacing the organic solvents by water-based solvents led to a 100 per cent reduction of waste, with a payback period of less than one year.

Next Steps

1 Look over the questions below so that you have some idea of what you will want to learn from the video.

2 Watch the video *Pollution Prevention: Swedish Experiences.*

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What motivated the company Landskrona Emballage to try water-based inks?

2 How does the use of water-based printing inks improve the working environment?

3 What importance did the manager of Landskrona Emballage attach to his employees' involvement in developing the cleaner printing technology?

4 How can the traditional alkaline degreasing processes be replaced?

Answers

1. *They were forced by the authorities to reduce their solvent emissions.*
2. *The printer is no longer forced to work in close proximity to ethanol-based inks. He can wash out with water instead of volatile organic solvents.*
3. *It would not have been possible without their full support and enthusiasm.*
4. *An alternative is biological alkaline decreasing process, using naturally occurring bacteria which degrade the oil pollution.*

Introduce Cleaner Production to Industry

Industry can make Cleaner Production happen through a commitment to action within the company. Many corporations in industrialized countries have already introduced Cleaner Production without waiting for government action.

Because Cleaner Production often involves a change in attitudes, people need incentives to work towards an integrated, systematic approach to environmental protection.

Without a clear, written commitment from top management to Cleaner Production, other personnel will not contribute effectively.

Without the involvement of all workers at all organizational levels in a plant, good results will be hard to get. Motivation, incentives and a workplace culture where suggestions from the shop-floor are acted on are needed to achieve such universal involvement.

The internal training of workers, supervisors and managers is necessary to identify opportunities for Cleaner Production and to implement it.

Ten steps for introducing a Cleaner Production program in an enterprise are as follows:

- Develop and implement a comprehensive corporate environment policy that focuses on prevention.
- Set corporate goals for the Cleaner Production programme, with specific percentages and timetables.
- Allocate responsibility, time and financial support for the entire Cleaner Production programme.
- Involve employees at all levels.
- Develop waste reduction audit procedures within the company and use them on a regular basis to identify, evaluate and eliminate waste at each stage in the production process. This gives the information on which in-plant Cleaner Production options can be based.

- Obtain and use the best possible technical and other information, from both inside and outside the company. Waste reduction criteria can cover technical environmental factors, regulatory compliance, public acceptance and economic viability. Research the industry specific Cleaner Production publications, newsletters and databases of UNIDO and IE/PAC.
- Monitor and evaluate progress of the company's Cleaner Production programme.
- Regularly inform all employees on the Cleaner Production progress made by the company in the last month, six months, year and five years.
- Encourage and reward successful individual and group efforts to implement Cleaner Production.
- Remember that success in Cleaner Production is a journey not a destination. Update the waste minimization goals and timetables on a regular basis.

Identifying Cleaner Production Opportunities in a Factory

In an existing plant, there is a need to study where the pollution comes from in order to take the most cost-effective remedial action.

One way of doing this is a waste audit, which systematically looks at all processes and operations. The idea behind the audit is that any raw material that does not end up in the product must go out as waste. The audit procedure systematically identifies these losses, many of which may be hidden from view.

UNIDO and UNEP have produced a technical guide to waste reduction audits. You will learn about waste reduction audits in Learning Unit 5.

Barriers to Introducing Cleaner Production

The introduction of Cleaner Production is sometimes hampered by:

- Resistance to new ideas and approaches in which staff have no formal training. Demonstration projects are essential to show that Cleaner Production can work in "our country" or in "my company".
- Lack of financial resources, awareness and training, expertise and know-how, information and access to existing knowledge.
- Uncertainty about the right information, technology or regulations.
- Government policies/regulations that focus on single-medium pollutant reductions that discourage innovative solutions to pollution reduction and that offer tax incentives for investment in end-of-pipe technologies.
- Lack of familiarity with Cleaner Production practices and techniques on the part of engineers and consultants. Often they do not pay enough attention to improvements in housekeeping, small modifications of existing equipment and other less technical matters that can be very cost-effective.
- Fear of being put at competitive disadvantage as a result of perceived high costs.

Next Steps

1 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

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1 List some of the main barriers to the introduction of Cleaner Production.

2 How can a firm induce all workers to become involved in Cleaner Production?

3 Are engineers and consultants always familiar with Cleaner Production practices and techniques?

4 What should motivate consulting firms to advise clients on Cleaner Production rather than end-of-pipe treatment?

Answers

1. Lack of know-how.
Resistance to the new approach by the staff.
Financial difficulties.
Uncertainty about the right way to apply Cleaner Production.
Difficulty in getting governmental support.

2. For good results, it is necessary to get the participation of all workers in a plant by motivation, incentives and a workplace culture where shop-floor suggestions are acted on.

3. No, often they do not pay enough attention to improvements in housekeeping or to small and less technical modifications of the production process.

4. What is good for the client is ultimately the best also for the consulting firm.

Additional Suggested Reading

This concludes the study section of Learning Unit 4. For additional information on Cleaner Production, you may refer to the following sources.

Berglund, R.L., and C.T. Lawson, "Preventing pollution in the CPI", *Chemical Engineering*, September 1991.

Crittenden, B.D., and S.T. Kolaczkowski, *Waste Minimisation Guide* (Institution of Chemical Engineers, 1992).

de Hoo, S., and others, "The PRISMA Project as a model for use in other countries: background, methodology, results and some follow-up projects", paper presented at the UNEP Ministerial Meeting and Second Senior Level Cleaner Production Seminar, 27-29 October, 1992, Paris.

Huisingh, D., and L.W. Baas, "Cleaner Production: the most effective approach to achieving improved water quality", *European Water Pollution Control*, vol. 1, No.1, (1991).

Johansson, A., *Clean Technology* (Boca Raton, Florida, Lewis Publishers, 1992).

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Case Studies

Next Steps

1 Study these cases, all of which are adapted from the brochure *Clean Technology*, published by the Department of the Environment (United Kingdom). Then answer the questions that follow, if possible working in a small group.

2 Compare your answers with those suggested.

Case Study 1: Reduction of Chromium Pollution and Waste in Leather Tanning

The conversion of hides to leather has been carried out from the earliest times and still follows the same basic procedure. Many agents (vegetable, organic and metallic) can be used in the tanning stage, each conferring different characteristics to the leather.

The use of trivalent chromium as a tanning agent is comparatively recent, only becoming established on a large commercial scale by about 1910. Now it is the most widely used process. Chromium imparts desirable qualities of wear, softness, feel and texture to the leather. The level of chromium normally used for high quality leather is 4-5 per cent by weight. To achieve this, even by the most efficient processing, some 30 per cent of the chrome offered to the hide is left in the tanning liquor and wasted.

The British Leather Company, which processes about 6,000 hides a week employs a cleaner technology that entails two stages. The first stage uses a liquor based on titanium, aluminium and magnesium, with no chromium. This is the TAL process of ICI. In the second stage, a chromium tan is used with 9 per cent chromium instead of the normal 17 per cent. This results in a leather with a chromium content of about 3 per cent but with characteristics comparable to traditional leather. Residual chrome in the spent liquor is reduced because less chrome is used initially and the percentage uptake is greater. The overall effect is to reduce the chromium content of the spent liquor from 1,200 to 350 ppm and the level in the final effluent to 10 ppm.

Advances in leather technology combined with extensive tanning trials have made this process commercially viable. Considerable research was carried out to identify the optimum tanning properties of the various combinations of metals used in the first stage of the process.

The solution adopted has two advantages:

- The chromium level in the discharge is substantially reduced, removing a potential constraint on production.
- The technology requires no additional capital equipment and can be used in an existing plant.

There are also modest savings in tanning reagent costs. The main incentive to move to cleaner technology is the anticipation of higher future standards. The company can expect to save at least US$ 300,000 that would be required for an abatement plant to achieve the same chromium reduction as that obtained by cleaner technology.

Questions

1 Which of the various techniques for Cleaner Production (good housekeeping/operating procedures, material substitution, technology changes, on-site recycling and product redesign) is illustrated in Case Study 1?

2 Why do you think the plant considered implementing a Cleaner Production approach?

3 Why do you think the tannery did not want to install pollution control equipment?

4 What do you think might be some barriers in transferring this Cleaner Production approach to other places?

Answers

1. Basically a material substitution.

2. Increasingly stringent discharge standards for chromium and significant reductions in the cost of waste treatment.

3. Pollution control equipment would not recover chromium and it would entail a large capital investment, with no financial return.

4. Attitudes, lack of knowledge and lack of discharge standards.

Case Study 2: Cement Kiln Pollution and Waste Reduction by Improved Process Control

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The manufacture of cement in its present form was patented in 1824. Known as Portland cement, it requires the burning of fuel together with limestone and clay, yielding a clinker which is then ground with gypsum to give cement. Burning is carried out in a rotating, inclined kiln. The process is complex, in terms of the reaction chemistry, the thermal conditions in the kiln and the dynamics of the process. The temperature largely determines the quality of the product cement. However, both the NO_x and SO_x levels increase with higher temperatures.

The process must, therefore, be operated within a certain band of temperature, with the optimum at the lower end. If the process is operated too far below this optimum, an unusable product is generated. If the temperature is too high, energy is wasted, cement quality reduced and air pollution increased. There are many possible disturbances to the process, for example, changes in the calorific value of the coal and the composition of the feed, which make it difficult to operate manually.

The LINKman expert system, developed by Image Automation, continuously monitors all the appropriate process variables such as the flue gas temperature, oxygen, NO_x level and the power used to turn the kiln. It then makes adjustments to the coal, air and feed rates on the basis of a model of the plant's behaviour derived from operational experience. The system can also make smaller adjustments more frequently. This allows the plant to be run much closer to its optimum conditions than is possible under manual control. One significant novel feature of the instrumentation is the measurement of the NO_x level in the flue gas, which gives valuable information on the temperature in the firing zone and can be used to help minimize NO_x air pollution.

The system has been made possible by improvements in the science of expert system control and in measurement technology, which have led to a reliable and sensitive NO_x analyser.

The system was installed on two of its kilns by Blue Circle Industries in the United Kingdom. It generated cost savings of US$ 1,860,000 in 1987. The payback period for the capital investment of US$ 406,000 was three months.

The advantages are as follows:

- Coal wastage avoided.
- Better quality product.
- Less energy for clinker grinding.
- Kiln lining has longer life.
- NO_x and SO_x emissions are reduced from 500 ppm to 200 ppm.

Questions

1 Which of the various Cleaner Production techniques is illustrated in Case Study 2?

2 Was the introduction of Cleaner Production cost-effective?

3 Why might workers in this plant have resisted the introduction of this Cleaner Production action?

4 Do you think cement plants need end-of-pipe pollution control technologies?

Answers

1. *Improved operating procedures.*
2. *Reduced fuel use and improved product quality. Three months payback.*
3. *They may fear that giving away their unique professional knowledge to a computer expert system may cause them to become redundant.*
4. *Yes. They need filters on their smokestacks to recover particulate matter.*

Case Study 3: Upgrading of Tin Concentrate

Tin has been mined from the earliest times. There has been a steady improvement in the percentage of tin in the concentrate that is sent to the smelters. The tin content of the concentrate has a strong bearing on its value. Other materials such as copper, tungsten and zinc are also recovered from the ore.

The traditional process involves a number of steps culminating in flotation. The slurry containing the tin ore flows cross-current to the rising bubbles, which float as a foam carrying the tin-rich particles. The separation and upgrading of the ore have now been improved by introducing column flotation. The rising bubbles and falling ore flow counter-current, giving the effect of multiple stages of normal flotation. A water wash gives improved separation at the top of the column.

Carnon Consolidated, in the United Kingdom, reported that based on annually upgrading concentrate with a tin content of 800 tonnes, the capital investment of US$ 32,000 had a payback period of only 18 days, because the price for the tin concentrate increased by US$ 640,000.

The advantages can be summarized as follows:

- Higher market value for the concentrate.
- Less waste from smelting.
- Less energy used for smelting.
- Low capital investment.

Questions

1 Which Cleaner Production measure was applied in this situation?

2 What is the main reason this Cleaner Production programme was successful?

3 What do you think was the company's main motive for this change—increased profits or environmental protection?

Answers

1. Technology change.

2. It resulted in a very short payback period.

3. Increased profits. The example shows that environmental protection through Cleaner Production is fully compatible with normal business objectives.

Case Study 4: Trivalent Chromium Plating

High quality chromium plating, used for decorative finishes and to impart resistance to wear and corrosion, has traditionally required a high concentration of toxic hexavalent chromium ions, which give a highly toxic effluent. One company in the United Kingdom, W. Canning Materials, has introduced an electrolyte with a much lower concentration of the less toxic trivalent chromium ion. Two technical problems had to be overcome:

- The tendency of the trivalent chromium to oxidize to hexavalent at the anode. This was overcome by using a membrane that had originally been developed for the mercury-free electrolysis of brine.

- The low rate of deposition at the cathode due to the kinetics of the reaction. This was overcome by in-house development of organic additives that modify the reaction and give a performance superior to the traditional process.

For a new plant, economic benefits arise from the use of smaller baths to achieve the same production rate and from reduced expenditure on effluent clean-up. Where there is a premium on quality or where hexavalent chromium is not permitted, savings are even greater. The new technology leads to five advantages:

- A safer working environment.

- Reduced discharges of toxic hexavalent chromium, typically from 80 ppm to less than 3 ppm of less-toxic trivalent chromium.

- Quality is improved because the plating is more uniform. This also saves chromium and allows more articles to be plated in the same bath.

- Only half as much electricity is required to deposit the same quantity of chromium.

- Reduced effluent treatment costs.

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Questions

1 Which Cleaner Production technique is illustrated in Case Study 4?

2 Could this plant solve all its water pollution control problems with Cleaner Production?

3 Why do you think management might have resisted the introduction of an alternative electrolyte?

4 Why was the change cost-effective?

Answers

1. Basically a material substitution.

2. No. It still needed traditional end-of-pipe waste-water treatment, but the plant was much smaller.

3. Concerns about the effects on product quality.

4. It reduced the operating cost of both the plating and the effluent treatment plant.

Review

Test

The following test will help you review the material presented in Learning Unit 4.

1 The first step in improving Cleaner Production in industry is a change in

a. Technology
b. Customer preference systems
c. Attitudes
d. Legislation on recycling

2 The approaches to industrial environmental management have evolved through which three stages?

a. Abatement to prevention to dilution
b. Prevention to dilution to abatement
c. Dilution to prevention to abatement
d. Dilution to abatement to prevention

3 The most cost-effective management choice for combating industrial pollution is pollution

a. Prevention
b. Dilution
c. Abatement
d. Control

4 Cleaner Production eliminates waste

a. During production
b. At every stage of the life cycle of a product
c. By disposing of wastes safely in approved facilities
d. By recycling processing residues

5 Cleaner Production does not include

a. Better housekeeping
b. Ecologically benign products
c. Recycling of wastes by outside contractors
d. Low- and non-waste technology

6 From the practical business point of view, pollution prevention

a. Often pays
b. Does not pay
c. Has a long payback period
d. Is not possible

7 Cleaner Production is all of the following except

a. Preventive or proactive
b. Idea-oriented
c. Reactive
d. Front-ended

8 Cleaner Production provides a competitive advantage in all of the following situations except

a. Environmental regulations becoming more severe
b. Company adopting quality management standards
c. Customers beginning to care
d. Government increasing energy and water subsidies

9 The implementation of Cleaner Production actions does not necessarily need

a. Training
b. Cooperation between government and industry
c. A change in management attitudes
d. Advanced technology

10 "Cleaner Production is just not realistic in developing countries where per capita GNP is below $1000." This statement is

a. False
b. Correct
c. True
d. Helpful

11 The 10 steps for introducing Cleaner Production in an enterprise include all of the following except

a. Implementing an environmental policy
b. Conducting an environmental compliance audit
c. Setting goals and timetables
d. Allocating responsibility, time and financial support

12 The 10 steps for introducing Cleaner Production in an enterprise include all of the following except

a. Involvement of senior employees
b. Seeking government subsidies
c. Monitoring and evaluation
d. Disseminating information to employees

13 In a Cleaner Production project, funding will usually be

a. Donated by the workforce
b. Provided by eventual cost savings
c. Available from UNIDO
d. Needed before any plans can be implemented

14 All of the following are barriers to Cleaner Production except

a. Lack of financial resources, awareness, training, expertise and access to know-how
b. Uncertainty about the right information, technology and regulations
c. Attitudes of employees who feel threatened by change
d. Demonstration projects

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15 Cleaner Production is

a. Vital for business survival
b. Moral
c. A good management choice and sometimes profitable
d. A social rather than a business priority

Answers
1-5 *c d a b c*
6-10 *a c d d a*
11-15 *b b b d c*

Some Ideas to Think About

The following are some questions that arise in connection with Cleaner Production. Take some time to think about them. If possible, work in a small group.

1 How will industry in a country with a per capita GNP of less than US$ 500 react to Cleaner Production concepts? Why? What can UNIDO, UNEP or UNDP do about it?

2 How is the concept of ESID interpreted in your country?

3 How will the manager of a nationalized company react to Cleaner Production? Why?

4 How will the manager of a multinational company react to Cleaner Production? How could this be helpful to you?

5 Why should industry in developing countries be interested in Cleaner Production?

6 Select an industry or company with which you are familiar. Describe briefly its environmental situation. Identify some obstacles that you think will prevent or delay Cleaner Production approaches. Think about what you, as a UNIDO representative, can do to help implement Cleaner Production in this situation.

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Reading Excerpts

The Road to Ecologically Sustainable Industrial Development

Excerpted, with permission, from UNIDO, *Proceedings of the Conference on Ecologically Sustainable Industrial Development*, Copenhagen, Denmark, 14-18 October 1991 (PI/112), Working paper No. I, chaps. V and VI.

Chapter V. The Road to Ecologically Sustainable Industrial Development

The Opportunity

Predicting the future is difficult, but a plausible scenario for achieving ESID is clear. A recent report from the World Resources Institute stated as follows: "human impact on the natural environment depends fundamentally on an interaction among population, economic growth and technology. A simple identity encapsulates the relationship:

$$Pollution = \frac{Pollution}{GDP} \; x \; \frac{GDP}{Population} \; x \; Population$$

Here, pollution, understood as environmental degradation, emerges as the product of population, income levels (the GDP per capita term) and the pollution intensity of production (the pollution/GDP term)".

Clearly, the one variable that can be most easily affected in the short run in this relationship is pollution intensity. Over the next 20 years (the time frame for this analysis), world population is predicted to increase from 5.3 billion to 7.2 billion. Similarly, per capita GDP is predicted to increase from $2,900 to $4,100 and per capita MVA from $960 to $1,400. The only choice for avoiding environmental disruption is to reduce pollution intensity by, in the short term, cleaner production and, in the long term, closing the materials and product cycles and shifting to renewable energy resources.

The interaction of the three variables is much more complex than indicated by the simple identity above. For example, as per capita GDP increases, the resources needed for reducing pollution intensity increase and the growth of population declines. Similarly, as per capita income increases, the public demand for reducing pollution intensity increases.

Cleaner Production

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The concept of Cleaner Production is evolving from earlier concepts of clean technology and low and non-waste technology. The old concept of clean technology was seen in 1979 by the Commission of the European Communities as having three distinct but complementary purposes:

- less pollution discharged into the natural environment (water, air and soil);
- less waste (low waste and non-waste technology); and
- less demand on natural resources (water, energy and raw materials).

Although there is no agreed definition for Cleaner Production, just as there is no agreed definition for sustainable development, there is some consensus emerging, as evidenced at the United Nations Environment Programme (UNEP) Seminar on the Promotion of Cleaner Production. The advisory group for the seminar suggested that Cleaner Production should be defined as "...a more global approach to environmental protection which would address all phases of the production process or product life cycles, with the objective of prevention and minimization of short- and long-term risks to humans and the environment. Such an approach includes 'cradle-to-grave' minimization of wastes and emissions to air, water and soil, as well as minimization of energy consumption and the use of raw materials".

The term Cleaner Production is technically and operationally very difficult to define, particularly in relation to the "cleanliness" of products. For the purposes of this paper, Cleaner Production is best thought of as two things at once: a new environmental quality goal for industry and, at the same time, a new approach for achieving that goal.

The new environmental quality goal would require industry to move beyond the current norm, which generally calls for meeting ambient standards which normally just consider the effects of one pollutant in the environment immediately surrounding the source. As stated earlier, ambient standards are not able to protect the environment from cumulative loadings of pollutants into it. The emerging environmental norm, total loading standards, initially calls for reducing wasteful loading into the environment. Industry would meet these total loading standards by increasing the efficiency of energy use, reducing dependence on non-renewable resources, reducing dissipative uses of toxic materials etc. In the long run (50-100 years), total loading standards would aim for closing the materials and product cycles and shifting to renewable energy resources. Closing the materials cycle would require industrial processes to move, as technically and economically feasible, to zero waste discharge, particularly of fossil-fuel-related pollutants and toxic chemicals. Closing the product cycle would require industry to manage products over their entire life cycle, from material extraction, manufacturing and use through disposal. Elements of such a policy are already in place, e.g. in the automobile industries of several countries.

The new approach for achieving this goal would turn the traditional approach to environmental management upside down. The current approach looks first for ways to reduce pollutants after industrial processes have already generated them. It requires the application of end-of-pipe technologies, such as waste-water treatment plants, filters on smoke stacks and the incineration or neutralization of wastes and, finally, the burial of the residue. The current hierarchy for pollutant reduction is as follows:

- Final disposal
- Treatment
- Treatment with energy and materials recovery
- Reuse and recycling
- Reduction
- Prevention.

The new approach that is emerging for environmental management reverses the priorities for management of pollutants at the firm or establishment level. The new hierarchy looks first for pollution prevention opportunities, such as product and process changes and on-site recycling and recovery, before turning to pollution abatement measures. It is as follows:

- Prevention
- Reduction
- Reuse and recycling
- Treatment with energy and materials recovery
- Treatment
- Final disposal.

This new approach to environmental management is emerging for several reasons. First, industry, particularly progressive companies, is realizing that the new priorities are a less expensive and thus more profitable approach to environmental management. Secondly, it is aware that sooner or later it will be forced by Governments and public pressure to reduce pollutant loadings to the environment. Both industry and

Government know that the treatment and burial approach will not meet total loading standards and sometimes not even ambient standards.

One example of the inability to meet ambient standards is the reduction of dioxin discharge from pulp and paper mills. The treatment of waste water will not reduce dioxin discharge sufficiently to meet ambient standards, so industry is changing its bleaching process and significantly reducing the amount of chlorine use.

The availability of Cleaner Production options, which includes both source reduction and pollution control equipment, depends on whether ambient or total loading standards are being pursued. Cleaner Production options are generally available for meeting ambient standards, as is attested to by the success of some industrialized and developing countries.

Although Cleaner Production options are generally available, they may not yet be applicable to all production processes. For example, some developing countries use agricultural residues (straw and bagasse) in the pulping process. Since these raw materials have different properties from wood pulp, e.g. a higher silica content, not all Cleaner Production options developed for reducing the conventional water pollutants associated with wood pulping are applicable to the pulping of agricultural residue.

The availability of Cleaner Production options for meeting total loading standards, which call for significant reduction in pollutants beyond that needed to meet ambient standards, can be questioned, but there is some evidence that significant reductions are possible. A number of approaches have proven themselves useful—and, in many cases, profitable—in practical applications in the industrialized countries. This is particularly true for technologies that optimize the use of energy. Indeed, many of these technologies are not only available today but, if implemented, could realize net savings of both energy and money and simultaneously decrease the burden on the environment.

The existing inefficiencies give an indication of potential energy savings. A comparison of energy consumption per unit of output in developing countries and industrialized countries shows that energy consumption, in tonnes of oil equivalent, per million dollars of real GDP is 440 in the former as opposed to 290 in the latter, i.e. over 50 per cent more per unit of output (table 1). Another comparison is industrial energy consumption per million dollars of real industrial value added. On average, developing countries use twice as much energy as developed countries to produce the same output. These inefficiencies may be attributed to factors such as the improper management of the industrial production process, lack of sophisticated technologies, and wrong pricing.

There are several options for achieving total loading standards for energy-related pollutants. These options include the following:

Table 1. Final Energy Consumption and Economic Activity in OECD Countries and Developing Countries, 1985

Item a/	**OECD**	**Developing countries**	**Ratio of OECD to Developing Countries**
Per capita final energy consumption, toe	3.102	0.323	9.6
Per capita industrial energy consumption, toe	1.096	0.159	6.89
Real GDP per capita, 1980 dollars	10 815.0	773	14.75
Real MVA per capita, 1980 dollars	2 769.0	289	9.58
Final energy consumption per million dollars of real GDP, toe	286.8	440.16	0.65
Industrial energy consumption per million dollars of real industrial value added, toe	276	550	0.50

a/ Tonnes of oil equivalent = toe.

Source: UNIDO, *Industry and Development: Global Report 1991/92,* forthcoming.

- Devices to control the speed of rotating process equipment such as fans, pumps and agitators;
- The enhancement of heat recovery from gases and liquids and the recycling of this heat;
- Computer-aided systems to control the temperature, flow and speed of energy etc.;
- Cogeneration to produce both heat and power.

Several options are also available for achieving total loading standards for toxic chemical pollutants. These options include the following:

- The replacement of chemical processes by mechanical processes;
- The replacement of single-pass rinse processes by counter-current processes;
- The replacement of single-pass processes by closed-loop processes;
- The replacement of organic-solvent-based inks, paints and coatings by water-based ones;
- The replacement of mercury, cadmium and lead by other less toxic substances for pigments, catalysts, batteries etc.;

- The replacement of halogenated compounds by non-halogenated compounds;
- The installation of physical separation technologies such as ion exchange, ultrafiltration and reverse osmosis to allow the recycling of useful components;
- The installation of more accurate sensors, microprocessors and other types of monitoring equipment.

Many dissipative uses of toxic metals could essentially be banned by a stroke of the pen. In the case of tetraethyllead, some cost was involved: the same octane number can be achieved only at higher cost, either by the addition of alcohols or by more intensive refining and the use of greater amounts of aromatics, such as benzene, xylene and toluene. It is difficult to generalize about the cost of eliminating other dissipative uses. Many have been replaced by better substitutes (largely the case with organometallic pesticides, for instance). A few may be very difficult to eliminate, in which case the emphasis should probably be on recovery and recycling.

The full attainment of sustainable practices remains an open-ended task. The main difficulty is clearly in the area of recycling and remanufacturing. The closing of the materials cycle and the product cycle is essential for long-run sustainability. Additional research into the potential for remanufacturing is needed because it remains an opportunity for both developed and developing countries that has yet to be exploited and that has significant implications for ESID. Remanufacturing may be defined as "the disassembly, inspection, refurbishing, reassembly and final testing of worn durable products, a process that renders them usable and less costly to both producers and consumers". It requires smaller capital investments and fewer labour skills than the manufacture of original equipment. In remanufacturing, the cost of energy is only 20-25 per cent that of the energy cost in original manufacture; the cost of materials is cut even more, to 15-20 per cent. In addition, recycling and remanufacturing activities will need supporting industries, such as those that manufacture measuring and automatic control devices, and they will in many cases offer new employment opportunities because they are labour-intensive.

The above is only part of the story, and in the long run probably the less important part. The adoption of Cleaner Production at the establishment level is clearly necessary, but it is not sufficient. It is increasingly clear that the world economic system must be re-oriented. There is a need to reduce dependence on fossil fuels, especially coal; the need to close the material and product cycles has already been mentioned. Structural changes like these will occur only if and when appropriate economic and regulatory incentives are created. Such incentives may include resource or emissions taxes, tradeable permits, subsidies and even outright bans on certain materials.

Chapter VI. The Effects of Cleaner Production on Unit Costs

Although neither UNIDO nor any other institution has assessed in detail the economic aspects of achieving ESID through Cleaner Production, fragmentary data suggest that such production would also be more efficient. Clearly, additional research is needed in this area.

The evidence that Cleaner Production measures can reduce rather than increase unit production costs and hence improve productivity is still fragmentary. To date, such measures account for only a relatively small fraction of total environmental investments in both industrialized and developing countries. Nevertheless, numerous case-studies suggest that Cleaner Production systems can lower production costs and reduce emissions and are available for many sectors. An enterprise adopting

Table 2. Examples of Waste Reduction and Payback Periods of Clean Technologies in the United States

Industry	Method	Reduction of waste	Payback period
Pharmaceutic production	Water-based solvent replaced organic solvent	100%	< 1 year
Equipment manufacture	Ultrafiltration	100% of solvent	2 years
Farm equipment manufacture	Proprietary process	80% of sludge	2.5 years
Automotive manufacture	Pneumatic cleaning process replaced caustic process	100% of sludge	2 years
Micro-electronics	Vibratory cleaning replaced caustic process	100% of sludge	3 years
Organic chemicals production	Absorption, scrap condenser, conservation vent, floating roof	95% of cumene	1 month
Photographic film processing	Electrolytic recovery ion exchange	85% of developer; 95% of fixer; silver and solvent	< 1 year

Source: Huisingh, D. "Cleaner technologies through process modifications, materials substitutions and ecologically based ethical values", *Industry and Environment*, vol. 12, No. 1 (1989).

Cleaner Production processes may realize one or more of the following benefits while reducing industrial pollution:

- Savings in raw materials and energy;
- Decreased waste management costs;
- Improved product quality;
- Enhanced productivity;
- Decreased down-time;
- Reduced worker health risks and environmental hazards;
- Decreased long-term liability for the clean-up of waste materials that might otherwise have been buried;
- Improved public image for the company.

A survey in the United States of more than 500 companies that adopted Cleaner Production processes found that each company reduced industrial wastes by between 85 and 100 per cent; even more importantly, the investment payback periods were short, only one month to three years. These benefits accrued to old industries as well as to high technology industries. The technological changes included the incorporation of advance technologies, such as ion exchange and ultrafiltration; process modifications involving the replacement of an old substance by a new, less-polluting material; and the adoption of processes that were less chemical-intensive and more mechanical-intensive. The most dramatic case was that of the photographic firm PCA International Inc., which is included in table 2. The initial cost of 2,120,000 for the process modification was paid back in a few months by annual savings in the cost of developing solutions (2,360,000), fixer solution (225,000), bleach solution (2,780,000) and silver recovery (21,410,000), a total annual saving of 22,575,000.

Case-studies in Europe are reporting similar findings. The Landskrona in Sweden and the PRISMA projects in the Netherlands confirm results achieved in the United States.

Although Cleaner Production systems are penetrating industry in developing countries, the number of applications is probably not as great as in industrialized countries, and the documentation is minimal. There are some data, however in the International Cleaner Production Information Clearinghouse of UNEP, including reports on several textile mills in India. Where such data are reported, the payback is in the range of one month to a few years. Another example is a meat factory in Poland, which reports a payback period of five months for reduced water consumption and of one year for heat recovery.

There is, moreover, little reason to believe that meeting the requirements of ESID will require extraordinary resources, even in the case of the pollution control approach, which in the long run is likely to be more costly than the prevention of pollution through better management and technology. A recent OECD study of pollution control expenditures for eight countries with relatively complete data showed that expenditures varied between 0.8 and 1.7 per cent of gross national product (GNP). On average, countries with the most stringent environmental programmes spend about 1.5 per cent of their GNP to reduce pollutants from all sectors. On the basis of data from the United States and Germany, the manufacturing sector appears to account for about 25 per cent of the total expenditure, or about 0.4 per cent of GNP. The new approach to pollutant releases, which starts with source reduction (process and product changes) rather than pollution abatement and which emphasizes ambient rather than uniform discharge standards, would result in the manufacturing sector in developing countries spending reasonable sums on pollutant reduction to achieve compliance with ambient and total loading standards.

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Facility Pollution Prevention Guide

Excerpted, with permission, from the
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U. S. Environmental Protection Agency
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Risk Reduction Engineering Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

Chapter 1

Deciding on Pollution Prevention

Pollution prevention is the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous and nonhazardous materials, energy, water, or other resources as well as those that protect natural resources through conservation or more efficient use.

A pollution prevention program addresses all types of waste.

A pollution prevention program is an ongoing, comprehensive examination of the operations at a facility with the goal of minimizing all types of waste products. An effective pollution prevention program will:

- reduce risk of criminal and civil liability
- reduce operating costs
- improve employee morale and participation
- enhance company's image in the community
- protect public health and the environment.

This Guide is intended to assist you in developing a pollution prevention program for your business. It will help you decide which aspects of your operation you should assess and how detailed this assessment should be.

This chapter provides background information on pollution prevention. Specifically, it:

- Summarizes the benefits you can obtain from a company-wide pollution prevention program that integrates raw materials, supplies, chemicals, energy, and water use.

- Describes the US EPA's Environmental Management Hierarchy.
- Explains what pollution prevention is and what it is not.
- Provides an overview of federal and state legislation on pollution control.

> *Those companies struggling to maintain compliance today may not be around by the end of the '90s. Those toeing the compliance line will survive. But those viewing the environment as a strategic issue will be leaders.*
>
> — Richard W. MacLean, chief of environmental programs at Arizona Public Service Co., as quoted in *Environmental Business Journal*, December, 1991.

Benefits of a Pollution Prevention Program

In the case of pollution prevention, national environmental goals coincide with industry's economic interests. Businesses have strong incentives to reduce the toxicity and sheer volume of the waste they generate. A company with an effective, ongoing pollution prevention plan may well be the lowest-cost producer and have a significant competitive edge. The cost per unit produced will decrease as pollution prevention measures lower liability risk and operating costs. The company's public image will also be enhanced.

Reduced Risk of Liability

You will decrease your risk of both civil and criminal liability by reducing the volume and the potential toxicity of the vapor, liquid, and solid discharges you generate. You should look at all types of waste, not just those that are currently defined as hazardous. Since toxicity definitions and regulations change, reducing the volume of wastes in all categories is a sound long-term management policy.

Environmental regulations at the federal and state levels require that facilities document the pollution prevention and recycling measures they employ for wastes defined as hazardous. Companies that produce

> *Above all, companies want to pin down risk... Because the costs can be so enormous, risk must now be taken into account across a wide range of business decisions.*
>
> — Bill Schwalm, senior manager for environmental programs and manufacturing at Polaroid, in an interview with Environmental Business Journal, December, 1991.

excessive waste risk heavy fines, and their managers may be subject to fines and imprisonment if potential pollutants are mismanaged.

Civil liability is increased by generating hazardous waste and other potential pollutants. Waste handling affects public health and property values in the communities surrounding production and disposal sites. Even materials not currently covered by hazardous waste regulations may present a risk of civil litigation in the future.

Look beyond the wastes currently defined as hazardous.

Workers' compensation costs and risks are directly related to the volume of hazardous materials produced. Again, it is unwise to confine your attention to those materials specifically defined as hazardous.

Reduced Operating Costs

A comprehensive pollution prevention program can reduce current and future operating costs.

An effective pollution prevention program can yield cost savings that will more than offset program development and implementation costs. Cost reductions may be immediate savings that appear directly on the balance sheet or anticipated savings based on avoiding potential future costs. Cost savings are particularly noticeable when the costs resulting from the treatment, storage, or disposal of wastes are allocated to the production unit, product, or service that produces the waste. Refer to chapter 6 for more information on allocating costs.

Materials costs can be reduced by adopting production and packaging procedures that consume fewer resources, thereby creating less waste. As wastes are reduced, the percentage of raw materials converted to finished products increases, with a proportional decrease in materials costs.

Waste management and disposal costs are an obvious and readily measured potential savings to be realized from pollution prevention. Federal and state regulations mandate special in-plant handling procedures and specific treatment and disposal methods for toxic wastes. The costs of complying with these requirements and reporting on waste disposition are direct costs to businesses. There are also indirect costs, such as higher taxes for such public services as land fill management. The current trend is for these costs to continue to increase at the same or higher rates. Some of these cost savings are summarized in box 1.

Optimizing processes and energy use reduces waste and controls production costs.

Production costs can be reduced through a pollution prevention assessment. When a multi-disciplinary group examines production processes from a fresh perspective, opportunities for increasing efficiency are likely to surface that might not otherwise have been noticed. Production scheduling, material handling, inventory control, and equipment maintenance are all areas that can be optimized to reduce the production of waste of all types and also control the costs of production.

Energy costs will decrease as pollution prevention measures are implemented in various production lines. In addition, energy used to

Box 1. Waste management costs will decrease as pollution prevention measures are implemented:

- Reduced manpower and equipment requirements for on-site pollution control and treatment
- Less waste storage space, freeing more space for production
- Less pretreatment and packaging prior to disposal
- Smaller quantities treated, with possible shift from treatment, storage, and disposal (TSD) facility to non-TSD status
- Less need to transport for disposal
- Lower waste production taxes
- Reduced paperwork and record-keeping requirements, e.g., less Toxic Release Inventory (TRI) reporting when TRI-listed chemicals are eliminated or reduced.

operate the overall facility can be reduced by doing a thorough assessment of how various operations interact.

Facility cleanup costs may result from a need to comply with future regulations or to prepare a production facility or off-site waste storage or disposal site for sale. These future costs can be minimized by acting now to reduce the amount of wastes of all types that you generate.

Improved Company Image

Corporate image is enhanced by a demonstrated commitment to pollution prevention.

As the quality of the environment becomes an issue of greater importance to society, your company's policy and practices for controlling waste increasingly influence the attitudes of your employees and of the community at large.

Employees are likely to feel more positive toward their company when they believe that management is committed to providing a safe work environment and is acting as a responsible member of the community. By participating in pollution prevention activities, employees can interact positively with each other and with management. Helping to implement and maintain a pollution prevention program should increase their sense of identity with company goals. This positive atmosphere helps to retain a competitive workforce and to attract high-quality new employees.

Community attitudes will be more positive toward companies that operate and publicize a thorough pollution prevention program. Most communities actively resist the siting of new waste disposal facilities in

> *We regard the environment as a long-term strategic set of issues. To have a strong, viable company, the environment has to be taken into account...by planning for [consumer demand for more environmental quality] we will be more competitive in the marketplace.*
>
> — Bill Riley, director of Environment-Marketing at Clorox, as quoted in *Environmental Business Journal*, December, 1991.

their areas. In addition, they are becoming more conscious of the monetary costs of treatment and disposal. Creating environmentally compatible products and avoiding excessive consumption and discharge of material and energy resources, rather than concentrating solely on treatment and disposal, will greatly enhance your company's image within your community and with potential customers.

Public Health and Environmental Benefits

Reducing production wastes provides upstream benefits because it reduces ecological damage due to raw material extraction and refining operations. Subsequent benefits are the reduced risk of emissions during the production process and during recycling, treatment, and disposal operations.

The Environmental Management Hierarchy

Source reduction and reuse prevent pollution.

The Pollution Prevention Act of 1990 reinforces the US EPA's Environmental Management Options Hierarchy, which is illustrated in figure 1. The highest priorities are assigned to preventing pollution through source reduction and reuse, or closed-loop recycling.

Preventing or recycling at the source eliminates the need for off-site recycling or treatment and disposal. Elimination of pollutants at or near the source is typically less expensive than collecting, treating, and disposing of wastes. It also presents much less risk to your workers, the community, and the environment.

What is Pollution Prevention?

Change products and production processes to reduce pollution at the source.

Pollution prevention is the maximum feasible reduction of all wastes generated at production sites. It involves the judicious use of resources through source reduction, energy efficiency, reuse of input materials during production, and reduced water consumption. There are two general methods of source reduction that can be used in a pollution prevention program: product changes and process changes. They reduce the volume and toxicity of production wastes and of end-products during their life-cycle and at disposal. Figure 2 provides some examples.

Redesign products to minimize their environmental impact.

Product changes in the composition or use of the intermediate or end products are performed by the manufacturer with the purpose of reducing waste from manufacture, use, or ultimate disposal of the products. Chapter 7 in this *Guide* provides information on designing products and packaging that have minimal environmental impact.

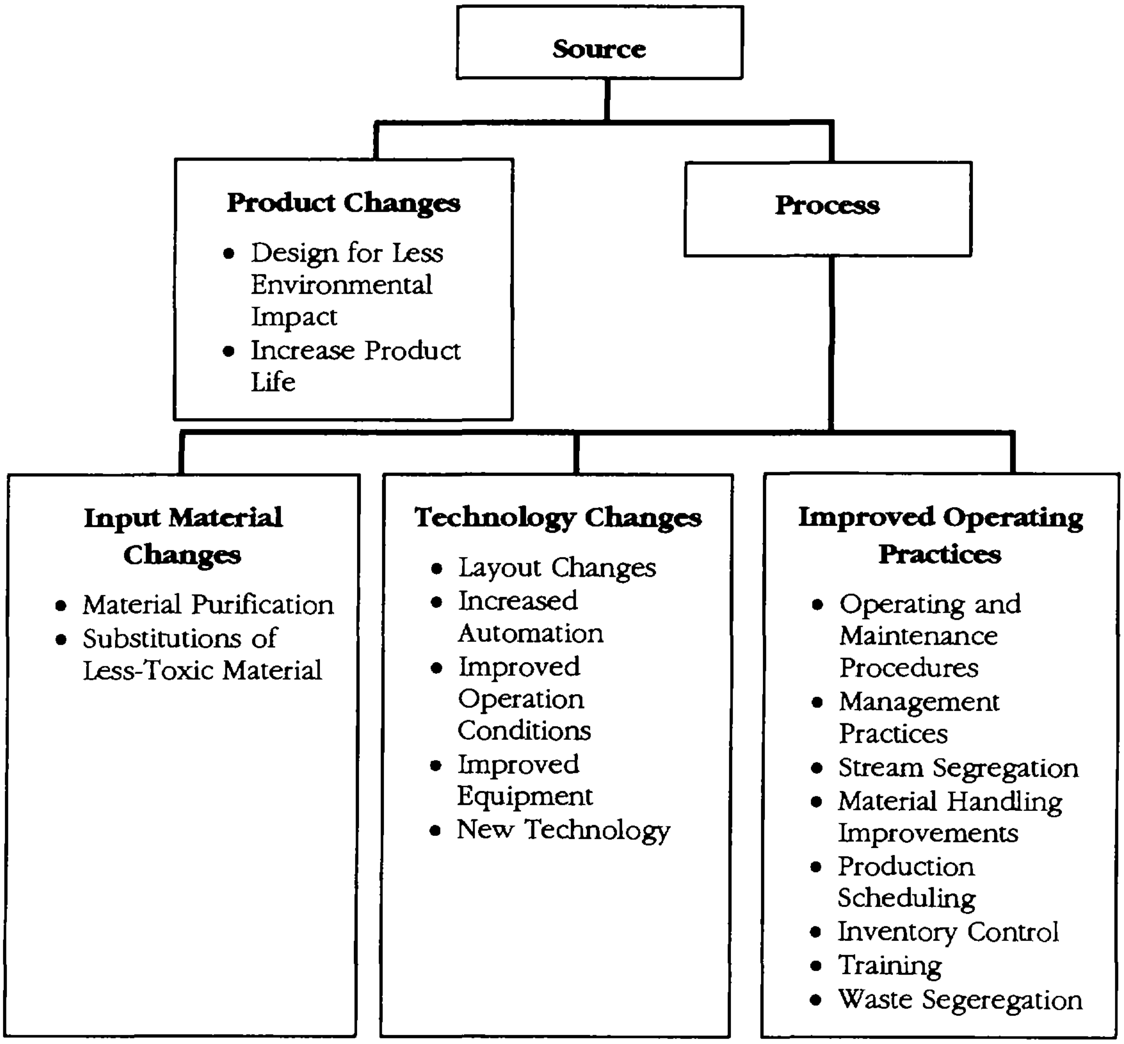
Process changes may be implemented more quickly than product changes.

Process changes are concerned with how the product is made. They include input material changes, technology changes, and improved operating practices. All such changes reduce worker exposure to pollutants during the manufacturing process. Typically, improved operating practices can be implemented more quickly and at less expense than input material and technology changes. Box 2 provides examples of process changes.

Figure 1: Environmental Management Options Hierarchy

Method	Example Activities	Example Applications
Source Reduction (Highest Priority)	• Environmentally Friendly Design of New Products • Product Changes • Source Elimination	• Modify Product to Avoid Solvent Use • Modify Product to Extend Coating Life
Recycling	• Reuse • Reclamation	• Solvent Recycling • Metal Recovery from a Spent Plating Bath • Volatile Organic
Treatment	• Stabilization • Neutralization • Precipitation • Evaporation • Incineration	• Thermal Destruction of Organic Solvent • Precipitation of Heavy Metal from a Spent Plating Bath
Disposal	• Disposal at a Permitted Facility	• Land Disposal

Figure 2: Source Reduction Methods



What Is Not Pollution Prevention?

Waste treatment is not pollution prevention.

There are a number of pollution control measures that are applied only after wastes are generated. They are, therefore, not correctly categorized as pollution prevention. Box 3 provides some examples of procedures that are waste handling, not pollution prevention, measures.

Off-site recycling carries some risk.

Off-site recycling is vastly preferable to other forms of waste handling because it helps to preserve raw materials and reduces the amount of material that will require disposal. However, compared with closed-loop recycling (or reuse), performed at the production site, there is likely to be more residual waste that will require disposal. Further, waste transportation and the recycling process itself carry the risks of worker exposure and of release into the environment.

Box 2. The following process changes are pollution prevention measures because they reduce the amount of waste created during production:

Examples of input material changes:
- Stop using heavy metal pigment.
- Use a less hazardous or toxic solvent for cleaning or as coating.
- Purchase raw materials that are free of trace quantities of hazardous or toxic impurities.

Examples of technology changes:
- Redesign equipment and piping to reduce the volume of material contained.
- Cutting losses during batch or color changes or when equipment is drained for maintenance or cleaning.
- Change to mechanical stripping/cleaning devices to avoid solvent use.
- Change to a powder-coating system.
- Install a hard-piped vapor recovery system to capture and return vaporous emissions.
- Use more efficient motors.
- Install speed control on pump motors to reduce energy consumption.

Examples of improved operating practices:
- Train operators.
- Cover solvent tanks when not in use.
- Segregate waste streams to avoid cross-contaminating hazardous and nonhazardous materials.
- Improve control of operating conditions (e.g., flow rate, temperature, pressure, residence time, stoichiometry).
- Improve maintenance scheduling, record keeping, or procedures to increase efficiency.
- Optimize purchasing and inventory maintenance methods for input materials.
- Purchasing in quantity can reduce costs and packaging material if care is taken to ensure that materials do not exceed their shelf life. Re-evaluate shelf life characteristics to avoid unnecessary disposal of stable items.
- Stop leaks, drips, and spills.
- Turn off electrical equipment such as lights and copiers when not in use.
- Place equipment so as to minimize spills and losses during transport of parts or materials.

Transferring hazardous wastes to another environmental medium is not pollution prevention. Many waste management practices to date have simply collected pollutants and moved them from one environmental medium to another. For example, solvents can be removed from waste water by means of an activated carbon absorber. However, regenerating the carbon requires the use of another solvent or heating, which transfer the waste to the atmosphere. In some cases, transfer is a valid treatment option. However, too often the purpose has been to shift a pollutant to a

Box 3. The following are not pollution prevention measures because they are taken after the waste is created:

- **Off-site recycling:**

  Off-site recycling (e.g., solvent recovery at a central distillation facility) is an excellent waste management option. However, it does create pollution during transport and during the recycling procedure.

- **Waste treatment:**

  Waste treatment involves changing the form or composition of a waste stream through controlled reactions to reduce or eliminate the amount of pollutant. Examples include detoxification, incineration, decomposition, stabilization, and solidification or encapsulation.

- **Concentrating hazardous or toxic constituents to reduce volume:**

  Volume reduction operations, such as dewatering, are useful treatment approaches, but they do not prevent the creation of pollutants. For example, pressure filtration and drying of a heavy metal waste sludge prior to disposal decreases the sludge water content and waste volume, but it does not decrease the number of heavy metal molecules in the sludge.

- **Diluting constituents to reduce hazard or toxicity:**

  Dilution is applied to a waste stream after generation and does not reduce the absolute amount of hazardous constituents entering the environment.

- **Transferring hazardous or toxic constituents from one environmental medium to another:**

  Many waste management, treatment, and control practices used to date have simply collected pollutants and moved them from one environmental medium (air, water, or land) to another. An example is scrubbing to remove sulfur compounds from combustion process off-gas.

less-tightly regulated medium. In either case, media transfers are not pollution prevention.

Transfer to another environmental medium should be avoided in most cases.

Waste treatment prior to disposal reduces the toxicity and/or disposal-site space requirements but does not eliminate all pollutant materials. This includes such processes as volume reduction, dilution, detoxification, incineration, decomposition, stabilization, and isolation measures such as encapsulation or embedding.

Further information may be obtained from:

Environment and Energy Branch, UNIDO
Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49

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Learning Unit 5

ANALYTICAL TOOLS FOR IDENTIFYING CLEANER PRODUCTION OPPORTUNITIES

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

Additional Course Materials

Reading: *Audit and Reduction Manual for Industrial Emissions and Wastes*, a UNIDO/UNEP technical report

Video: *Competitive Edge*, a film by the Ontario Waste Management Corporation

Introduction

Cleaner Production opportunities abound. Identifying them is mainly a matter of being observant and thinking through the production and waste disposal processes. The most important analytical tool to be used by companies should be a waste reduction audit. Other tools include environmental compliance audit, product life-cycle analysis and environmental impact assessment. In Learning Unit 5 we present the basics of each of these analytical tools for identifying Cleaner Production opportunities.

Objectives

The specific learning objectives of this unit are as follows:

- To introduce the analytical tools that can be used to identify Cleaner Production opportunities: waste reduction audit, environmental compliance audit, product life-cycle analysis and environmental impact assessment.
- To develop special knowledge and skills in waste reduction auditing, which will enable you to communicate the specific steps in the audit process to workers and staff in an industrial enterprise or trade association.
- To determine when, where and how each tool can be used effectively.
- To examine the special difficulties and constraints on using these tools in developing countries.

Key Learning Points

1 A waste reduction audit is a systematic examination of the materials flow in a process or plant to identify opportunities to reduce emissions and wastes, thereby saving money.

2 An environmental compliance audit assesses how an enterprise complies with current and anticipated future environmental standards. It creates a more positive organizational setting for introducing Cleaner Production.

3 A product life-cycle analysis estimates the environmental impacts of a product from raw materials extraction through final disposal and identifies cost-effective options for minimizing wastes at each stage of the product life cycle. Usually, the most cost-effective options are those that prevent pollution.

4 An environmental impact analysis predicts the most significant environmental impacts of a project. It also identifies opportunities for avoiding adverse impacts. The least-cost mitigation opportunities are often source reduction measures rather than pollution control technologies.

5 A waste reduction audit is applied to an existing plant that is seeking to minimize its waste generation. An environmental compliance audit is applied to an existing plant concerned about compliance with environmental norms. Product life-cycle analysis is applied to a product, either existing or new, to determine its overall ecological impact. An environmental impact assessment is applied to a new plant or a major modification of an existing plant to assess its potential impact on the environment.

Suggested Study Procedure

1 Take the test in the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.

2 Work through the *Study Materials*, including the *Reading Excerpts* and the video.

3 Prepare answers for each of the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

4 Complete the exercises in the *Review*.

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Study Materials

There are four principal analytical tools for identifying Cleaner Production opportunities and thereby encouraging the adoption of Cleaner Production technologies:

- Waste reduction audit.
- Environmental compliance audit.
- Product life-cycle analysis.
- Environmental impact assessment.

These tools for identifying Cleaner Production opportunities are designed to support the objectives of the industrial enterprise: survival, profitability and growth.

Waste Reduction Audit

A waste reduction audit is conducted at an industrial facility to see what comes into the plant and what goes out, to make sure that resources are being used efficiently and to identify ways to reduce or eliminate the generation of wastes.

The main activities in a waste reduction audit are as follows:

- Prepare audit procedures.
- Determine process inputs.
- Determine process outputs.
- Derive a material balance.
- Identify waste reduction options.

- Evaluate waste reduction options.
- Prepare a waste reduction action plan.
- Implement the action plan.

The material balance demonstrates the opportunities for reducing the use of resources: water, chemicals, raw materials and energy.

A waste reduction audit is the analytical tool most central to achieving Cleaner Production, because it follows material inputs through the production process and accounts for them quantitatively to identify wastes that can be reduced.

A waste reduction audit is a highly cost-effective tool for Cleaner Production that often provides immediate cost savings and in the long-run provides the "competitive edge" for industrial survival.

Next Steps

1 Familiarize yourself with the UNEP/UNIDO publication *Audit and Reduction Manual for Industrial Emissions and Wastes.*

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 Why should a company do a waste reduction audit?

2 What is the principle of a material balance?

3 What are some causes for discrepancies in a material balance? (Hint: see step 13 in the manual)

4 What are some characteristics of a good waste reduction audit?

LU5

Answers

1. *For many reasons, including complying with regulations, reducing waste disposal costs, addressing complaints and staying competitive.*
2. *What goes into the process must come out, either as product or waste.*
3. *Overlooked outflows, poor measurement, incorrect recording of data and spills or leaks.*
4. *It draws attention to process inefficiencies and areas of poor management; permits the development of cost-effective waste management strategies; increases knowledge of the process.*

Next Steps

1 Look over the questions below so that you have some idea of what you will want to learn from the video.

2 Watch the video *Competitive Edge*.

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

LU5

Questions

1 What is meant by the term competitive edge?

2 What is a material balance?

3 What happens in the first walk-through of the plant?

4 In the example of material imbalance, what was the output error?

LU5

5 What are the intangible benefits of the longer term alternatives?

Answers

1. *A reduction in production costs relative to those of your competitor.*
2. *The reconciling of inputs and outputs for a process.*
3. *Processes, raw materials and obvious wastage are identified, material flow diagrams are drawn up and leaks, spills and excessive water use are looked for.*
4. *Wash water was incorrectly measured.*
5. *Improved worker health, cleaner plant, better public image, market access, ability to withstand a supplier audit by a major customer.*

Environmental Compliance Audit

An environmental compliance audit assesses how enterprises are complying with both current and anticipated future environmental norms. It is thus a systematic review of the manage- ment, production, marketing, product development and organizational systems of an enterprise to assess how well they are performing with regard to accepted, or even anticipated, environmental standards and practices.

LU5

To conduct an environmental compliance audit requires the full cooperation of top management, managers and workers.

An environmental compliance audit may be done in response to an emergency situation, but it is more useful to management when it is carried out routinely each year by external, independent environmental auditors.

The main activities in an environmental compliance audit are as follows:

- Pre-audit activities
  - Select and schedule facility to audit.
  - Select audit team members.
  - Contact facility and plan audit.
- Activities at the site
  - Identify and understand the management control system.
  - Assess the management control system.
  - Gather audit evidence.
  - Evaluate audit findings.
  - Report findings.
- Post-audit activities
  - Issue draft report.

- Issue final report.
- Prepare action plan.
- Implement action plan.

The advantages of an environmental compliance audit include:

- Safeguarding the environment.
- Assuring compliance with environmental laws and regulations.
- Assuring compliance with company environmental policies.
- Identifying matters that need correction.
- Reducing exposure to litigation and regulatory enforcement actions.
- Reducing potential liabilities.
- Making the company more environmentally proactive.

An environmental compliance audit can change environmental attitudes throughout an industrial organization, shifting them from reactive secrecy to proactive problem-solving, thereby creating a positive organizational atmosphere in which to introduce Cleaner Production policies.

The term environmental audit is often used to refer to what is called here an environmental compliance audit, but this can lead to confusion because environmental audit can also refer to a waste reduction audit, discussed above.

Next Steps

1 Read *Environmental Auditing*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What is the goal of an environmental compliance audit?

2 What is the main difference between an environmental compliance audit and a waste reduction audit?

3 Why is the term environmental audit confusing?

Answers

1. *An environmental compliance audit is a technique to make enterprises more proactive in their environmental policies by assessing compliance with both current and anticipated future environmental norms.*
2. *An environmental compliance audit assesses how well an organization is performing in regard to environmental norms. A waste reduction audit identifies opportunities to minimize waste in the production process.*
3. *Because it can refer to both environmental compliance audits and waste reduction audits.*

Product Life-Cycle Analysis

Product life-cycle analysis is an analytical tool that considers all stages of the production and consumption of goods and services, with the aim of minimizing the use of resources and preventing the production of waste. This concept is often referred to as cradle-to-grave environmental management.

Product life cycle analysis seeks ways to minimize adverse impacts on the environment at each phase in a product's life cycle. Usually, the most cost-effective options are those that prevent pollution.

There may be many reasons for conducting a product life-cycle analysis:

- To mitigate the environmental impact of a product.
- To support environmental certification, for example, eco-labelling.
- To provide information that will help market a product.
- To educate management and personnel about the environmental consequences of their activities.
- To educate consumers about how best to use and dispose of a product.

The main activities in a product life-cycle analysis are as follows:

- Inventory analysis
  - Define the purpose and the system boundaries of the analysis.
  - Gather data.
  - Construct a model of the environmental impacts.
  - Interpret the results.

- Impact analysis
  - Assess the environmental effects of resource requirements and environmental loadings.
  - Assess risks to human health and the environment.
- Improvement analysis
  - Identify the environmental burdens that need reducing.
  - Evaluate reduction opportunities.

Product life-cycle analysis is most appropriate at a broad policy-making level to influence major decisions on product design, process engineering etc.

Next Steps

1 Read the chapter from *Life-Cycle Assessment: Inventory Guidelines and Principles*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 Why is product life-cycle analysis often considered cradle-to-grave environment management?

LU5

2 What are the three main components of a life-cycle analysis?

3 What are the main stages in a typical product's life cycle?

Answers

1. Product life-cycle analysis is a tool that considers all stages in the production and consumption of goods and services to minimize the use of resources and prevent the production of waste.

2. Inventory analysis, impact analysis and improvement analysis.

3. Raw materials acquisition: manufacturing, including materials and final product fabrication packaging and distribution; consumer use, reuse and maintenance; and recycle/waste management.

Environmental Impact Assessment

An environmental impact assessment estimates the possible environmental consequences of a new plant or a major modification of an existing plant. It also identifies opportunities for avoiding the adverse impacts (mitigation opportunities).

Cleaner Production is highly relevant to environmental impact assessments, because the best mitigation opportunities are usually source reduction or pollution prevention.

There are five important principles in managing an environmental impact assessment:

- Focus on the main issues.
- Involve the appropriate persons and groups.
- Link information to decisions about the project.
- Present clear options for the mitigation of impacts.
- Provide information in a form that is useful to decision makers.

The main activities in conducting an environmental impact assessment are as follows:

- Planning the environmental impact assessment.
    - Screen the environmental impacts of similar projects.
    - Conduct a preliminary assessment of anticipated impacts.
    - Organize the study.
    - Define the scope of the environmental impact assessment.
- Conducting the environmental impact assessment.
    - Identify the potential environmental impacts.

  - Estimate the extent of the impacts.
  - Evaluate their significance.
  - Identify mitigation opportunities.
  - Document the environmental impact assessment process and the conclusions.
- Using the environmental impact assessment.
  - Prepare a plan for reducing environmental impacts.
  - Allocate institutional responsibilities.
  - Carry out the plan.
  - Conduct a post-audit to evaluate the results.

The quality of an environmental impact assessment depends very much on the professional competence of the staff involved and their economic/political independence. Environmental impact assessment reports should communicate all essential matters to the general public, should clearly set out their underlying assumptions and should be subject to rigorous professional analysis before being accepted. A professional analysis of environmental impact assessment reports in the United Kingdom during 1985-1990 indicated that 40 per cent of them were defective.

Many times, an environmental impact assessment is prepared to obtain approval for a project but is not followed up to ensure that the project complies with the environmental plan.

The World Bank refers to an environmental impact assessment as an environmental assessment.

USEPA distinguishes between an environmental impact assessment (the activity) and an environmental impact statement (document).

Next Steps

1 Read *Environmental Impact Assessment: Basic Procedures for Developing Countries*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What is an environmental impact assessment?

2 List five principles in managing an environmental impact assessment.

3 What questions does an environmental impact assessment ask?

Answers

1. *An environmental impact assessment predicts the environmental consequences of a proposed development project and identifies opportunities for avoiding adverse environmental impacts.*

2. *Focus on the main issues.*
   Involve the appropriate persons.
   Link information to decisions about the project.
   Present clear options for the mitigation of impacts.
   Provide information in a form useful to the decision-makers.

3. *What will happen as a result of the project?*
   What will be the extent of the environmental impacts?
   Do the impacts matter?
   What can be done about them?
   How can decision makers be informed about what needs to be done?

Applying the Tools

A waste reduction audit should be applied to existing processes/plants to determine whether there is wastage of raw materials and energy and if there are financially attractive opportunities to reduce the wastage. It is often conducted after an environmental compliance audit has identified pollutant discharges that are violating norms.

An environmental compliance audit should be applied to existing facilities to determine how well environmental organization, management and equipment are performing in regard to environmental norms. Environmental compliance audits are usually conducted in situations where there is a strong government regulatory programme and the penalty for violating norms is high. The identification of specific pollutant reduction measures would require a waste reduction audit.

A product life-cycle analysis should be applied in industrial sectors with rapidly changing technologies and new products. It is also useful for new factories that need to evaluate alternative production processes. A product life-cycle analysis is a data-intensive effort that must be done with care to produce usable results. Product life-cycle analysis cannot, and should not, be used to assess the severity of environmental impacts, because it is not conducted for specific environmental settings. If this type of information is desired, an environmental impact assessment would be the appropriate analytical tool.

An environmental impact assessment should be applied to new plants and major modifications of existing plants that have the potential for significant adverse environmental impacts. The scope of the analytical effort depends on the significance of the impact and the potential for modification of project design.

Questions

1 Which Cleaner Production analytical tool must be applied in each of the following situations?

a A producer of cotton shirts wants to know which impacts result from his production directly and indirectly.

b An entrepreneur is thinking about developing an aluminium plant. He wants to know whether production in his plant will be clean enough to obtain the required permissions from the responsible authorities.

LU5

c The owner of a chemical plant pays a lot for waste treatment. He wants to know whether he can reduce these costs by decreasing the wastage of raw materials.

d A government announces its intention to enact new, strong environmental regulations. An entrepreneur wants to know how he has to change the environmental organization, management and equipment of his facility to comply with the expected norms.

Answers

a. Product life-cycle analysis.

b. Environmental impact assessment.

c. Waste reduction audit.

d. Environmental compliance audit.

Additional Suggested Reading

This concludes the study section of Learning Unit 5. For additional information on tools for identifying Cleaner Production opportunities, you may refer to the following sources.

LU5

Curran, M.A., "Broad-based environmental life-cycle assessment", *Environmental Science and Technology*, vol. 27, No. 3 (1993).

International Chamber of Commerce, *An ICC Guide to Effective Environmental Auditing* (Paris, 1991).

Luebkert, Barbara, and others, *Life-Cycle Analysis Idea: An International Database for Ecoprofile Analysis: A Tool for Decision Makers* (Laxenburg, Austria, International Institute for Applied Systems Analysis, 1991).

UNEP, *Environmental Auditing*, Technical Report Series No. 2 (United Nations publication, Sales No. 90.III.D.1).

Case Studies

Next Steps

1 Think about the questions raised in each of these *Case Studies* and prepare answers to the questions, preferably working with a small group.

2 Compare your answers with those suggested.

Case Study 1: Waste Reduction Audit for a Peanut Factory

Provided by Rene van Berkel, IVAM Environmental Research, University of Amsterdam, the Netherlands.

For this *Case Study* you will be looking at a factory that produces deep-fried salted peanuts, using shelled, blanched peanuts. The next two paragraphs describe the factory; the third paragraph describes one process in that factory.

The peanuts, which are supplied in plastic bags, are emptied directly onto a conveyor belt. They are transported through a deep-frying oven; then they pass through a cooling unit. Finally they are sprinkled with oil and salt. The peanuts are then poured into containers for interim storage. After several hours they are ready to be packaged. The containers are attached to a packaging machine, which forms bags from rolls of foil and then fills them with peanuts. To prevent loss of flavour, the air is removed from the bag, using nitrogen.

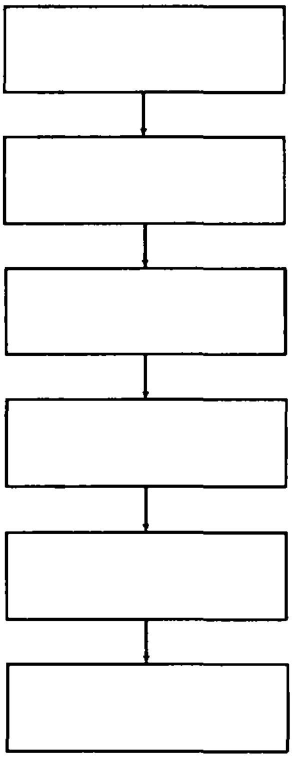
From time to time, the oil used for deep-fat frying must be replaced, as a residue gradually accumulates at the bottom of the oven (due to broken peanuts and decomposition of the oil). The deep-fried peanuts are cooled by means of outside air. The salt is brought into the plant in paper bags and the oil in metal drums.

The process of deep-frying the peanuts can be described as follows. The peanuts are poured onto a conveyor belt which transports them at a constant speed through a frying oven filled with oil. They are deep-fried for 10 minutes in this frying oil, which is kept at a constant temperature of 160°C. Broken peanuts drop to the bottom of the oven, and this residue speeds up the process of decomposition. For this reason the quality of the frying oil is monitored every 15 minutes. If the concentration of decomposition products is too high, the process is halted and the oil replaced. The used frying oil is stored in a drum, and the oven is thoroughly cleaned with hot water and detergent. When the oven is completely clean, the oven is filled with new frying oil and the process is restarted.

Question

1 Draw up a process flow diagram for this peanut factory. List potential wastes and emissions.

Inputs **Unit Processes** **Waste Streams**



2 Does the process suggest to you any changes that might be made to the process flow diagram? Give your reasons.

3 Analyze this process description to generate opportunities for the prevention of waste and emissions, using the five prevention techniques listed in Learning Unit 4, pages 9 and 10. Solve the waste problems by finding appropriate answers to the following questions.

a. Which improvements in housekeeping could be considered to minimize each of the waste streams?

b. Which input substitutions could be considered to minimize each of the waste streams?

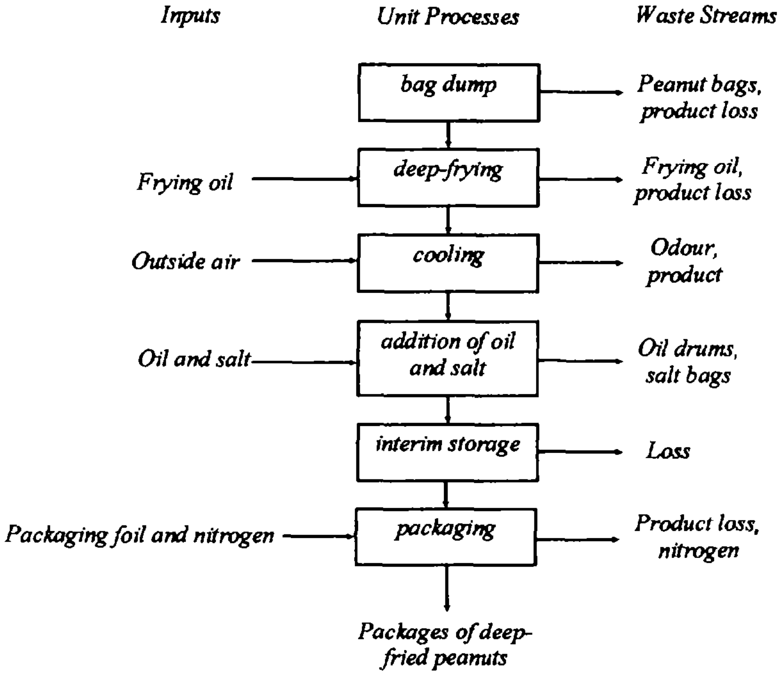
c. Which product modifications could be considered to minimize each of the waste streams?

d. Do opportunities for on-site recycling exist? How do these contribute to the minimization of waste and emissions?

e. Which technology modifications could be considered to minimize each of the waste streams?

Answers

1. *The process flow diagram for the peanut factory is divided into six stages: bag dump, deep-frying, cooling, adding oil and salt, interim storage and packaging. When the peanuts are poured onto the conveyor belt, this results in packaging waste (plastic bags). At the deep-frying stage, oil is used which is supplied in metal drums, while another waste flow is formed by the used frying oil. Outside air is used in the cooling of the peanuts; this air is later expelled, which causes odours. When oil and salt are added to the peanuts, this results in packaging waste (drums and paper). The interim storage stage does not involve any material flow other than that of the product itself. During packaging, foil and nitrogen are consumed; this stage also involves nitrogen emissions and waste (when the foil rolls are changed). And finally, product loss occurs at each of these stages when peanuts get broken or fall off the conveyor belt.*



2. *This process flow diagram represents only the production-related waste streams. It is clear from the description that there is also a non-production-related source of waste water, which originates when the deep frying equipment is cleaned before being filled with new oil.*

3. *a. According to the process description, the production processes in the peanut factory are highly automated. However, at the cleaning stage simple good housekeeping is an important factor. The amount of water and cleanser used could be reduced to a minimum, leading to a considerable reduction in waste generation.*

   b. Another possibility is to switch to a frying oil that is less susceptible to decomposition· it would not have to be changed as often, which would help to reduce waste. Moreover, if an environment-friendly oil were used, the waste oil produced would be less harmful to the environment.

   c. Certain adjustments to plant equipment might be considered. As we have seen, broken peanuts left behind in the oven speed up the decomposition of the frying oil. If this residue were continuously filtered out of the deep fryer, the decomposition of the frying oil would be slowed down. This would mean that the frying oil could be changed less frequently, thus reducing the amount of waste oil.

   d. It may be possible to recycle the frying oil within the plant, if it can be reprocessed. It is not clear from the description whether this is feasible.

   e. Changing the type of product could help to reduce the waste generation; a type of peanut would have to be found that is less subject to breakage.

Case Study 2: Environmental Compliance Audit

Provided by R.G.A. Bolands, AGL International, Previssins-Moens, France.

The board of directors of the Hobbs Corporation has proposed that the corporation be subject to an annual external environmental compliance audit. Four senior line managers refuse to submit to an external environmental compliance audit. They resent the interference of corporate personnel and external experts. They feel that their job is primarily to produce goods for their customers and not to worry about peripheral environmental issues that are, after all, only a passing fashion and best handled by the public relations division.

Questions

1 What misconceptions might managers have about environmental compliance auditing?

2 Develop a list of specific benefits that could persuade them to take a more positive attitude.

Answers

1. *Misconceptions about environmental compliance audit·*

   Environmental compliance audit is not cost-effective.

   Environmental compliance audit is a policing function.

   Audit teams are not professionals.

   External experts cannot offer new perceptions and ideas.

   Environmental compliance audit does not seek business goals: profit, growth and survival.

   Environmental compliance audit does not seek to help managers do a better job for the customers.

2. *A fresh view of the problems may stimulate some new ideas.*

   It may uncover serious, high-risk environmental impacts.

   Other departments have used suggestions emanating from an environmental compliance audit to reduce waste and costs and to improve efficiency and profitability.

   An environmental compliance audit generates information on the basis of which the board of directors can justify its environment-related decisions to operating managers. It does not interfere with day-to-day operations.

   Older managers can begin to become familiar with current and developing environmental management tools.

   Environmental compliance audit is the inevitable long-term solution for business that will allow it to face the increasing political, economic and legal pressures generated by environmental concern.

Case Study 3: Product Life-Cycle Analysis

Adapted from "Washed up", *The Economist,* 1 August 1992, p. 54.

A report prepared by the Ministry of Environment of the Netherlands attempts to answer the question: which are more environmentally friendly, china coffee cups and saucers, polystyrene (styrofoam) mugs or paper mugs? To find the answer the study examines the life cycle of the coffee cup from cradle-to-grave: from the extraction and processing of raw materials through production and use to final disposal. It takes account of the consumption of raw materials, the use of energy (for processing, transport and cleaning), the output of hazardous substances into the air and water and the volume of rubbish created (assuming 40 per cent is incinerated). It ignores some other environmental effects that are more locally varied, such as noise, smell and harm to the landscape.

China cups and saucers start with one big handicap: they need to be washed. "To wash a porcelain cup and saucer once, in an average dishwasher", avers the report, "has a greater impact on the water than the entire life cycle of a disposable cup". The surfactants in detergents, which clean off the grease, see to that. In their impact on air, energy consumption and volume of rubbish, china cups may do less harm in the end than their disposable rivals. But each time a china cup and saucer are put through a dishwasher, they use energy, cause nasty gases to be released into the air and create a bit more solid rubbish.

Whether it is greener to drink coffee from a china cup and saucer or a plastic or paper one depends on two things: how many times the china cup and saucer are used and how frequently they are washed. Have only one cup between washes, and the cup and saucer need to be used 1,800 times before they have less impact on the air during their lifetime than a polystyrene mug. That still gives china the edge: Dutch caterers reckon to use a china cup and saucer 3,000 times. But ask for a refill, and the china crockery need be used only 114 times before it beats polystyrene on energy use and only 86 times before it does less damage to the air. Paper cups do more harm than polystyrene on every count except their impact on water.

The answer, says the report, is to pay more attention to the amount of energy used by dishwashers and the pollution caused by detergents. Most office-workers have another answer: allow a fine patina of old coffee to develop around the inside of the mug. It may not be hygienic, but it is good for the planet.

© The Economist, London (1 August 1992).

Questions

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1 Which is the most environmentally friendly, a china cup or a disposable cup of polystyrene or paper?

2 What would you say was the most important result of the coffee cup study?

Answers

1. *It depends on how you use it. Excessive washing of your china cup would render its use less environmentally friendly than the use of disposable cups.*
2. *It tells us that the use stage of a product can be at least as important as the production and disposal stages from an environmental impact point of view. This study highlighted the pollution caused by energy and detergent use during normal washing-up.*

Case Study 4: Product Life-Cycle Analysis

Excerpted, with permission, from Yrjö Virtanen and Sten Nilsson, *Some Environmental Policy Implications of Recycling Paper Products in Western Europe,* Laxenburg, Austria, International Institute for Applied Systems Analysis.

Public opinion and legislators have, in response to the environmental debate, requested the introduction of mandatory recycling systems and certain minimal levels of recycling. But too narrow a focus on the recycling concept may, on implementation, generate unexpected effects that can at least partially offset the expected benefits. This is especially true for paper, which is a major component of municipal waste. Since paper has a high energy content and is a renewable resource, the issues involved in large-scale paper recycling systems can be very complex.

The objectives of a feasibility study undertaken by the International Institute for Applied Systems Analysis (IIASA) on recycling paper products in Western Europe were to evaluate the applicability of a life-cycle approach to paper recycling, to provide new insights into the complexity of introducing large-scale recycling into existing production and distribution systems and to broaden the debate with new arguments. In several respects, and up to certain levels, recycling paper seems to be beneficial. However, as often occurs in the case of complex systems with multiple interdependencies and feedback loops, simplified policy actions tend to produce counterintuitive effects.

In order to demonstrate more explicitly the consequences of alternative policies on paper recycling, two extreme scenarios and one medium scenario as regards the extent of recycling were studied: this means a maximum, a selective and a zero recycling scenario. In the latter scenario old paper is used for energy recovery. The average rate at which recycled paper fibres were used was 28 per cent for Western Europe in 1986. The reuse rates in the selective and maximum scenarios were 35 per cent and 56 per cent, respectively.

The differences between gross energy demand and the net non-renewable energy demand (i.e. fossil fuels consumed) for the different scenarios were investigated and it was found that:

- The gross energy demand is lowest for the maximum and highest for the zero recycling scenario.

- The opposite is the case for the net fossil fuel demand, i.e. the net fossil fuel derived is highest for the maximum recycling scenario.

- Thus, the maximum recycling scenario gives the highest emissions of SO_2, NO_x and net CO_2.

Furthermore, the selective and maximum recycling scenarios show a forest utilization considerably below that estimated as a sustainable level for Western Europe. Underutilization of forest resources may lead to unsatisfactory economic conditions for the necessary forest management, resulting in fewer vital forests and higher vulnerability to natural stress and air pollutants.

The conclusions of the feasibility study, while too preliminary to permit solid quantitative comparisons, indicate that the recycling of paper in Western Europe has economic and environmental advantages. However, the renewable character and the high energy content of paper and wood seem to make energy recovery more attractive than recycling under some conditions. Therefore, a balanced mixture of recycling and energy recovery seems to be a suitable solution, since recycling minimizes the use of certain resources and emissions, while energy recovery minimizes the overall use of fossil fuels. The appropriate balance may vary from country to country in Western Europe.

There remain a number of important questions that must be investigated further before large-scale programmes for the increased recycling of paper products are introduced. These questions are connected with the fact that the environmental impacts of recycling strongly depend on how far recycling is taken and how selective it is.

Questions

1 What were the objectives of the paper recycling study? Which scenarios were investigated?

2 What is the essence of the report's recommendation concerning waste paper in Western Europe?

Answers

1. The objectives were to evaluate the applicability of a life-cycle approach to paper recycling, to provide new insights into the complexity of introducing large-scale recycling into existing production and distribution systems and to broaden the debate with new arguments. A maximum, a selective and a zero paper recycling scenario were investigated.

2. The report recommends a balanced mixture of recycling and energy recovery of waste paper, since recycling minimizes the use of certain resources and emissions, while energy recovery minimizes the overall use of fossil fuels.

Case Study 5: Environmental Impact Analysis

Provided by R.A. Luken, Senior Environmental Adviser, UNIDO.

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A Ministry of Power is seeking to expand the production of electric power. It has proposed a new project that would increase coal mining and construct two coal-fired power plants of 400 MW each.

Negative impacts can occur during both the construction and operation of the coal mines and power plants. Construction impacts are associated with site preparation. In addition, the large influx of construction workers can have a significant impact on local communities.

Coal mining can, depending on site-specific conditions, result in underground mine subsidence, land disturbance from surface mining, contamination of surface water, fugitive dust and noise.

Coal-fired power plants can be a major source of air emissions that can effect both local and regional air quality. The combustion of coal results in emissions of sulfur dioxide, oxides of nitrogen, carbon monoxide, carbon dioxide and particulates. The environmental degradation associated with these emissions depends on a complex interaction among the physical characteristics of the plant's stack, physical and chemical characteristics of the emissions, meteorological conditions at or near the site, topographical conditions at the plant site and surrounding areas and the type and location of the receptors (people, crops, native vegetation).

The most significant waste-water streams from a coal-fired power plant are, typically, rather clean cooling water. It can be recycled or discharged into water bodies with minimal impact on the chemical quality. Waste heat, however, can impair ambient quality, particularly for plants using once-through cooling. Other effluents from coal-fired power plants include cooling system blowdown, boiler blowdown, ash transport waste water and run-off from coal piles.

Questions

1 Which would be the more significant pollution problem associated with a coal-fired power plant, water or air pollution? (Hint: see Learning Unit 2, Atmospheric Pollution, pages 16-18.)

2 Why would you advise against locating the coal-fired power plant in a valley?

3 Which environmental impact associated with air pollutants do you think might be ignored? (Hint: see Learning Unit 2, Acidification, pages 24-26.)

LU5

4 What do you anticipate will be a significant barrier to introduction of Cleaner Production options in this project?

Answers

1. *Air pollution is usually the more significant pollution problem particularly if the plant recycles its cooling waters. The more significant pollutants are sulfur oxides and particulates.*
2. *Location in a valley could trap the emissions of air pollutants around the plant, resulting in higher than usual ambient concentrations.*
3. *Given the size of the total project, there will be acid deposition impacts. The power generating authority would probably commit itself to meeting ambient SO_2 standards but would ignore the potential acid deposition problems.*
4. *The greatest barrier to the introduction of Cleaner Production options is that most managers have already decided on specific project components before the environmental impact assessment is prepared. Consequently, alternative technologies, fuels and plant locations are not considered.*

Review

Test

The following test will help you review the material in Learning Unit 5.

1 Pollution prevention opportunities may best be identified through

a. Environmental impact assessment
b. Waste reduction audit
c. Environmental compliance audit
d. Product life-cycle analysis

2 A waste reduction audit makes a detailed analysis of plant processes and wastes with the purpose of

a. Producing waste
b. Completely eliminating waste
c. Identifying wastes
d. Hiding waste

3 A waste reduction audit is best described as

a. An input characterization
b. A material balance
c. A balanced financial statement
d. A least-cost production programme

4 A waste reduction audit usually does not include

a. Water use
b. Materials use
c. Labour use
d. Chemicals use

LU5

5 All of the following are the four *R*'s of waste reduction except

a. Reduction
b. Reuse
c. Remanufacture
d. Recovery

6 The critical barrier to a waste reduction audit is

a. Political interference
b. Financial resources
c. Technical competence
d. Management attitudes

7 The main purpose of an environmental compliance audit is to

a. Ensure that a firm is complying with environmental norms
b. Provide information to environmental management agencies
c. Meet the requirements of the Business Charter of ICC
d. Protect environmental quality

8 Conducting an environmental compliance audit requires the commitment of

a. Top management
b. Supervisors
c. Workers
d. All of the above

9 Environmental compliance audit activities at a site require all of the following except

a. Identification of the management control system
b. Determining process inputs
c. Gathering of audit evidence
d. Evaluation of the audit findings

10 A product life-cycle analysis considers

a. Only the design of a product
b. The potential for product recycling
c. All stages of production and consumption
d. The production process

11 The most controversial step in a product life-cycle analysis is

a. Cost analysis
b. Inventory analysis
c. Impact analysis
d. Improvement analysis

12 A product life-cycle analysis is more appropriate for

a. Selection of raw materials
b. Minimizing the wastes associated with production
c. Identification of new markets
d. Major decisions on product design

13 An environmental impact assessment predicts

a. Effects on the environment
b. Effects on production cost
c. Effects on management
d. Effects on pollutant discharge

14 Scoping for an environmental impact assessment means

a. Finding the best environmental location for a project
b. Identifying the major environmental impacts
c. Choosing the least-cost mitigation strategy
d. Finding the most qualified team of experts

15 All of the following are important principles in managing an environmental impact assessment except

a. Balancing the benefits and costs of mitigation measures
b. Involving the appropriate persons and groups
c. Linking information to decisions about the project
d. Presenting clear options for the mitigation of impacts

Answers
1-5 *b c b c c*
6-10 *d a d b c*
11-15 *c d a b a*

Some Ideas to Think About

The following are some additional questions that Cleaner Production raises. Take some time to think about them. If possible, work in a small group and try to achieve consensus.

1 Why did Cleaner Production and waste reduction audits become prominent only in the 1980s?

2 Does Cleaner Production usually require new investments for its implementation?

3 If waste reduction audits are so profitable, why hasn't every industrial enterprise been doing them for years?

4 Why is an environmental impact assessment so political?

5 Why does even big business in the European Community fight hard to make environmental compliance audits private rather than public?

Reading Excerpts

Environmental Auditing

Excerpted, with permission, from ICC, *Environmental Auditing*, Publication 468 (Paris, 1989), pp. 6-15.

What exactly does environmental auditing mean? Why should industrial companies in particular arrange for environmental audits? Who should be responsible for them, and to whom should they report? What sort of methodology should be applied?

This essay gives the first internationally agreed answers to these questions. The ICC defines audits as a management tool, and emphasizes that the responsibility for conducting them should be that of companies themselves. The essay has five other objectives:

- stressing the benefits of audits to management;
- emphasizing their value to regulatory authorities;
- helping to establish audits as a credible and trustworthy instrument in the minds of the work-force, local community, environmentalist associations and the general public;
- settling an agreed basis for discussion and action worldwide;
- suggesting a standard practical methodology for personnel charged with undertaking the audits.

Definition and Purpose of Audits

During recent years the concept and practice of environmental management have developed rapidly within industrial organisations. The ICC Guidelines represent one illustration of this development. The underlying objective of environmental management is to provide a structured and comprehensive mechanism for ensuring that the activities and products of an enterprise do not cause unacceptable effects in the environment. All stages are considered from initial planning and con- ception to final termination.

Most approaches to environmental management include provision for systematic examination of performance to ensure compliance with requirements. This paper is concerned with such systematic examination of performance during the operational phase of the industrial activity. The distinction is made between this process and, for example, Environmental Impact Assessment (EIA) which considers potential environmental effects during the planning phase before an operation starts. Various terms have been used for such examination (audit, appraisal, survey, surveillance, review), leading to possible confusion. Here the term 'Environmental Audit' is adopted.

The advantages and nature of environmental audits are considered below. However, the broad purpose is to provide an indication to company management of how well environmental organisation, systems and equipment are performing. If this purpose is to be fulfilled with full cooperation and commitment of those involved, it is essential that the procedure should be seen as the responsibility of the company itself, should be voluntary and for company use only. Thus audits would not normally be used to instigate prosecutions or litigation. Accordingly, the definition of environmental auditing adopted here is as follows:

"A management tool comprising a systematic, documented, periodic and objective evaluation of how well environmental organisation, management and equipment are performing with the aim of helping to safeguard the environment by:

- facilitating management control of environmental practices;
- assessing compliance with company policies, which would include meeting regulatory requirements".

Advantages of Audits

The primary and obvious advantage of environmental auditing is to help safeguard the environment and to assist with and substantiate com- pliance with local, regional and national laws and regulations, and with company policy and standards. A related advantage is reduced exposure to litigation and regulatory risk (e.g. penalties, additional regulations). The process ensures an independent verification, identifies matters needing attention and provides timely warning to management of potential future problems.

Experience demonstrates that environmental audits can have other benefits, the importance of which may vary from situation to situation, as follows:

- facilitating comparison and interchange of information between operations or plants;
- increasing employee awareness of environmental policies and responsibilities;

- identifying potential cost-savings, including those resulting from waste minimization;
- evaluating training programmes and providing data to assist in training personnel;
- providing an information base for use in emergencies and evaluating the effectiveness of emergency response arrangements;
- assuring an adequate, up-to-date environmental data base for internal management awareness and decision-making in relation to plant modifications, new plans, etc;
- enabling management to give credit for good environmental performance;
- helping to assist relations with authorities by convincing them that complete and effective audits are being undertaken, by informing them of the type of procedure adopted;
- facilitating the obtaining of insurance coverage for environmental impairment liability.

It should be emphasized again that the major value to the operating facility is as a management tool which provides information on environmental performance in relation to goals and intentions.

Essential Elements of Environmental Audits

The practice of environmental auditing involves examining critically the operations on a site and, if necessary, identifying areas for improvement to assist the management to meet requirements. The essential steps are the collection of information, the evaluation of that information and the formulation of conclusions including identification of aspects needing improvement. Suggested procedures are described in the appendix. For environmental auditing to be effective and yield maximum benefit, the following elements are necessary:

Full Management Commitment

It is important that management from the highest levels overtly supports a purposeful and systematic environmental audit programme. Such commitment is demonstrated by for example, personal interest and concern, the adoption of high standards, the allocation of appropriate manpower and resources, and the active follow-up of recommendations.

Audit Team Objectivity

The principal members of the audit team should be sufficiently detached to ensure objectivity. How this is best arranged will depend upon the size and structure of the company concerned and the nature of the specific audit.

Professional Competence

Team members should be appropriately qualified and sufficiently senior to provide a technically sound and realistic appraisal, and to command respect. The skills required fall under the headings of general environmental affairs and policy, specific environmental expertise and operational experience and knowledge of environmental auditing.

Well-defined and Systematic Procedures

To ensure comprehensive and efficient coverage of relevant matters, considered procedures such as those outlined in the appendix should be adopted.

Written Reports

It is self-evident that the process should be properly documented, and that a clear report should be submitted to the management appropriate to the organization of the company. This report should concentrate on factual, objective observations.

Quality Assurance

It is desirable to have some mechanism to maintain the quality of the auditing system itself, and provide assurance of consistency and reliability to the company.

Follow-up

Clearly the full value from auditing can only be obtained if there is active implementation and follow-up of matters identified.

Conclusion

The ICC supports and encourages the adoption of environmental auditing programmes by industrial organisations as one element in their environmental management systems. Just as the environmental management systems should reflect the nature of the organisation, culture and products of individual businesses, environmental auditing programmes should be individually designed and operated to best meet the specific needs and objectives of the business served.

Experience has demonstrated that the full utility of this management tool can best be achieved if its use is voluntary, and findings are for the exclusive use of company management in carrying out their responsibility to correct all deficiencies promptly.

Appendix

Suggested Basic Steps in an Environmental Audit

Introduction

This brief description of suggested basic steps in typical environmental audits summarizes key features, and highlights the well-defined and planned structure characteristic of environmental audits wherever they are conducted. There are three essential phases: preparatory pre-audit activities; a site visit normally involving interviews with personnel and inspection of facilities; and post-visit activities.

Environmental audits may have different objectives, and be conducted in many different settings by individuals with varied backgrounds and skills, but each audit tends to contain certain common elements. During the audit, a team of individuals completes a field assignment which involves gathering basic facts, analyzing the facts, drawing conclusions concerning the status of the programmes audited with respect to specific criteria, and reporting the conclusions to appropriate management.

These activities are conducted within a formal structure in a sequence that is repeated in each location audited to provide a level of uniformity of coverage and reliability of findings that is maintained from audit to audit. On the following pages a typical audit work flow can be found. Although not all audit programmes necessarily contain each step, the design of each programme generally makes provision for each of the activities described.

Pre-Audit Activities

Preparation for each audit covers a number of activities including selecting the review site and audit team, developing an audit plan which defines the technical, geographic and time scope, and obtaining background information on the plant (for example by means of a questionnaire) and the criteria to be used in evaluating programmes. The intent of these activities is to minimize time spent at the site and to prepare the audit team to operate at maximum productivity throughout the on-site portion of the audit.

With respect to the composition of the audit team, there are both advantages and disadvantages in including a member from the site being audited. Advantages include:

- the insider's knowledge of the specifics of the plant as regards both physical installations and organizational patterns;

- associating a local employee with the audit report may make it appear more credible to the plant's workforce.

The main disadvantage is that the insider may have difficulty in taking or expressing an objective view, especially if this might be seen as criticism of his superior or immediate colleagues.

Independent consultants may provide assistance, especially to smaller companies, in the event of a lack of internal expertise.

Activities at the Site

The audit activities at the site typically include five basic steps:

Identifying and Understanding Management Control Systems

Internal controls are incorporated in the facility's environmental management system. They include the organisational monitoring and recordkeeping procedures, formal planning documents such as plans for prevention and control of accidental release, internal inspection programmes, physical controls such as containment of released material, and a variety of other control system elements. The audit team gains information on all significant control system elements from numerous sources through use of formal questionnaires, observations and interviews.

Assessing Management Control Systems

The second step involves evaluating the effectiveness of management control systems in achieving their objectives. In some cases, regulations specify the design of the control system. For example, regulations may list specific elements to be included in plans for responding to accidental releases. More commonly, team members must rely on their own professional judgement to assess adequate control.

Gathering Audit Evidence

In this step the team gathers evidence required to verify that the controls do in practice provide the result intended. Team members follow testing sequences outlined in the audit protocol which have been modified to consider special conditions at the site. Examples of typical tests include review of a sample of effluent monitoring data to confirm compliance with limits, of training records to confirm that appropriate people have been trained, or of purchasing department records to verify that only approved waste disposal contractors have been used. All of the information gathered is recorded for ease of analysis and as a record of conditions at the time of the audit. Where a control element is in some way deficient, the condition is recorded as a 'finding'.

Evaluating Audit Findings

After the individual controls have been tested and team members have reached conclusions concerning individual elements of the control system, the team meets to integrate and evaluate the findings and to assess the significance of each deficiency or pattern of deficiencies in the overall functioning of the control system. In evaluating the audit findings, the team confirms that there is sufficient evidence to support the findings and summarizes related findings in a way that most clearly communicates their significance.

Reporting Audit Findings

Findings are normally discussed individually with facility personnel in the course of the audit. At the conclusion of the audit, a formal exit meeting is held with facility management to report fully all findings and their significance in the operation of the control system. The team may provide a written summary to management which serves as an interim report prior to preparation of the final report.

Post-Audit Activities

At the conclusion of the on-site audit two important activities remain: preparation of the final report and development of a corrective action programme.

Final Audit Report

The final audit report is generally prepared by the team leader and, after review in draft by those in a position to evaluate its accuracy, it is provided to appropriate management.

Action Plan Preparation and Implementation

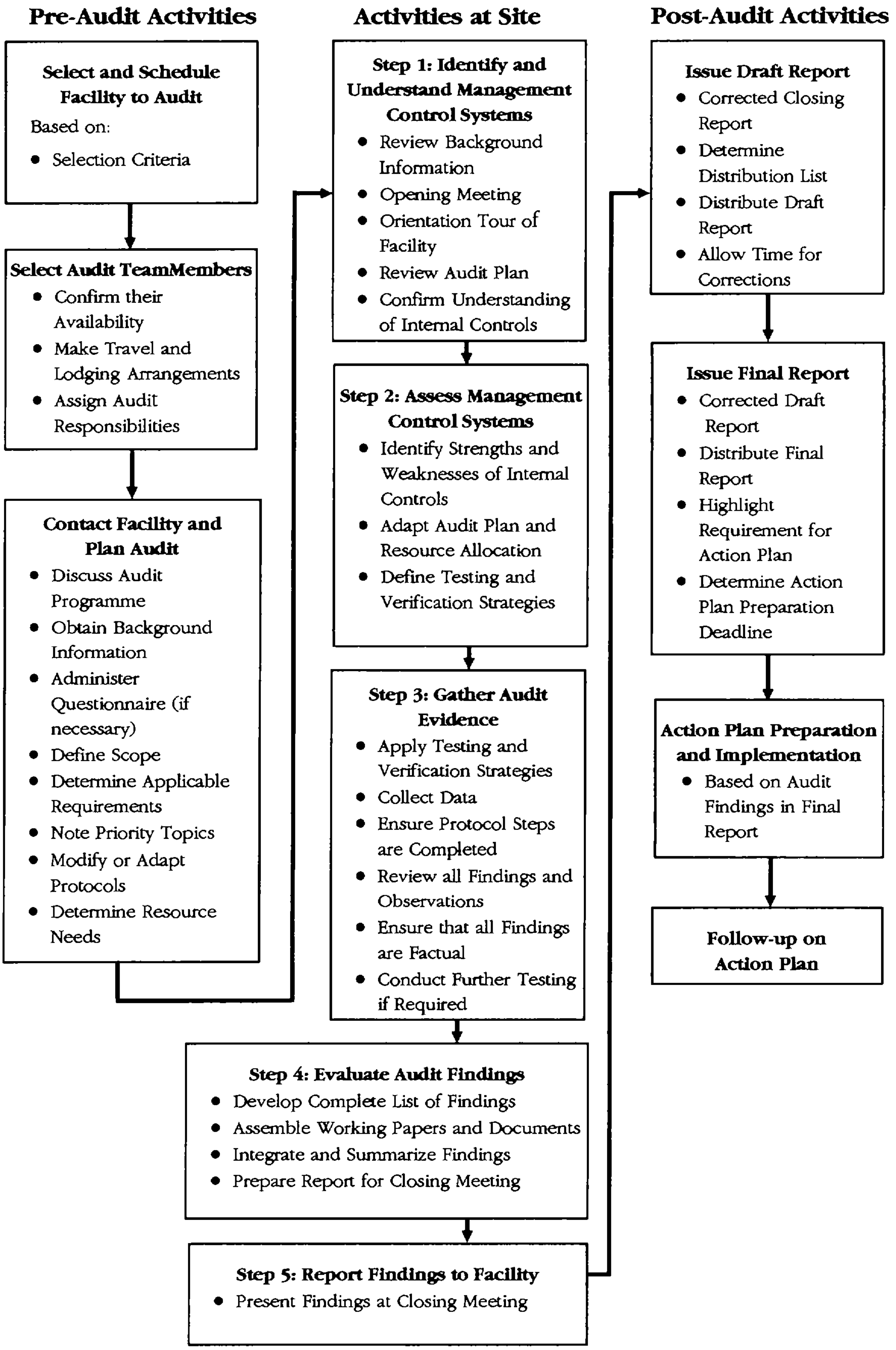
Facility personnel, sometimes assisted by the audit team or outside experts, develop a plan to address all findings. This action plan serves as a mechanism for obtaining management approval and for tracking progress toward its completion. It is imperative that this activity take place as soon as possible so that management can be assured that appropriate corrective action is planned. A primary benefit of the audit is lost, of course, if corrective action is not taken promptly.

Follow-up to ensure that the corrective action plan is carried out and all necessary corrective action is taken is an important step. This may be done by an audit team, by internal environmental experts, or by management.

Summary

Environmental audits, while they may vary in some details, have certain generic characteristics as described above. The approach is characterized by a well-defined and planned structure, careful, methodical investigations and strong emphasis on reporting to all appropriate management. These characteristics form the basis for the reputation that environmental auditing has earned for providing reliable and useful information to management in all settings where it is practiced around the world.

Basic Steps of an Environmental Audit



Pre-Audit Activities

Select and Schedule Facility to Audit

Based on:

- Selection Criteria

Select Audit TeamMembers

- Confirm their Availability
- Make Travel and Lodging Arrangements
- Assign Audit Responsibilities

Contact Facility and Plan Audit

- Discuss Audit Programme
- Obtain Background Information
- Administer Questionnaire (if necessary)
- Define Scope
- Determine Applicable Requirements
- Note Priority Topics
- Modify or Adapt Protocols
- Determine Resource Needs

Activities at Site

Step 1: Identify and Understand Management Control Systems

- Review Background Information
- Opening Meeting
- Orientation Tour of Facility
- Review Audit Plan
- Confirm Understanding of Internal Controls

Step 2: Assess Management Control Systems

- Identify Strengths and Weaknesses of Internal Controls
- Adapt Audit Plan and Resource Allocation
- Define Testing and Verification Strategies

Step 3: Gather Audit Evidence

- Apply Testing and Verification Strategies
- Collect Data
- Ensure Protocol Steps are Completed
- Review all Findings and Observations
- Ensure that all Findings are Factual
- Conduct Further Testing if Required

Step 4: Evaluate Audit Findings

- Develop Complete List of Findings
- Assemble Working Papers and Documents
- Integrate and Summarize Findings
- Prepare Report for Closing Meeting

Step 5: Report Findings to Facility

- Present Findings at Closing Meeting

Post-Audit Activities

Issue Draft Report

- Corrected Closing Report
- Determine Distribution List
- Distribute Draft Report
- Allow Time for Corrections

Issue Final Report

- Corrected Draft Report
- Distribute Final Report
- Highlight Requirement for Action Plan
- Determine Action Plan Preparation Deadline

Action Plan Preparation and Implementation

- Based on Audit Findings in Final Report

Follow-up on Action Plan

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Life-Cycle Assessment: Inventory Guidelines and Principles

Excerpted, with permission, from B.W. Vigon and others, *Life-Cycle Assessment: Inventory Guidelines and Principles*, EPA/600/R-92/036, chap. 2.

Life-Cycle Assessment Concept

Over the past 20 years, environmental issues have gained greater public recognition. The general public has become more aware that the consumption of manufactured products and marketed services, as well as the daily activities of our society, adversely affect supplies of natural resources and the quality of the environment. These effects occur at all stages of the life cycle of a product, beginning with raw material acquisition and continuing through materials manufacture and product fabrication. They also occur during product consumption and a variety of waste management options such as landfilling, incineration, recycling, and composting. As public concern has increased, both government and industry have intensified the development and application of methods to identify and reduce the adverse environmental effects of these activities.

Life-cycle inventory is a "snapshot" of inputs to and outputs from a system. It can be used as a technical tool to identify and evaluate opportunities to reduce the environmental effects associated with a specific product, production process, package, material, or activity. This tool can also be used to evaluate the effects of resource management options designed to create sustainable systems. Life-cycle inventories may be used both internally by organizations to support decisions in implementing product, process, or activity improvements and externally to inform consumer or public policy decisions. External uses are expected to meet a higher standard of accountability in methodology application. Life-cycle assessment adopts a holistic approach by analyzing the entire life cycle of a product, process, package, material, or activity. Life-cycle stages encompass extraction and processing of raw materials; manufacturing, transportation, and distribution; use/reuse/maintenance; recycling and composting; and final disposition. It is not the intent of a life-cycle

This study was conducted in cooperation with the Office of Air Quality Planning and Standards, the Office of Solid Waste, and the Office of Pollution Prevention and Toxics.
Risk Reduction Engineering Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

Major Concepts

- Life-cycle assessment is a tool to evaluate the environmental consequences of a product or activity holistically across its entire life.
- There is a trend in many countries toward more environmentally benign products and processes.
- A complete life-cycle assessment consists of three complementary components: Inventory, Impact, and Improvement Analyses.
- Life-cycle inventories can be used both internally to an organization and externally, with external applications requiring a higher standard of accountability.
- Life-cycle inventory analyses can be used in process analysis, material selection, product evaluation, product comparison, and policy-making.

assessment to analyze economic factors. A life-cycle assessment can be used to create scenarios upon which a cost analysis could be performed.

The three separate but interrelated components of a life-cycle assessment include:

- the identification and quantification of energy and resource use and environmental releases to air, water, and land (inventory analysis);
- the technical qualitative and quantitative characterization and assessment of the consequences on the environment (impact analysis); and
- the evaluation and implementation of opportunities to reduce environmental burdens (improvement analysis).

Some life-cycle assessment practitioners have defined a fourth component, the scoping and goal definition or initiation step, which serves to tailor the analysis to its intended use.

Life-cycle assessment is not necessarily a linear or stepwise process. Rather, information from any of the three components can complement information from the other two. Environmental benefits can be realized from each component in the process. For example, the inventory analysis alone may be used to identify opportunities for reducing emissions, energy consumption, and material use. The impact analysis addresses ecological and human health consequences and resource depletion, as well as other effects, such as habitat alteration, that cannot be analyzed in the inventory. Data definition and collection to support impact analysis may occur as part of inventory preparation. Improvement analysis helps ensure that any potential reduction strategies are optimized and that improvement programs do not produce additional, unanticipated adverse impacts to human health and the environment. This guidance document is concerned primarily with inventory analyses.

A Brief History of Life-Cycle Inventory Analysis

Life-cycle inventory analysis had its beginnings in the 1960s. Concerns over the limitations of raw materials and energy resources sparked interest in finding ways to cumulatively account for energy use and to project future resource supplies and use. In one of the first publications of its kind, Harold Smith reported his calculation of cumulative energy requirements for the production of chemical intermediates and products at the World Energy Conference in 1963.

Later in the 1960s, global modeling studies published in *The Limits to Growth* (Meadows et al., 1972) and *A Blueprint for Survival* (Club of Rome) resulted in predictions of the effects of the world's changing population on the demand for finite raw materials and energy resources. The predictions of rapid depletion of fossil fuels and climatological changes resulting from excess waste heat stimulated more detailed calculations of energy use and output in industrial processes. During this period, about a dozen studies were performed to estimate costs and environmental implications of alternative sources of energy.

In 1969 researchers initiated a study for the Coca-Cola Company that laid the foundation for the current methods of life-cycle inventory analysis in the United States. In a comparison of different beverage containers to determine which container had the lowest releases to the environment and least affected the supply of natural resources, this study quantified the raw materials and fuels used and the environmental loadings from the manufacturing processes for each container. Other companies in both the United States and Europe performed similar comparative life-cycle inventory analyses in the early 1970s. At this time, many of the data were derived from publicly available sources such as government documents or technical papers, as specific industrial data were not available.

The process of quantifying the resource use and environmental releases of products became known as a Resource and Environmental Profile Analysis (REPA), as practiced in the United States. In Europe it was called an Eco-balance. Stimulated by the formation of public interest groups encouraging industry to ensure the accuracy of information in the public domain, and by the oil shortages in the early 1970s, approximately 15 REPAs were performed between 1970 and 1975.

Through this period, a protocol or standard research methodology for conducting these studies was developed. This multi-step methodology involves a number of assumptions. During these years, the assumptions and techniques used underwent considerable review by EPA and major industry representatives, with the result that reasonable methodologies evolved.

A Life-Cycle Assessment has Three Components

These components overlap and build on each other in the development of a complete life-cycle assessment.

- Inventory Analysis
- Impact Analysis
- Improvement Analysis

Scoping is an activity that initiates an assessment, defining its purpose, boundaries, and procedures.

From 1975 through the early 1980s, as interest in these comprehensive studies waned because of the fading influence of the oil crisis, environmental concern shifted to issues of hazardous waste management. However, throughout this time, life-cycle inventory analyses continued to be conducted and the methodology improved through a slow stream of about two studies per year, most of which focused on energy requirements. During this time, European interest grew with the establishment of an Environment Directorate (DG XI) by the European Commission. European life-cycle assessment practitioners developed approaches parallel to those being used in the USA. Besides working to standardize pollution regulations throughout Europe, DG XI issued the Liquid Food Container Directive in 1985, which charged member companies with monitoring the energy and raw materials consumption and solid waste generation of liquid food containers.

When solid waste became a worldwide issue in 1988, the life-cycle inventory analysis technique again emerged as a tool for analyzing environmental problems. As interest in all areas affecting resources and the environment grows, the methodology for life-cycle inventory analysis is again being improved. A broad base of consultants and research institutes in North America and Europe have been further refining and expanding the methodology. With recent emphasis on recycling and composting resources found in the solid waste stream, approaches for incorporating these waste management options into the life-cycle inventory analysis have been developed. Interest in moving beyond the inventory to analyzing the impacts of environmental resource requirements and emissions brings life-cycle assessment methods to another point of evolution.

During the past two years, the Society of Environmental Toxicology and Chemistry (SETAC) has served as a focal point for technical developments in the life-cycle assessment arena. Workshops on the overall technical framework, impact analysis, and data quality were held to allow consensus building on methodology and acceptable professional practice.

Public forums and a newsletter have provided additional opportunity for input from the user community.

Over the past 20 years, most life-cycle inventories have examined different forms of product packaging such as beverage containers, food containers, fast-food packaging, and shipping containers. Many of these inventories have supported efforts to reduce the amount of packaging in the waste stream or to reduce the environmental emissions of producing the packaging.

Some studies have looked at actual consumer products, such as diapers and detergents, while others have compared alternative industrial processes for the manufacture of the same product.

Overview of Life-Cycle Assessment Methodology

Three Components

Inventory Analysis

The inventory analysis component is a technical, data-based process of quantifying energy and raw material requirements, atmospheric emissions, waterborne emissions, solid wastes, and other releases for the entire life cycle of a product, package, process, material, or activity. Qualitative aspects are best captured in the impact analysis, although it could be useful during the inventory to identify these issues. In the broadest sense, inventory analysis begins with raw material extraction and continues through final product consumption and disposal. Some inventories may have more restricted boundaries because of their intended use (e.g., internal industrial product formulation improvements where raw materials are identified). Inventory analysis is the only component of life-cycle analysis that is well developed. Its methodology has been evolving over a 20-year period. Refinement and enhancement continue to occur following the SETAC workshop in 1990.

Impact Analysis

The impact analysis component is a technical, quantitative, and/or qualitative process to characterize and assess the effects of the resource requirements and environmental loadings (atmospheric and waterborne emissions and solid wastes) identified in the inventory stage. Methods for impact analysis are in the early stage of development following a SETAC workshop in early 1992. The analysis should address both ecological and human health impacts, resource depletion, and possibly social welfare. Other effects, such as habitat modification and heat and noise pollution that are not easily amenable to the quantification demanded in the inventory, are also part of the impact analysis component.

The key concept in the impact analysis component is that of stressors. The stressor concept links the inventory and impact analysis by associated resource consumption and releases documented in the inventory with potential impacts. Thus, a stressor is a set of conditions that may lead to an impact. For example, a typical inventory will quantify the amount of SO_2 released per product unit, which then may produce acid rain and which in turn might affect the acidification in a lake. The resultant acidification might change the species composition to eventually create a loss of biodiversity.

An important distinction exists between life-cycle impact analysis and other types of impact analysis. Life-cycle impact analysis does not necessarily attempt to quantify any specific actual impacts associated with a product or process. Instead, it seeks to establish a linkage between the product or process life cycle and potential impacts. The principal methodological issue is managing the increased complexity as the stressor-impact sequence is extended. Methods for analysis of some types of impacts exist, but research is needed for others.

Improvement Analysis

The improvement analysis component of the life-cycle assessment is a systematic evaluation of the needs and opportunities to reduce the environmental burden associated with energy and raw material use and waste emissions throughout the life cycle of a product, process, or activity. This analysis may include both quantitative and qualitative measures of improvements. This component has not been widely discussed in a public forum.

Scoping or Initiation

Scoping is one of the first activities in any life-cycle assessment and is considered by some practitioners as a fourth component. During scoping, the product, process, or activity is defined for the context in which the assessment is being made. The scoping process links the goal of the analysis with the extent, or scope, of the study, i.e., what will or will not be included. For some applications, an impact analysis will be desired or essential. In these cases, the preparation of the inventory is not a stand alone activity. The scoping process will need to reflect the intent to define and collect the additional inventory data for the impact analysis.

For internal life-cycle inventories, scoping may be done informally by project staff. Scoping for external studies may require the establishment of a multi-organization group and a formal procedure for reviewing the study boundaries and methodology.

Although scoping is part of life-cycle analysis initiation, there may be valid reasons for reevaluating the scope periodically during a study. As the life-cycle inventory model is defined or as data are collected, scope modifications may be necessary.

Identifying and Setting Boundaries for Life-Cycle Stages

The quality of a life-cycle inventory depends on an accurate description of the system to be analyzed. The necessary data collection and interpretation is contingent on proper understanding of where each stage of a life cycle begins and ends.

General Scope of Each Stage

Raw Materials Acquisition

This stage of the life cycle of a product includes the removal of raw materials and energy sources from the earth, such as the harvesting of trees or the extraction of crude oil. Transport of the raw materials from the point of acquisition to the point of raw materials processing is also considered part of this stage.

Manufacturing

The manufacturing stage produces the product or package from the raw materials and delivers it to consumers. Three substages or steps are involved in this transformation: materials manufacture, product fabrication, and filling/packaging/distribution.

Materials manufacture. This step involves converting a raw material into a form that can be used to fabricate a finished product. For example, several manufacturing activities are required to produce a polyethylene resin from crude oil: The crude oil must be refined; ethylene must be produced in an olefins plant and then polymerized to produce polyethylene; transportation between manufacturing activities and to the point of product fabrication is considered part of materials manufacture.

Productfabrication. This step involves processing the manu- factured material to create a product ready to be filled or packaged, for example, blow molding a bottle, forming an aluminum can, or producing a cloth diaper.

Filling/packing/distribution. This step includes all manufacturing processes and transportation required to fill, package, and distribute a finished product. Energy and environmental wastes caused by transporting the product to retail outlets or to the consumer are accounted for in this step of a product's life cycle.

Use/Reuse/Maintenance

This is the stage consumers are most familiar with: the actual use, reuse, and maintenance of the product. Energy requirements and environmental wastes associated with product storage and consumption are included in this stage.

Stages of a Life Cycle

- Raw Materials Acquisition
- Manufacturing
  - Materials Manufacture
  - Product Fabrication
  - Filling/Packaging/Distribution
- Use/Reuse/Maintenance
- Recycle/Waste Management

Recycle/Waste Management

Energy requirements and environmental wastes associated with product disposition are included in this stage, as well as post-consumer waste management options such as recycling, composting, and incineration.

Issues that Apply to all Stages

The following general issues apply across all four life-cycle stages:

Energy and Transportation

Process and transportation energy requirements are determined for each stage of a product's life cycle. Some products are made from raw materials, such as crude oil, which are also used as sources of fuel. Use of these raw materials as inputs to products represents a decision to forego their fuel value. The energy value of such raw materials that are incorporated into products typically is included as part of the energy requirements in an inventory analysis. Energy required to acquire and process the fuels burned for process and transportation use is also included.

Environmental Waste Aspects

Three categories of environmental wastes are generated from each stage of a product's life cycle: atmospheric emissions, water-borne wastes, and solid wastes.

These environmental wastes are generated by both the actual manufacturing processes and the use of fuels in transport vehicles or process operations.

Waste Management Practices

Depending on the nature of the product, a variety of waste management alternatives may be considered: land filling, incineration, recycling, and composting.

Allocation of Waste or Energy Among Primary and Co-Products

Some processes in a product's life cycle may produce more than one product. In this event, all energy and resources entering a particular process and all wastes resulting from it are allocated among the product and co-products. Allocation is most commonly based on the mass ratios of the products, but there are exceptions to this.

Summing the Results of Each Stage

To calculate the total results for the entire life cycle of a particular product, the energy requirements and certain emission values for each stage of the product's life cycle can be summed. For example, energy requirements for each stage are converted from fuel units to million British Thermal Units (Btus) or megajoules and summed to find the total energy requirements. Solid wastes may be summed in pounds or converted to volume and summed. The current, preferred practice is to present the individual environ- mental releases into each of the environmental media on a pollutant- by-pollutant basis. Where such specificity in an external study would reveal confidential business information, exceptions should be made on a case-by-case basis. Claims for confidentiality should be made only when it is reasonable to expect that release of the information would damage the supplier's competitive position. Even then, the data inputs to an external use are legitimately expected to be independently verified. A peer review process leading to agreed-upon reporting is one possible mechanism for dealing with this issue. Other approaches for independent verification are possible.

Applications of an Inventory Analysis

An inventory conforming to the scope defined in this document will provide a quantitative catalog of energy and other resource requirements, atmospheric emissions, waterborne emissions, and solid wastes for a specific product, process, package, material, or activity. Once an inventory has been performed and is deemed as accurate as possible within the defined scope and boundaries of the system, the results can be used directly to identify areas of greater or lesser environmental burden, to support a subsequent life-cycle impact analysis, and as part of a preliminary improvements analysis. Life-cycle impact assessment can be applied to quantify the human and ecological health consequences associated with specific pollutants identified by the inventory.

The following are possible applications for life-cycle inventories. These are organized according to whether the application is supportable with the inventory alone or whether some level of additional impact analysis is appropriate. The critical issue that users should keep in mind is that if an application results only in an inventory, the resulting information must not be over-interpreted. Inventories can be applied internally to an organization or externally to convey information outside of the sponsoring organization. External uses are broadly defined in this document to include any study where results will be presented or used beyond the boundaries of the sponsoring organization. Most applications will require some level of impact analysis in addition to the inventory.

To Support Broad Environmental Assessments

The results of an inventory are valuable in understanding the relative environmental burdens resulting from evolutionary changes in given processes, products, or packaging over time; in understanding the relative environmental burdens between alternative processes or materials used to make, distribute, or use the same product; and in comparing the environmental aspects of alternative products that serve the same use.

To Establish Baseline Information

A key application of a life-cycle inventory is to establish a baseline of information on an entire system given current or predicted practices in the manufacture, use, and disposition of the product or category of products. In some cases it may suffice to establish a baseline for certain processes associated with a product or package. This baseline would consist of the energy and resource requirements and the environmental loadings from the product or process systems analyzed. This baseline information is valuable for initiating improvement analysis by applying specific changes to the baseline system.

To Rank the Relative Contribution of Individual Steps or Processes

The inventory provides detailed data regarding the individual contributions of each step in the system studied to the total system. The data can provide direction to efforts for change by showing which steps require the most energy or other resources, or which steps contribute the most pollutants. This application is especially relevant for internal industry studies to support decisions on pollution prevention, resource conservation, and waste minimization opportunities.

These first three applications are supportable with the understanding that the inventory data convey no information as to the possible environmental consequences of the resource use or releases. Any interpretation beyond the "less is best" approach is subjective.

To Identify Data Gaps

The performance of life-cycle inventory analyses for a particular system reveals areas in which data for particular processes or regarding current practices are lacking or are of uncertain or questionable quality. When the inventory is to be followed by an impact analysis, this use can also identify areas where data augmentation for the impact analysis is appropriate.

To Support Policy

For the public policy maker, life-cycle inventories and impact analyses can help broaden the range of environmental issues considered in developing regulations or setting policies.

To Support Product Certification

Product certifications have tended to focus on relatively few criteria. Life-cycle inventories, only when augmented by appropriate impact analyses, can provide information on the individual, simultaneous effects of many product attributes.

To Provide Education for Use in Decision-Making

Life-cycle inventories and impact analyses can be used to educate industry, government, and consumers on the tradeoffs of alternative processes, products, materials, and/or packages. The data can give industry direction in decisions regarding production materials and processes and create a better informed public regarding environmental issues and consumer choices.

These last three applications of life-cycle inventories are the most prone to over-interpretation. This is partly due to their more probable use external to the performing organization and partly due to their implicit orientation towards assessing the environmental consequences of a product or process.

Environmental Impact Assessment: Basic Procedures for Developing Countries

Excerpted, with permission, from UNEP, Regional Office for Asia and the Pacific, *Environmental Impact Assessment: Basic Procedures for Developing Countries* (Bangkok, 1988).

What Is Environmental Impact Assessment?

Environmental Impact Assessment, or "EIA" for short, is a formal study process used to predict the environmental consequences of a proposed major development project. Such projects may include, for example, building a hydroelectric dam or a factory, irrigating a large valley, or developing a harbour.

An EIA concentrates on problems, conflicts or natural resource constraints that could affect the viability of a project. It also examines how the project might cause harm to people, their homeland or their livelihoods, or to other nearby developments. After predicting potential problems, the EIA identifies measures to minimise the problems and outlines ways to improve the project's suitability for its proposed environment.

The aim of an EIA is to ensure that potential problems are foreseen and addressed at an early stage in the project's planning and design. To achieve this aim, the assessment's findings are communicated to all the various groups who will make decisions about the proposed project: the project developers and their investors, as well as regulators, planners and politicians. (In some countries, a report—called an Environmental Impact Statement—is prepared at the end of the EIA study, and this is submitted to a Government department as part of a permit application for the project). Having read the conclusions of an Environmental Impact Assessment, project planners and engineers can shape the project so that its benefits can be achieved and sustained without causing inadvertent problems.

The EIA is an important phase in the process of deciding about the final shape of a proposed project. It helps officials make decisions about a project and it helps the project's proponents achieve their aims more successfully:

- A project that has been designed to suit the local environment is more likely to be completed on time and within budget, and is more likely to avoid difficulties along the way.

- A project that conserves the natural resources it relies upon will continue to be sustained by the environment for years to come.
- A project that yields its benefits without causing serious problems is more likely to bring credit and recognition to its proponents.

In summary, an Environmental Impact Assessment:

- Predicts the likely environmental impacts of projects.
- Finds ways to reduce unacceptable impacts and to shape the project so that it suits the local environment.
- Presents these predictions and options to decision-makers.

EIA Is a Management Tool

Like economic analysis and engineering feasibility studies, EIA is a management tool for officials and managers who must make important decisions about major development projects.

All developers are familiar with economic and engineering studies. These tools provide the basis for designing robust, economically-viable projects. EIA is now seen as an equally important tool in designing a viable project.

In recent years, major projects have encountered serious difficulties because insufficient account has been taken of their relationship with the surrounding environment. Some projects have been found to be unsustainable because of resource depletion. Others have been abandoned because of public opposition, become financially encumbered by unforeseen costs, held liable for damages to natural resources and even been the cause of disastrous accidents.

Given this experience, it is clearly very risky to undertake, finance, or approve a major project without first taking into account its environmental consequences—and then siting and designing the project so as to minimise adverse impacts. For instance, the following questions need to be asked about any major project:

- Can it operate safely, without serious risk of dangerous accidents or long-term health effects?
- Can the local environment cope with the additional waste and pollution it will produce?
- Will its proposed location conflict with nearby land uses, or preclude later developments in the surrounding area?
- How will it affect local fisheries, farms or industry?
- Is there sufficient infrastructure, such as roads and sewers, to support it?

- How much water, energy and other resources will it consume, and are these in adequate supply?
- What human resources will it require or replace, and what social effects may this have on the community?
- What damage may it inadvertently cause to national assets such as virgin forest, tourism areas, or historical and cultural sites?

Who Is Involved in the EIA Process?

An EIA review is normally undertaken by those responsible for the development—the "developer". In some cases, the developer is a private company; in other cases, the developer is the government authority responsible for the relevant sector (e.g., transportation or agriculture).

Increasingly, governments and international agencies are adopting regulations that legally require developers to undertake EIAs. In such cases, the EIA report may need to be submitted as part of the application to a permit-granting government department—the "competent authority". But many developers, on their own initiative, are incorporating the EIA process into their routine project cycle. They recognise that environmental problems not only lead to risks and costly liabilities, but that they also cause concern about the developer's effectiveness across the full range of its responsibilities. A prudent developer uses all the management tools available to ensure a project's success in advance.

Although the developer is usually responsible for undertaking the EIA, the "competent authority" also has a role to play:

- By providing general guidance, past EIA formats or examples to follow.
- After the EIA is done, using its results to reach a decision on the project, and later ensuring that all the mitigation measures are implemented.

The concerns and points-of-view of all the various groups interested in and affected by the project should be taken into account throughout the process. Each of these participants will have a different use for the results of the EIA:

- The *developer* needs to know where to site a project and how to reduce adverse environmental impacts.
- The *investor* needs to know how the impacts will affect the viability of the project, and what liabilities are incurred.
- The *competent authority* uses the EIA's results to decide on a response to the permit application.

- Other *government authorities* will want to know the implications of the project's adverse impacts for other projects they may wish to promote.
- The *regulator* needs to know the extent of environmental impacts and whether they are acceptable.
- The *regional planner* needs to know how the impacts will interfere with adjacent developments and land uses.
- The *local community* or its representatives will need to know how the project's impacts will affect their quality of life.
- The *politician* needs to know who is affected and in what way, and what issues should be of concern.

EIA Should Be Integrated with the Project Cycle

Most governments are now well aware of the possibility of undesirable side-effects from large scale industrial development. In 1970, the USA became the first country to make Environmental Impact Assessment a legal requirement for major development projects.

Since then, countries throughout the world have enacted similar laws, suited to their own constitutions, economies and social values. Governments of all these countries—as well as international lending agencies and organisations like the United Nations Environment Programme—are still learning how to make EIA a practical management tool, useful in day-to-day decisions about building a country's economy. The key seems to lie in the management of the EIA: by designing the process so that it provides useful information to decision-makers at just the right time in the project cycle, EIA can have a real effect on projects. In other words, EIA should enhance and augment the project planning process. Only by actually shaping projects can EIA become an important instrument for protecting the environment and ensuring sustainable economic success.

Important Principles in Managing an EIA

Principle I

Focus on the Main Issues

It is important that an Environment Impact Assessment does not try to cover too many topics in too much detail.

At an early stage, the scope of the EIA should be limited to only the most likely and most serious of the possible environmental impacts. Some EIAs have resulted in large and complex reports running to several thousand pages. Such extensive work is unnecessary, and can be counterproductive, because the EIA's findings must be readily accessible and immediately useful to decision-makers and project planners.

When mitigation measures are being suggested, it is again important to focus the study only on workable, acceptable solutions to the problems. It is easy for the study to waste time considering measures that are impractical or totally unacceptable to the developer or to the Government.

When it is time to communicate the conclusions, the EIA should provide a summary of information relevant to the needs of each group for making its decision. Supporting data should be provided separately.

Principle 2

Involve the Appropriate Persons and Groups

Just as it is important not to waste time and effort on irrelevant issues, it is also important to be selective when involving people in the EIA process. Generally, three categories of participants are needed to carry out an EIA:

- Those appointed to manage and undertake the EIA process (usually a co-ordinator and a staff of experts)
- Those who can contribute facts, ideas or concerns to the study, including scientists, economists, engineers, policy makers, and representatives of interested or affected groups
- Those who have direct authority to permit, control or alter the project that is, the decision-makers—including for example the developer, aid agency or investors, competent authorities, regulators and politicians.

Principle 3

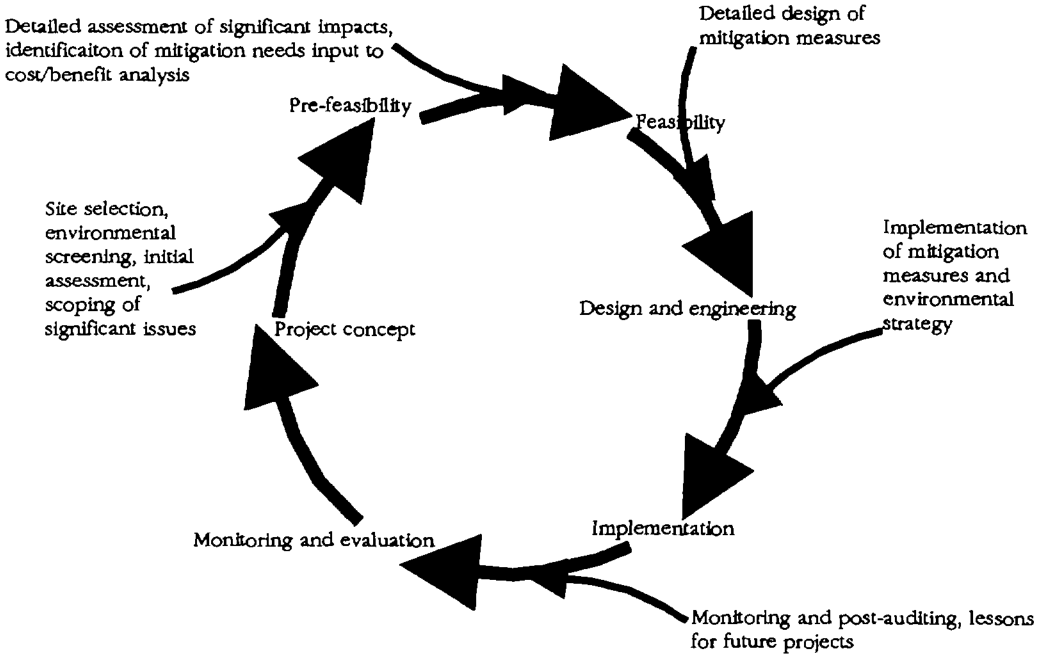
Link Information to Decisions about the Project

An EIA should be organised so that it directly supports the many decisions that need to be taken about the proposed project. It should start early enough to provide information to improve basic designs, and should progress through the several stages of project planning. In a typical sequence:

- When the developer and investors first broach the project concept, they consider likely environmental issues.
- When the developer is looking for sites or routes, environmental considerations are used to aid the selection process.
- When the developer and investors are assessing the project's feasibility, an EIA is in progress, helping them to anticipate problems.
- When engineers are creating the project design, the EIA identifies certain standards for the design to meet.

Project Cycle

Illustrated here is a generalised project cycle, showing when and how an Environmental Impact Assessment can contribute positively to the cycle's progress



- When a permit is requested, a completed EIA report is submitted, and also published for general comment.
- When the developer implements the project, monitoring or other measures provided for in the EIA are undertaken.

Principle 4

Present Clear Options for the Mitigation of Impacts and for Sound Environmental Management

To help decision-makers, the EIA must be designed so as to present clear choices on the planning and implementation of the project, and it should make clear the likely results of each option. For instance, to mitigate adverse impacts, the EIA could propose:

- Pollution control technology or design features.
- The reduction, treatment or disposal of wastes.
- Compensation or concessions to affected groups.

To enhance environmental compatibility, the EIA could suggest:

- Several alternative sites.
- Changes to the project's design and operation.

- Limitations to its initial size or growth.
- Separate programmes which contribute in a positive way to local resources or to the quality of the environment.

And to ensure that the implementation of an approved project is environmentally sound, the EIA may prescribe:

- Monitoring programmes or periodic impact reviews.
- Contingency plans for regulatory action.
- The involvement of the local community in later decisions.

Principle 5

Provide Information in a Form Useful to the Decision-Makers

The objective of an EIA is to ensure that environmental problems are foreseen and addressed by decision-makers. To achieve this, decision-makers must fully understand the EIA's conclusions. Most decision-makers are unlikely to use information, no matter how important it is, unless it is presented in terms and formats immediately meaningful:

- Briefly present "hard" facts and predictions about impacts, comment on the reliability of this information, and summarise the consequences of each of the proposed options.
- Write in the terminology and vocabulary that is used by the decision-makers and the community affected by the project.
- Present the essential findings in a concise document, supported by separate background materials where necessary.
- Make the document easy to use, providing visuals whenever possible.

The Environmental Impact Assessment Process

Before Starting the EIA

Despite its usefulness in finding ways to make projects more successful, the full EIA process is not necessary for every kind of development project. For a major project, an EIA may use considerable resources and expertise. If a detailed EIA is not really needed, these resources can be put to better use elsewhere.

There are two "tiers" of assessment which should be applied to the project before proceeding with a full EIA: *screening* and *preliminary assessment*. Where these first tiers of assessment are a regulatory requirement, the developer normally does the work and submits the results to the regulatory agency. The agency may then decide:

- There is nothing to be concerned about, or
- The evaluation should proceed to the next tier.

The advantage of a tier approach is that the extent of the inquiry expands with the advancing development of the project plans. *"Screening"* is appropriate when the project is only a rough concept. Later, when the project is under more general discussion, a *"preliminary assessment"* can look deeper into possible sites and potential impacts. Then, just before the preliminary stages of feasibility and design work get underway, a full "EIA study" can commence, so that it can influence the detailed decisions to come. This tier approach also ensures that impacts are examined at a very early stage in the project planning, and not later when sites or designs are already decided by other factors.

Screening

Screening is the first and simplest tier of project evaluation. Screening helps to clear types of projects which in past experience are not likely to cause serious environmental problems. The exercise may take one of several forms:

- Measuring environmental impact against simple criteria such as size or location.
- Comparing the proposal with lists of project types rarely needing an EIA (e.g., schools) or definitely needing one (e.g., coal mines).
- Estimating general impacts (e.g., increased infrastructure needed) and comparing these impacts against set thresholds.
- Doing complex analyses, but using readily available data.

Preliminary Assessment

If screening does not automatically clear a project, the developer may be asked to undertake a *preliminary assessment*. This involves sufficient research and expert advice to:

- Identify the project's key impacts on the local environment
- Generally describe and predict the extent of the impacts
- Briefly evaluate their importance to decision-makers.

The preliminary assessment can be used to assist early project planning, for instance to narrow the discussion of possible site—and it can serve as an early warning that the project may have serious environmental difficulties. It is in the developer's interest to do a preliminary assessment, since in practice, this step can clear projects of the need for a full EIA.

Organisation

If after reviewing a preliminary assessment the competent authority deems that a full EIA is needed, the next step for the project developer is the *organisation* of the EIA study. This entails:

- Commissioning and briefing an independent co-ordinator and expert study team (the disciplines that will be represented are decided after the "scoping" stage, but the team always includes a communications expert).
- Identifying the key decision-makers who will plan, finance, permit and control the proposed project, so as to characterise the audience for the EIA.
- Researching laws and regulations that will affect these decisions.
- Making contact with each of the various decision-makers.
- Determining how and when the EIA's findings will be communicated.

Scoping

The first task of the EIA study team is "scoping" the EIA. The aim of scoping is to ensure that the study addresses all the issues of importance to the decision-makers. First the study team's outlook is broadened—by discussions with the project developers, decision-makers, the regulatory agency, scientific institutions, local community leaders, and others—to include all the possible issues and concerns raised by these various groups. Then the study team selects primary impacts for the EIA to focus on, choosing on the basis of magnitude, geographical extent, significance to decision-makers, or because of special local sensitivities (e.g., soil erosion, the presence of an endangered species, or a nearby historical site).

The EIA Study

After "scoping," the EIA study itself begins. Simply put, the EIA study attempts to answer five questions:

- *What will happen as a result of the project?*
- *What will be the extent of the changes?*
- *Do the changes matter?*
- *What can be done about them?*
- *How can decision-makers be informed of what needs to be done?*

After controls on the project's impacts are proposed in answer to the fourth question, the study team may again ask: *"What will happen as a result of the (now revised) project?"* Thus the EIA often becomes a cyclical process of asking and re-asking the first four questions, until decision-makers can be offered workable solutions.

Identification

The answer to the first question—*"What will happen as a result of the project?"* has already been partly addressed, but only in general terms: if a "preliminary assessment" has been done, it will have broadly reviewed the project's effects; also, "scoping" will have focused the study on the most important issues for decision-makers. Taking these findings into account, the full EIA study now formally identifies those impacts which should be assessed in detail. This *identification* phase of the study may use these or other methods:

- Compile a candidate list of key impacts—such as changes in air quality, noise levels, wildlife habitats, species diversity, landscape views, social and cultural systems, settlement patterns and employment levels—from other EIAs for similar projects. This should draw on as many examples of similar projects as possible.
- Name all the project's "sources" of impacts (e.g., smoke emissions, water consumption. construction jobs) using check lists or questionnaires; then list possible "receptors" in the environment (e.g. crops, communities using the same water for drinking, migrant labourers) by surveying the existing environment and consulting with interested parties. Where the "sources" may affect the "receptors", a potential impact is suspected.
- Identify impacts themselves through the use of checklists, matrices, networks, overlays, models and simulations.

Prediction

The next step, called *Prediction*, answers the EIA's second question—*"What will be the extent of the changes?"* As far as is practicable, prediction scientifically characterises the impact's causes and effects, and its secondary and synergistic consequences for the environment and the local community. Prediction follows an impact within a single environmental parameter (e.g., a toxic liquid effluent) into its subsequent effects in many disciplines (e.g., reduced water quality, adverse impacts on fisheries, economic effects on fishing villages, and resulting socio-cultural changes). Prediction draws on physical, biological, socio-economic, and anthropological data and techniques. In quantifying impacts, it may employ mathematical models, photomontages, physical models, socio-cultural models, economic models, experiments or expert judgements.

To prevent unnecessary expense, the sophistication of the prediction methods used should be kept in proportion to the "scope" of the EIA. For instance, a complex mathematical model of atmospheric dispersion should not be used if only a small amount of relatively harmless pollutant is emitted. Simpler models are available and are sufficient for the purpose. Also, it is unnecessary to undertake expensive analyses if they're not required by the decision-makers for whom the EIA is being done.

All prediction techniques, by their nature, involve some degree of uncertainty. So along with each attempt to quantify an impact, the study team should also quantify the prediction's uncertainty in terms of probabilities or "margins of error".

It has been a shortcoming of many EIAs that social and cultural impacts are not given the prominence they deserve in describing the extent of changes expected to result from a major development project. This has probably been due to the bias of physical and biological scientists against the comparatively younger disciplines of cultural anthropology and sociology. This is an unfortunate bias, since socio-cultural impacts are the ones that the local community will feel most acutely in their everyday lives. A consideration of socio-cultural impacts should be integrated, wherever possible, into every discussion of physical/biological change, and not just treated separately in a minor chapter or appendix.

Evaluation

The third question addressed by the EIA—"*Do the changes matter?*"—is answered in the next step, *evaluation*, so called because it evaluates the predicted adverse impacts to determine whether they are significant enough to warrant mitigation. This judgement of significance can be based on one or more of the following:

- Comparison with laws, regulations or accepted standards.
- Consultation with the relevant decision-makers.
- Reference to pre-set criteria such as protected sites, features or species.
- Consistency with government policy objectives.
- Acceptability to the local community or the general public.

Mitigation

If the answer to the third question is *"Yes, the changes do matter"*, then the EIA proceeds to answer the fourth question— *"What can be done about them?"* In this phase, the study team formally analyses *Mitigation*. A wide range of measures are proposed to prevent, reduce, remedy or compensate for each of the adverse impacts "evaluated" as significant. Possible mitigation measures include:

- Changing project sites, routes, processes, raw materials, operating methods, disposal routes or locations, timing, or engineering designs.
- Introducing pollution controls, waste treatment, monitoring, phased implementation, landscaping, personnel training, special social services or public education.

- Offering (as compensation) restoration of damaged resources, money to affected persons, concessions on other issues, or off-site programmes to enhance some other aspect of the environment or quality of life for the community.

All mitigation measures cost something, and this cost must be quantified too.

These various measures are then compared, trade-offs between alternative measures are weighed, and the EIA study team proposes one or more "action plans", usually combining a number of measures. The action plan may include technical control measures, an integrated management scheme (for a major project), monitoring, contingency plans, operating practices, project scheduling, or even joint management (with affected groups). The study team should explicitly analyse the implications of adopting different alternatives, to help make the choices clearer for decision-makers. Several analytical techniques are available for this purpose:

- Cost/benefit analysis, in which all quantifiable factors are converted to monetary values, and actions are assessed for their effect on project costs and benefits (Be cautioned, however, that the unquantifiable and qualitative aspects can be equally important, and often need to be taken into account in the decision-making process).
- Explaining what course of action would follow from various broad "value judgements" (e.g., that social impacts are more important than resources).
- A simple matrix of environmental parameters versus mitigation measures, containing brief descriptions of the effects of each measure.
- Pairwise comparisons, whereby the effects of an action are briefly compared with the effects of each of the alternative actions, one pair at a time.

Documentation

The last step in the EIA process, which responds to the last question— *"How can decision-makers be informed of what needs to be done?"*— is the *documentation* of the process and the conclusions. Recall that the purpose of an EIA is to ensure that potential problems are foreseen and addressed in the project's design. Many technically first-rate EIA studies fail to exert their importance and usefulness because of poor documentation. The EIA can achieve its purpose only if its findings are well communicated to decision-makers.

Generally, to produce effective communications, one must identify the target audience or audiences, and then shape and style the publication to meet their specific needs. In documenting an EIA, this means identifying the key decision-makers, perceiving the questions they will be asking, and providing them with straightforward answers, formatted for easy interpretation in relation to their decision-making (e.g., tables, graphs, summary points). Successful EIA documentation is more readily produced if the audience and their needs are established at the start of the EIA, and then made to affect how the research is focused and reported. It is the job of the study team's communications expert to make this happen.

So that decision-makers can look more deeply into particular issues, the EIA report should also include a record of the EIA process and the judgements made by the study team. An EIA report typically contains:

- An executive summary of the EIA findings.
- A description of the proposed development project.
- The major environmental and natural resource issues that needed clarification and elaboration.
- The project's impacts on the environment (in comparison with a baseline environment as it would be without the project), and how these impacts were identified and predicted.
- A discussion of options for mitigating adverse impacts and for shaping the project to suit its proposed environment, and an analysis of the trade-offs involved in choosing between alternative action.
- An overview of gaps or uncertainties in the information.
- A summary of the EIA for the general public.

All of this should be contained in a very concise, easy-to-read document, with cross references to background documentation, which is provided in an appendix. (The short document is sometimes called an "Environmental Impact Statement", especially when it is submitted as part of a permit application.)

Using the Results

Decisions based on the EIA are usually made by persons who have not been closely involved with the day-to-day progress of the EIA study. Their first consideration of the project's environmental impact may well be the moment they pick up and skim through the EIA report. The EIA will hopefully tell them all they need to know about "what will happen as a result of the project", "the extent of the changes", "whether the changes matter", and "what can be done about them". But the decision-makers themselves must also consider political realities when selecting a course of action. Only decision-makers are in a position to balance the project's needs and problems with the other needs and problems over which they have jurisdiction. They must take into account not only the facts of the situation, but also people's perceptions.

If the project is accepted, perhaps with recommended modifications, then the decision-maker may need to take two further actions:

- Prepare a plan for reducing conflicts about the project; this may include public participation in planning, public education, and actions to compensate affected groups
- Allocate institutional responsibilities for overseeing the developer's adherence to its environmental requirements, for incorporating environmental management into further planning, and for enforcing any restrictions or carrying out any monitoring.

Sometimes, the competent authority sends the EIA to a review panel for comment on its adequacy and quality, before reaching its decision. The decision-maker may call for further study to answer additional questions about the project. The decision-maker may also ask that an opportunity be provided for public review and involvement. The competent authority simply places copies of the report on public display, and invites the public to comment. The EIA team may then be asked to re-draft the EIA to take account of the comments made, before a decision is taken. In cases where the decision-maker chooses to reject the proposed project altogether, there should be an appeal process open to the project developers.

The EIA's usefulness does not end with the decision on a course of action about the project. It still has several further contributions to make to the project's success:

- If the project goes ahead with recommended changes, the EIA's findings should be used to help shape the project to suit the environment, by influencing engineering designs.
- Decisions that need to be made in the latter phases of project planning, such as precisely where to route supporting road or rail links, should be based on the EIA.
- The EIA's precautions on environmental impacts can be part of the brief for tendering on contracts, and should be re-drafted as environmental safety guidance for workers.

Lastly, after the project is completed, a "post audit" can be done to determine how close the EIA's predictions were to the project's real impacts. This forms a valuable record for others doing EIAs on similar projects in the future.

Resources Needed for an EIA

Because of the EIA's acknowledged importance in planning a country's sustainable economic growth, EIAs are now undertaken throughout the world, even in places with very few resources to give to planning initiatives. There are, however, certain minimum resources needed to perform EIAs that can successfully shape major projects:

science, rural and urban planning, economics, waste and pollution control, process engineering, landscape design, sociology and cultural anthropology), and a communications expert.

Technical guidelines, agreed with the competent authority, for carrying out the various phases of the EIA process, especially screening, scoping, prediction, evaluation and mitigation.

Information about the environment (especially relating to the impacts being considered after "scoping") which can be sorted and evaluated.

Analytical capabilities for doing field work, laboratory testing, library research, data processing, photomontage, surveys and predictive modelling.

Administrative resources for the day-to-day running of the EIA process, including office staff, meeting rooms and support, communications facilities and records management.

Institutional arrangements, including a formal procedure for consultation with the decision-makers and other interested groups, the authority to obtain the necessary information of the proposed project, and a formal process for integrating the EIA into decision-making about projects.

Review, monitoring and enforcement powers, to ensure that accepted mitigation measures are included in the development.

Among the resources needed to perform an EIA, not least are money and time. As concerns time, the following are averages for a sampling of recent EIAs: preliminary assessments take between two and 10 weeks to complete; full EIAs may last between three months and two years. Regarding costs, officials often balk at some of the figures they hear, but developers and investors will realise that they represent but a very small percentage of the costs of any major development project—nearly always less than 1%. Indeed, it is a relatively small price to pay to prevent costly unforeseen problems, to promote development that can be sustained, to help prevent potentially ruinous environmental catastrophes, and to obtain approval and acceptance. EIAs mean better, more successful projects; they are a good investment in the future, for both the developer and the economy as a whole.

What To Do Next

If you want to know more about Environmental Impact Assessments done in your own country, consult these likely sources:

- The Ministry in charge of environmental protection.
- Authorities empowered to grant building or other permits.

- The Ministry in charge of environmental protection.
- Authorities empowered to grant building or other permits.
- Environmental research centres.
- Universities and related research establishments.

To find out more about how to do an Environmental Impact Assessment, contact the United Nations Environment Programme (UNEP) at one of the following addresses:

- **United Nations Environment Programme**
  Regional Office for Asia and the Pacific
  The United Nations Building, Rajadamnern Avenue, Bangkok 10200, Thailand
- **United Nations Environment Programme**
  Industry and Environment Office
  Tour Mirabeau
  39 43, Quai André Citröen
  75739 Paris Cedex 15, France
- **United Nations Environment Programme Headquarters**
  PO Box 30552
  Nairobi, Kenya

UNEP can provide guidelines on the EIA process, examples of EIAs done throughout the world, reference materials on EIA techniques, and assistance finding the necessary resources, including expert advice.

The Governing Council of UNEP has adopted "Goals and Principles of Environmental Impact Assessment". In brief, the goals are:

- To take environmental effects into account in decisions by competent authorities.
- To promote beneficial EIA procedures in all countries.
- To encourage consultation between States on projects involving impacts across national boundaries.

First among UNEP's principles for EIA is that environmental effects should be considered before doing any project, and that EIAs should be done when significant effects are expected. The other principles cover many of the points about the EIA process which are discussed in this essay: who to involve, how to focus the process, and how to integrate it with decision-making about the proposed project.

Further information may be obtained from:

Environment and Energy Branch, UNIDO
Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49

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Video: *Money Down the Drain*, a film by the Ontario Waste Management Corporation

Introduction

Cleaner Production usually requires an investment in time and resources. Often, this investment yields an immediate return in the form of savings at the plant level. At other times, the return on investment is a long-term improvement in the environment. When Cleaner Production leads to cost savings at the plant level, the investment can be justified with ordinary investment analysis techniques. When Cleaner Production results in higher manufacturing costs, then the investment must be justified by its environmental benefits. In these cases, micro-economic analyses are used to determine whether there will be adverse economic impacts on the industries concerned; benefit-cost analyses are used to determine whether the overall environmental benefits are greater than the costs; and macroeconomic analyses are used to estimate the impact on the entire economy. In Learning Unit 6 we present the basics of each of these economic analysis techniques.

Objectives

The specific learning objectives of this unit are as follows:

- To describe how investments in industrial environmental management may be justified at the plant, enterprise and national levels.
- To introduce analytical techniques for justifying Cleaner Production investments.

Key Learning Points

1 The economic analysis of environmental investments may take many forms and use a range of techniques, including:

- Financial analysis at the enterprise level.

- Micro-economic impact analysis at the enterprise and industry levels.
- Benefit-cost analysis at the local or regional levels.
- Macroeconomic analysis at the societal level.

2 Simple financial analysis, such as the payback period, is useful for justifying a Cleaner Production investment when there is a positive financial return and when the investment is recovered within a year or two. For longer investment horizons, proper capital investment analysis is more appropriate.

3 Micro-economic impact analysis is useful for justifying Cleaner Production investments when there is no significant positive financial return and/or industry claims that any environmental investment would force them to stop operation of part or all the industry.

4 Benefit-cost analysis is useful for justifying Cleaner Production investments when there is no positive financial return but there is a significant reduction of risks to human health and the environment at the local or regional level.

5 Macroeconomic impact analysis is useful in justifying Cleaner Production investments when there is a claim that the economy cannot afford such investments.

6 Economic analyses, especially when they involve long time horizons, should be questioned. The underlying assumptions are seldom adequately stated or justified.

Suggested Study Procedure

1 **Take the test in the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.**

2 **Work through the *Study Materials*, including the *Reading Excerpts* and the video.**

3 **Prepare answers to the questions posed for the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.**

4 **Complete the exercises in the *Review*.**

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Study Materials

The economic analysis of environmental issues may take many forms and use a whole variety of techniques, including financial analysis (capital investment analysis), micro-economic impact analysis, benefit-cost analysis and macroeconomic impact analysis. These various techniques can provide very powerful and convincing arguments for justifying Cleaner Production investments. The following sections are designed to help you become familiar with each of the analytic techniques, to recognize which techniques to apply to different situations and to under- stand the limitations of each technique.

Financial Analysis

When a project involves new investment, then some form of financial analysis is required to justify the investment. The new investment may be roughly compared with the savings to indicate the number of months or years required to pay back the investment. Thus, simple financial analysis can produce a crude measure of payback of the cash to be invested. Such payback analysis is a very limited measure of investment. It takes no account of critical factors such as horizon (economic life), income tax or present value of cash flows.

A complete financial analysis requires using discounted cash flow analysis to determine the net present value or the internal rate of return on the investment. Discounted cash flow analysis, in turn, requires the following:

- Identifying all cash payments and receipts (or savings) that result from the investment, including the initial capital outlay, the annual change in operating and maintenance costs, taxes and the final salvage value of the equipment.

- Determining how long the equipment will be used.

- Specifying an interest rate that represents the cost of capital.

Some Cleaner Production investments can be justified by their significant financial returns, particularly those with short (less than one year) paybacks. A payback period of one year is equivalent to a 100 per cent annual return on capital.

Some Cleaner Production investments may, however, have payback periods of 10-20 years or they may not produce a financial benefit. In such cases, Cleaner Production or even end-of-pipe technology may have to be justified by other types of economic analysis. In the United Nations context, the most commonly used investment criteria besides payback are internal rate of return and net present value.

Normally, financial analysis considers only direct costs such as capital expenditures, maintenance and expenses as well as savings in raw materials, labour, waste disposal, energy etc. Cleaner Production projects, however, often have indirect and difficult-to-value benefits in areas such as regulatory compliance, insurance, workers' compensation, on-site waste management, liability, product image, company image, employee health and morale etc., and these should somehow be considered.

Next Steps

1 **Read "Economic analysis of pollution prevention projects", included in the *Reading Excerpts* at the end of this Learning Unit.**

2 **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

1 What is total cost assessment?

2 What types of costs and benefits does a total cost assessment analyse? How does this compare to a normal investment analysis?

3 What could be the indirect cost/savings of a pollution prevention project?

4 How can reduced liability costs, which are difficult to value, still be incorporated in the investment analysis?

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5 Why are the financial indicators net present value and internal rate of return more suitable than payback period to judge pollution prevention projects?

Answers

1. *It is an investment analysis method suitable for pollution prevention projects because it accounts for the fact that such projects often affect multiple production areas and have long time horizons and benefits of a probabilistic nature that are difficult to value.*
2. *Total cost assessment analyses direct costs, indirect costs, liability costs and less tangible benefits. A normal investment analysis usually considers only direct costs.*
3. *Administrative costs, regulatory compliance costs (issuing permits, record-keeping and reporting, monitoring, manifesting), insurance, workers' compensation, costs of on-site waste management and on-site pollution control equipment operation.*
4. *By including an estimate or a qualitative description in the narrative part of the investment analysis or by loosening the financial performance requirements of projects that reduce liability.*
5. *Net present value and internal rate of return account for project cash flows and time value of money. The payback period does not meet these criteria and is therefore unsuitable for pollution prevention projects, which often have benefits stretching beyond the payback time.*

Next Steps

1 **Look over the questions below so that you have some idea of what you need to learn from the video.**

2 **Watch the video *Money Down the Drain.***

3 **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

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1 How did the firm that made motor parts transform the disposal of waste caused by washing the produced parts in hot alkaline cleaning solution? What was the greatest source of cost savings?

2 How did the electroplating firm replace the cost-intensive removal of heavy metals from the rinse-water solution? What was the greatest source of cost savings?

3 For the firm that had to paint metal parts, what was the source of cost savings of changing from liquid to powder paints? If the payback period had been 24 months rather than 12 months, what would the capital investment have been?

4 What gains were realized when the firm that made parts for car motors installed a centrifuge? How would the payback have changed if the centrifuge had cost US$ 12,000 instead of US$ 8,000?

5 What would have been the payback period for Uniroyal if the cost of the SO_2 scrubber had been US$ 1,500,000?

Answers

1. *By installing an ultrafiltration system that separated the oil and the debris from the cleaning solution and water. The greatest cost savings come from the reuse of wash water.*
2. *By installing an evaporator that collected the rinse water containing heavy metals. Water is evaporated and water vapor is released to the air. The greatest cost savings came from the reduced cost of waste treatment.*
3. *The changes reduced paint losses from 35 per cent to 5 per cent of total paint used. These losses came from overspray and run-off. The capital investment would have been US$ 1,000,000.*
4. *Owing to the reduced waste production the firm saved costs of administrative, labor and time. The quality of the parts increased and more parts could be produced.*
5. *5 years.*

Micro-Economic Impact Analysis

Micro-economics can be used to estimate the economic impact of environmental investments on an entire industry. micro-economic analysis looks at the effect of environmental investments on prices, plant closing, employment, capacity expansion and export potential.

Such analysis often shows that the economic impact of the Cleaner Production investment is not significant, with only small increases in prices (1-3 per cent) and little reduction in industrial output.

Some Cleaner Production investments can be justified by showing that a major reduction in pollution problems can be achieved without causing a significant economic effect on productive activities.

Next Steps

1 **Read "Choosing an appropriate water treatment", included in the *Reading Excerpts* at the end of this Learning Unit.**

2 **Test your comprehension of the information presented by answering the questions below. Compare your answers with those suggested.**

Questions

1 Why did the authors of this study recommend that the Government of Thailand relax its effluent standards for the tapioca starch mills?

2 Why did the authors recommend that second-grade mills should not be required to meet 1979 standards?

3 The article was written in 1977. How might the current discussion of Cleaner Production change the analysis?

Answers

1. *The current standards are not technically feasible, so they are not enforceable. Lower standards could be enforced, resulting in a significant reduction in waste discharges.*
2. *The micro-economic impact analysis showed that most second-grade mills would not be able to afford the more stringent standard and would be forced to close. Also, it is likely that they contribute only a small share of the organic pollution from the tapioca starch industry.*
3. *This analysis focused on end-of-pipe treatment. An analysis of Cleaner Production techniques might suggest larger but more affordable reductions in waste generation and pollutant discharges.*

Benefit-Cost Analysis

Benefit-cost analysis compares the benefits of improving the environment to the costs of achieving that improvement.

Benefit-cost analysis can be applied at the local, regional, national or even global level.

Benefit-cost analysis can be used to justify Cleaner Production investments that have no positive financial returns to the enterprises but significant benefits in terms of reduced risks to health and the environment.

Estimating the benefits of environmental investments requires linking the effect of pollutant reduction on ambient environmental quality, determining the effects of improved ambient en- vironmental quality on humans and the environment and establishing the value of these effects.

In a few cases, the value of environmental benefits is reflected in market prices, such as those for agricultural and forestry products. In most cases, however, the value of environmental benefits must be either

- Directly derived from complementary markets (housing prices as influenced by ambient air quality) or surveys (asking individuals what they are willing to pay for environmental quality improvement).
- Indirectly derived from physical science data and imputed market values.

There is often considerable uncertainty in linking changes in ambient environmental quality to physical effects (e.g. the relationship between exposure to sulfur dioxide and mortality) and in valuing these effects (e. g. what is the value of improved human health, atmospheric visibility etc.).

Some environmental effects, particularly effects on ecosystems and effects occurring in the distant future (e.g. leaking hazardous waste sites), are difficult to include in benefit-cost analyses.

Next Steps

1 Read chapters 1-4 and 6 from "Benefits estimates and environmental decision-making", included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What is one of the main difficulties of benefit-cost analysis?

2 How can some environmental investments that have no positive financial returns be justified?

3 Why is it important to place monetary measures on environmental gains and losses?

Answers

1. It is often difficult to quantify physical effects on health and environment.

2. These investments often reduce risks to health and improve the environment.

3. Monetary measures make it possible to measure the degree of concern and offer a supportive argument for environmental quality. They permit comparison with other monetary benefits arising from the alternative uses of funds.

Macroeconomic Impact Analysis

Macroeconomic models are useful for tracing the impact of pollution control expenditures on major variables in an economy: economic growth, inflation, unemployment, productivity and the balance of payments.

The difference between macroeconomic analysis and micro-economic analysis is that macroeconomic analysis assesses the overall effects that environmental expenditures exert on a national economy, whereas micro-economic analysis looks at the impacts on a particular plant, enterprise or industry.

Macroeconomic analysis captures important multiplier and feedback effects, such as the effects of price changes on firms that purchase the output of polluting companies and the effects of increased demand on the suppliers of pollution control equipment.

The macroeconomic consequences of environmental expenditures in developed countries have been quite small. The annual expenditure has been between 0.8 and 1.5 per cent of GDP. Industry accounts for about 25 per cent of this expenditure. The other sectors that must invest in the environment are Governments, households and transport.

The public ultimately pays the costs of environmental improvements, if not directly then indirectly through higher taxes, higher prices or reduced services.

Next Steps

1 **Read "Macroeconomic modelling techniques", included in the *Reading Excerpts* at the end of this Learning Unit.**

2 **Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.**

Questions

1 What is the difference between micro-economic and macro-economic impact analysis?

2 In which cases does the use of macroeconomic impact analysis make sense?

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3 What percentage of GDP in developed countries is being spent on environmental protection measures?

1. micro-economic impact analysis looks at the impacts of environmental investments on an enterprise or industry. Macroeconomic impact analysis explains the impacts on the entire national economy, including effects on economic growth, inflation, unemployment, productivity and the balance of pay-

2. Macroeconomic impact analyses are necessary when environmental issues overall effects, including important multiplier and feedback effects, a national economy.

3. Between 1 and 2 per cent of the GDP.

Additional Suggested Readings

This concludes the study section of Learning Unit 6. For additional information on financial and economic analysis, you may refer to the following sources.

Behrens, W., and P.M. Hawranek, *Manual for the Preparation of Industrial Feasibility Studies* (UNIDO publication, Sales No. E.91.III.E.18).

Pearce, D.W., and A. Markandya, *Environmental Policy Benefits: Monetary Valuation* (Paris, OECD, 1989).

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Tietenberg, T., *Environmental and Natural Resource Economics,* 2nd ed. (Glenview, Illinois, Scott, Foresman, 1988).

USEPA, Office of Policy Analysis, *Guidelines for Performing Regulatory Impact Analysis,* EPA-230-01-84-003, 1983.

USEPA, Office of Pollution Prevention and Toxics, *Total Cost Assessment: Accelerating Industrial Pollution Prevention Through Innovative Project Analysis: Unit Applications to the Pulp and Paper Industry,* EPA/741/R-92/002, 1992.

Case Studies

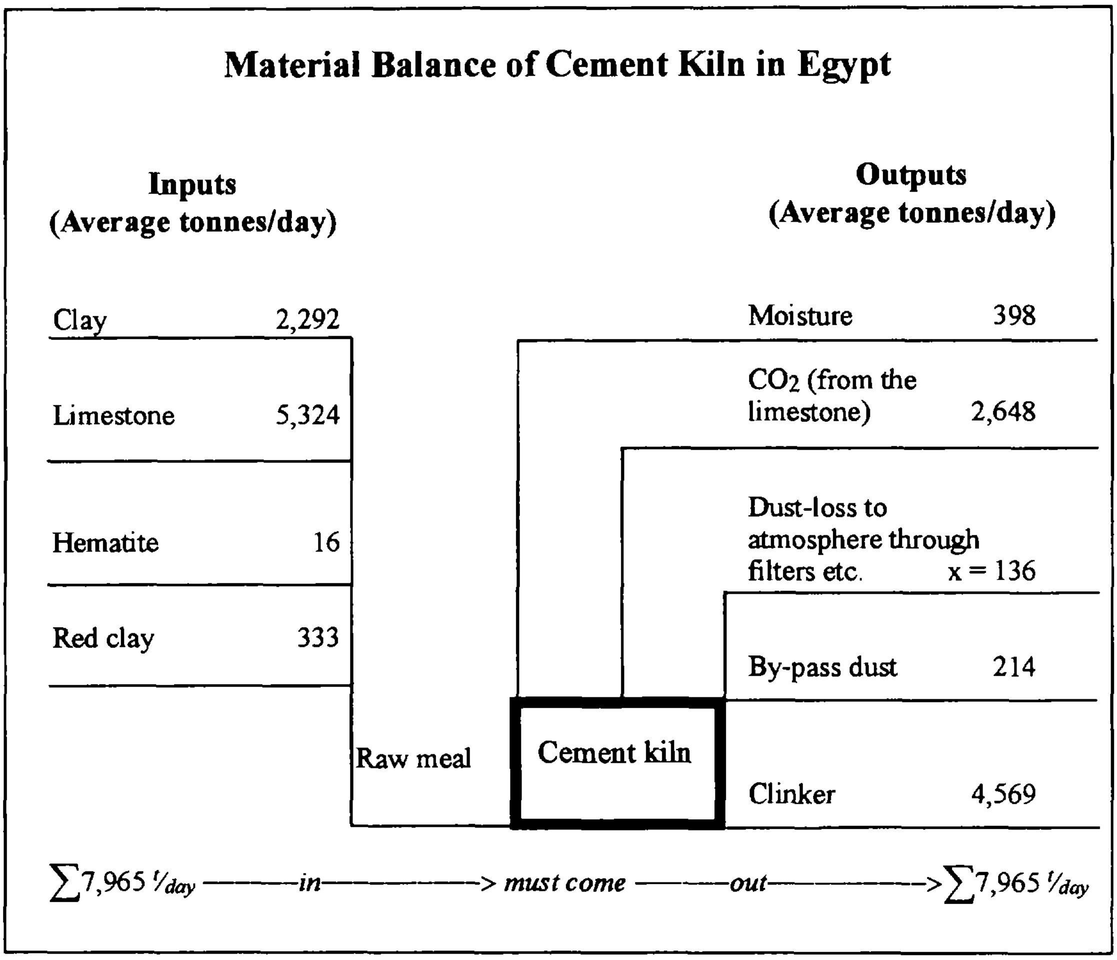
Case Study 1: Waste Reduction Audit for a Cement Plant

Based on UNIDO project US/INT/91/217, Demonstration of Cleaner Production Techniques.

Cement manufacture requires the burning of fuel together with limestone and clay, yielding a clinker which is then ground with gypsum to give cement. Burning with the modern energy- efficient dry process requires very large and efficient filters be- cause the combustion gases flow counter to the dry preheated raw material feed in the rotating kiln, carrying 10-20 per cent of the feed to the stack. Failure to catch and return this material to the process results in severe dust emissions and production losses.

In a pilot project to test the waste auditing technique, UNIDO assisted a cement industry in Egypt. After the initial preassessment, it was decided to focus on the cement kiln. Production records and laboratory data were used to determine input and output quantities over a period of one year and to derive a material balance for the kiln operation (see figure). Fuels and products of combustion were not included in the material balance since associated losses were deemed insignificant compared with the dust losses. Because there were no direct measurements of dust losses to the atmosphere, this quantity was determined by subtracting all known outputs from the inputs.

The material balance made management aware that potential product, 136 tonnes per day, was being lost through the stack.



Because equipment specification data suggested that something less than 18 tonnes per day should be escaping this way, the cement-making process and the filters were examined closely. Two important observations were made: (a) one filter, the gravel bed filter, was not functioning properly; (b) there were numerous kiln stoppages throughout the year (the electrostatic filters at the main stack work optimally only after some time in operation).

Emissions from the gravel bed filter were quickly addressed, reducing dust losses to the atmosphere by approximately 12 tonnes per day.

The company was already aware of the by-pass duct losses as this waste was being hauled by trucks and dumped in the surrounding desert. The problem is caused by the high alkali content of the Egyptian raw materials, which makes it necessary to bleed alkali-rich dust from the kiln to prevent clogging of the preheating equipment. The waste audit exercise spurred the company to find a sustainable and profitable solution. Trials suggested that the 214 tonnes per day of by-pass dust could, with the addition of 4 tonnes per day of additives, be successfully converted to clinker in a small dry kiln without preheaters. The processing would drive off an additional 26 tonnes per day of CO_2, thus yielding 192 tonnes per day of clinker. The investment for such a kiln is estimated at 10 million Egyptian pounds (LE) and the operating costs at LE 20 per tonne.

Questions

1 How much did the company increase its daily revenues by repairing the gravel bed filter, given that the semi-finished clinker escaping to the atmosphere is worth LE 110 per tonne?

2 What is the remaining potential for reducing dust emissions to the atmosphere at the plant? Suggest ways to achieve these savings.

3 How many years would be required to pay back the investment of the suggested by-pass dust kiln, given that the clinker is worth LE 120 per tonne and 300 operating days per year?

4 Do you think that the process technology in use (dry process preheating) was developed in Egypt?

5 Why were average data for one year used instead of making measurements over one day when the kiln was working properly?

6 What is the main advantage and the main disadvantage of determining the losses by difference, as was done in this case, and not by direct measurements?

7 World production of cement was in 1988 more than one billion tonnes. Estimate, using the material balance data for the Egyptian cement plant, how much CO_2 was emitted from the cement industry worldwide in that year and compare this with the estimate of CO_2 from fossil fuel burning given in Learning Unit 2. For ease of calculation, neglect the fact that gypsum has to be added to the clinker to make cement, the burning of fuel in the cement process and other processing. Having the answer, would you say that it is important to reduce losses of semi-finished clinker in the context of global warming?

Answers

1. *12x110=LE 1,320 per day (US$ 400 per day).*
2. *136-12-18=106 tonnes per day, or 110x106=LE 11,660 per day. Improve preventive maintenance of the kiln and filters to reduce the number of kiln stoppages and increase the efficiency of the filters.*
3. *10,000,000/[(120-20)x300x192]=1.7 years.*
4. *No, because if it had been, the alkali content of the raw materials would have been considered. This shows how difficult it is to transfer technology.*
5. *Kiln stoppages, build-up of dust in equipment etc. would not have been taken into account by measuring over one day only.*
6. *Losses are rarely measured, at least not continuously. It is therefore easier to determine them by subtracting process outputs from process inputs. The main drawback is that the figure thus derived cannot be checked.*
7. *2,648/4,569x1,000,000,000=580 million tonnes* CO_2*, which is a bit more than 10 per cent of the 5,700 million tonnes estimated yearly releases of* CO_2 *from fossil fuel burning. Yes, but it would be even better if this concentrated* CO_2 *stream could be captured and made use of.*

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Reading Excerpts

Economic Analysis of Pollution Prevention Projects

Excerpted, with permission, from USEPA, Office of Solid Waste, *Facility Pollution Prevention Guide*, EPA/600/R-92/088, chap.6.

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Although businesses may invest in pollution prevention because it is the right thing to do or because it enhances their public image, the viability of many prevention investments rests on sound economic analyses. In essence, companies will not invest in a pollution prevention project unless that project successfully competes with alternative investments. The purpose of this chapter is to explain the basic elements of an adequate cost accounting system and how to conduct a comprehensive economic assessment of investment options.

Total Cost Assessment

In recent years industry and the EPA have begun to learn a great deal more about full evaluation of prevention-oriented investments. In the first place, we have learned that business accounting systems do not usually track environmental costs so they can be allocated to the particular production units that created those wastes. Without this sort of information, companies tend to lump environmental costs together in a single overhead account or simply add them to other budget line items where they cannot be disaggregated easily. As a result, companies do not have the ability to identify those parts of their operations that cause the greatest environmental expenditures or the products that are most responsible for waste production. This chapter provides some guidance on how accounting systems can be set up to capture this useful information better.

It has also become apparent that economic assessments typically used for investment analysis may not be adequate for pollution prevention projects. For example, traditional analysis methods do not adequately address the fact that many pollution prevention measures will benefit a larger number of production areas than do most other kinds of capital investment. Second, they do not usually account for the full range of environmental expenses companies often incur. Third, they usually do not accommodate a sufficiently long time horizon to allow full evaluation of the benefits of many pollution prevention projects. Finally, they provide no mechanism for dealing with the probabilistic nature of pollution prevention benefits, many of which cannot be estimated with a high degree of certainty. This chapter provides guidance on how to overcome these problems as well.

In recognition of opportunities to accelerate pollution prevention, the USEPA has funded several studies to demonstrate how economic assessments and accounting systems can be modified to improve the competitiveness of prevention-oriented investments. EPA calls this analysis Total Cost Assessment (TCA). There are four elements of TCA: expanded cost inventory, extended time horizon, use of long-term financial indicators, and direct allocation of costs to processes and products. The first three apply to feasibility assessment, while the fourth applies to cost accounting. Together these four elements will help you to demonstrate the true costs of pollution to your firm as well as the net benefits of prevention. In addition, they help you show how prevention-oriented investments compete with company-defined standards of profitability. In sum, TCA provides substantial benefits for pre-implementation feasibility assessments and for post-implementation project evaluation.

The remainder of this chapter summarizes the essential characteristics of TCA. Much of the information is drawn from a report recently prepared for the USEPA by the Tellus Institute. The Tellus report addresses TCA methodology in much greater detail than can be provided here and provides examples of specific applications from the pulp and paper industry. The report also includes an extensive bibliography on applying TCA to pollution prevention projects. In a separate but related study for the New Jersey Department of Environmental Protection, Tellus analyzed TCA as it applies to smaller and more varied industrial facilities. A copy of this report can be obtained from the N.J. Department of Environmental Protection.

Expanded Cost Inventory

TCA includes not only the direct costs factors that are part of most project cost analyses but also indirect costs, many of which do not apply to other types of projects. Besides direct and indirect costs, TCA includes cost factors related to liability and to certain "less-tangible" benefits.

TCA is a flexible tool that can be adapted to your specific needs and circumstances. A full-blown TCA will make more sense for some businesses than for others. In either case it is important to remember that TCA can happen incrementally by gradually bringing each of its elements to the investment evaluation process. For example, while it may be quite easy to obtain information on direct costs, you may have more trouble estimating some of the future liabilities and less tangible costs. Perhaps your first effort should incorporate all direct costs and as many indirect costs as possible. Then you might add those costs that are more difficult to estimate as increments to the initial analysis, thereby highlighting to management both their uncertainty and their importance.

Direct Costs

For most capital investments, the direct cost factors are the only ones considered when project costs are being estimated. For pollution prevention projects, this category may be a net cost, even though a number of the components of the calculation will represent savings. Therefore, confining the cost analysis to direct costs may lead to the incorrect conclusion that pollution prevention is not a sound business investment.

Indirect Costs

For pollution prevention projects, unlike more familiar capital investments, indirect costs are likely to represent a significant net savings. Administrative costs, regulatory compliance costs (such as permitting, recordkeeping, reporting, sampling, preparedness, closure/post-closure assurance), insurance costs, and on-site waste management and pollution control equipment operation costs can be significant. They are considered hidden in the sense that they are either allocated to overhead rather than their source (production process or product) or are altogether omitted from the project financial analysis. A necessary first step in including these costs in an economic analysis is to estimate and allocate them to their source. See the section below on Direct Cost Allocation for several ways to accomplish this.

Liability Costs

Reduced lability associated with pollution prevention investments may also offer significant net savings to your company. Potential reductions in penalties, fines, cleanup costs, and personal injury and damage claims can make prevention investments more profitable, particularly in the long run.

In many instances, estimating and allocating future liability costs is subject of a high degree of uncertainty. It may, for example, be difficult to estimate liabilities from actions beyond your control, such as an accidental spill by a waste hauler. It may also be difficult to estimate future penalties and fines that might arise from noncompliance with regulatory standards that do not yet exist. Similarly, personal injury and property damage claims that may result from consumer misuse, from disposal of waste later classified as hazardous, or from claims of accidental release of hazardous waste after disposal are difficult to estimate. Allocation of future liabilities to the products or production processes also presents practical difficulties in a cost assessment. Uncertainty, therefore, is a significant aspect of a cost assessment and one that top management may be unaccustomed to or unwilling to accept.

Some firms have nevertheless found alternative ways to address liability costs in project analysis. For example, in the narrative accompanying a profitability calculation, you could include a calculated estimate of liability reduction, cite a penalty or settlement that may be avoided (based on a claim against a similar company using a similar process), or qualitatively indicate without attaching dollar value the reduced liability risk associated with the pollution prevention project. Alternatively, some firms have chosen to loosen the financial performance requirements of their projects to account for liability reductions. For example, the required payback period can be lengthened from three to four years, or the required internal rate of return can be lowered from 15 to 10 percent. (See the USEPA's Pollution Prevention Benefits Manual, Phase II for suggestions on formulas that may be useful for incorporating future liabilities into the cost analysis).

Less-Tangible Benefits

A pollution prevention project may also deliver substantial benefits from an improved product and company image or from improved employee health. These benefits, listed in the cost allocation section of this chapter, remain largely unexamined in environmental investment decisions. Although they are often difficult to measure, they should be incorporated into the assessment whenever feasible. At the very least, they should be highlighted for mangers after presenting the more easily quantifiable and allocatable costs.

Consider several examples. When a pollution prevention investment improves product performance to the point that the new product can be differentiated from its competition, market share may increase. Even conservative estimates of this increase can incrementally improve the payback from the pollution prevention investment. Companies similarly recognize that the development and marketing of the so-called "green products" appeals to consumers and increasingly appeals to intermediate purchasers who are interested in incorporating "green" inputs into their products. Again, estimates of potential increases in sales can be added to the analysis. At the very least, the improved profitability from adding these less-tangible benefits to the analysis should be presented to management alongside the more easily estimated costs and benefits. Other less tangible benefits may be more difficult to quantify, but should nevertheless be brought to management's attention. For example, reduced health maintenance costs, avoided future regulatory costs, and improved relationships with regulators potentially affect the bottom line of the assessment.

In time, as the movement toward green products and companies grows, as workers come to expect safer working environments, and as companies move away from simply reacting to regulations and toward anticipating and addressing the environmental impacts of their processes and products, the less tangible aspects of pollution prevention investments will become more apparent.

Expanded Time Horizon

Since many of the liability and less-tangible benefits of pollution prevention will occur over a long period of time, it is important that an economic assessment look at a long time frame, not the three to five years typically used for other types of projects. Of course, increasing the time frame increases the uncertainty of the cost factors used in the analysis.

Long-Term Financial Indicators

When making pollution prevention decisions, select long-term financial indicators that account for:

- all cash flows during the project
- the time value of money.

Three commonly used financial indicators meet these criteria: Net Present Value (NPV) of an investment, Internal Rate of Return (IRR), and Profitability Index (PI). Another commonly used indicator, the Payback Period, does not meet the two criteria mentioned above and should not be used.

Discussions on using these and other indicators will be found in economic analysis texts.

Direct Allocation of Costs

Few companies allocate environmental costs to the products and processes that produce these costs. Without a direct allocation, businesses tend to lump these expenses into a single overhead account or simply add them to other budget line items where they cannot be disaggregated easily. The result is an accounting system that is incapable of (1) identifying the products and processes most responsible for environmental costs, (2) targeting prevention opportunity assessments and prevention investments to the high environmental cost products and processes, and (3) tracking the financial savings of a chosen prevention investment. TCA will help you remedy each of these deficiencies.

Like much of the TCA method, implementation of direct cost allocation should be flexible and tailored to the specific needs of your company. To help you evaluate the options available to you, the discussion below introduces three ways of thinking about allocating your costs: single pooling, multiple pooling, and service centers. The discussion is meant as general guidance and explains some of the advantages and disadvantages of each approach. Please see other EPA publications, general accounting texts, and financial specialists for more detail.

Single Pool Concept

With the single pool method, the company distributes the benefits and costs of pollution prevention across all of its products or services. A general overhead or administrative cost is included in all transactions.

Advantages. This is the easiest accounting method to put into use. All pollution costs are included in the general or administrative overhead costs that most companies already have, even though they may not be itemized as pollution costs. It may therefore not be a change in accounting method but rather an adjustment in the overhead rate. No detailed accounting or tracking of goods is needed. Little additional administrative burden is incurred to report the benefits of pollution prevention.

Disadvantages. If the company has a diverse product or service line, pollution costs may be recovered from products or services that do not contribute to the pollution. This has the effect of inflating the costs of those products or services unnecessarily. It also obscures the benefits of pollution prevention to the people who have the opportunity to make it successful—the line manager will not see the effect of preventing or failing to prevent pollution in his area of responsibility.

Multiple Pool Concept

The next level of detail in the accounting process is the multiple pool concept, wherein pollution prevention benefits or costs are recovered at the department or other operating unit level.

Advantages. This approach ties the cost of pollution more closely to the responsible activity and to the people responsible for daily implementation. It is also easy to apply within an accounting system that is already set up for departmentalized accounting.

Disadvantages. A disparity may still exist between responsible activities and the cost of pollution. For example, consider a department that produces parts for many outside companies. Some customers need standard parts, while others require some special preparation of the parts. This special preparation produces pollution. Is it reasonable to allocate the benefit or cost for this pollution prevention project across all of the parts produced?

Service Center Concept

A much more detailed level of accounting is the service center concept. Here, the benefits or costs of pollution prevention are allocated to only those activities that are directly responsible.

Advantages. Pollution costs are accurately tied to the generator. Theoretically, this is the most equitable to all products or services produced. Pollution costs can be identified as direct costs on the appropriate contracts and not buried in the indirect costs, affecting competitiveness on other contracts. Pollution costs are more accurately identified, monitored, and managed. The direct benefits of pollution prevention are more easily identified and emphasized at the operational level.

Disadvantages. Considerable effort may be required to tack each product, service, job, or contract and to recover the applicable pollution surcharges. Added administrative costs may be incurred to implement and maintain the system. It may be difficult to identify the costs of pollution when pricing an order or bidding on a new contract. It may be difficult to identify responsible activities under certain conditions such as laboratory services where many small volumes of waste are generated on a seemingly continual basis.

Summary

Environmental costs have been rising steadily for many years now. Initially, these costs did not seem to have a major impact on production. For this reason, most companies simply added these costs to an aggregate overhead account, if they tracked them at all. The tendency of companies to treat environmental costs as overhead and to ignore many of the direct, indirect, and less-tangible environmental costs (including future liability) in their investment decisions has driven the development of TCA.

Expanding your costs inventory pulls into your assessments a much wider array of environmental costs and benefits. Extending the time horizon, even slightly, can improve the profitability of prevention investments substantially, since these investments tend to have somewhat longer payback schedules. Choosing long-term financial indicators, which consistently provide managers with accurate and comparable project financial assessments, allows prevention oriented investments to compete successfully with other investment options. Finally, directly allocating costs to processes and products enhances your ability to target prevention investments to high environmental cost areas, routinely provides information needed to do TCA analysis, and allows managers to track the success of prevention investments. Overall, the TCA method is a flexible tool, to be applied incrementally, as your company's needs dictate.

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Choosing an Appropriate Water Treatment

Excerpted, with permission, from R.A. Luken and Y. Unkulvasapaul, "Choosing an appropriate water treatment", *Environmental Science and Technology*, vol. 11, No. 13 (December 1977).

Increasing environmental awareness in the 1970's has led both developed and developing nations to adopt more stringent effluent standards. They have tended to establish uniform standards for similar categories of activities because uniform requirements are easier to administer. In addition, developing nations have tended to base their standards on the experiences of European and North American countries.

While the adoption of more stringent effluent standards is usually a wise decision, it is more important that these standards be implemented by developing nations. In many cases these standards are not implemented because they do not take into account:

- the waste treatment technology available to industrial and municipal dischargers
- the cost of the technology
- the economic impact on industry
- the local environmental conditions.

Thus the rate of compliance with the effluent standards has been slow in many cases.

Obviously, the rate of compliance with effluent standards would be increased if they were tailored to the unique conditions in each developing nation. One way to adjust the effluent standards for unique conditions is to take into account technological, environmental, and social conditions in each country.

For example, facultative oxidation ponds are usually much more appropriate than activated sludge waste-water treatment systems in the Southeast Asian countries because the latter require too much mechanical equipment and maintenance. Another example is that the permissible level of dissolved oxygen in rivers may be lower in Southeast Asia than Europe because aquatic organisms are more adaptable to adverse conditions in the tropics.

Assessment

The primary recommendation emerging from the technological and economic impact study [of the tapioca starch industry in Thailand] is that the Thai government adopt the 1977 and 1979 proposed effluent standards for first-grade mills, but only the 1977 proposed effluent standards for second-grade mills. For both categories of mills, appropriate technologies are available and effective. However, on the basis of economic analysis, only the first-grade mills would be required to meet the 1977 and 1979 standards. Requiring the second-grade mills to meet the 1979 standards is not recommended because of the severe economic impact and because trends in the market alone may force these plants to close in a few years.

The current and proposed effluent standards are very different. The current Thai effluent standards do not allow for significant variation between the two different types of production technologies and exceed the capacity of commonly used environmental control technology. While the proposed effluent standards are not as stringent as the current standards, they would result in a significant pollution reduction. More importantly, they would probably be implemented because they are feasible and do not impose significant adverse economic impacts.

Table 1. Size Distribution of Plants

Sub-categories	Estimated no. of mills	Size range	Size distribution
First-grade starch	27	40-59 t/day	15%
		60-69	55%
		70-120	30%
			100%
Second-grade starch	72	0-2.9	90%
		3.0-9.0	10%
			100%

The Starch Industry

Three representative starch mills rather than all 90-110 mills in Thailand were analyzed because of the impossibility of considering all mills. In defining representative mills, all mills were first classified as either first- or second-grade starch mills (table 1). First-grade mills are more capital intensive and thus more mechanized than second-grade mills. They have better extraction rates and are always significantly larger than second-grade mills. Within the second-grade category, mills were classified as either large (3-9 tons/day) or as small (less than 3 tons/day) mills. This distinction was made because of concerns about the impacts on very small mills.

Two rather than one set of effluent limitations were considered for each of the three representative mills. A less stringent limitation (low removal of organic material) was proposed for 1977. A more stringent limitation (higher removal of organic material) was proposed for 1979.

Control Technology and Costs

Several factors were used in selecting appropriate technologies on which to base the 1977 and 1979 effluent limitations. These factors were:

- sufficient data about the engineering design and removal efficiencies
- technology appropriate for reducing organic wastes
- costs
- availability of land.

Fortunately, the works by Pescod and Thanh (1976) and Unkulvasapaul (1975) reviewed the appropriate technologies on the basis of these criteria and the following material is a brief summary of their work. These studies have many of the features of a U.S. Environmental Protection Agency Development Document.

The selection of appropriate waste-treatment technologies assumes that starch mills would install primary clarification ponds as part of the production process. The settled starch would be recovered and sold along with other starch output.

As a first-stage limitation, the above-mentioned sources agreed that the anaerobic ponds appear to be the best choice. Anaerobic ponds are earthen basins in which the raw waste load is retained for a short time to contact with deposited digested solids. These ponds are most appropriate in view of the very high BOD concentration, low costs of treatment, and general availability of land.

As a second-stage limitation, the above-mentioned sources reviewed several technologies:

- One is a facultative oxidation pond that allows for sufficient surface area and detention time to stimulate aerobic reactions. This technology is appropriate where large land areas are available and cheap.
- Another is an aerated lagoon, which treats waste water on a flow-through basis and oxygen is supplied usually by means of surface aerators or diffused aeration units. This technology is appropriate where land is available to a limited degree, but is costly.
- A third is a rotating biological drum filter, which treats waste water in a heavy wire mesh drum filled with equal-sized plastic spheres. This technology is appropriate where land use must be minimized and land is very costly.

- A fourth is completely mixed continuous-activated sludge, which treats wastewater in a dispersed media by using diffused air. This technology is appropriate where land is available to a limited degree, but is costly.

Of the four available technologies, the best choice for the tapioca starch industry in Thailand appears to be aerated lagoons (table 2). A survey of the industry indicates that land is relatively available, particularly to first-grade mills, and is relatively inexpensive. Thus utilization of a rotating biological drum filter, which is a capital-intensive treatment system, is not necessary to minimize land use. The estimated cost of activated sludge is too high.

The work of Unkulvasapaul (1975) compared the capital, and operation and maintenance costs for a facultative oxidation pond and an aerated lagoon and found that both types of costs were greater for a facultative oxidation pond given land costs in the south of Thailand. The higher operation and maintenance costs were attributed to the monthly land rental, which accounted for 75% of these costs. In addition, facultative oxidation ponds probably could not achieve the same removal efficiencies as aerated lagoons. Thus utilization of an aerated lagoon rather than a facultative oxidation pond as the second-stage requirement is preferable on the basis of cost minimization.

Table 2. Technologies Available and Evaluations

Technology	Tested removal efficiency in Thailand	Appropriate for reducing organic wastes	Relative costs	Relative land requirements
First-stage requirement				
Anaerobic pond	Yes	Yes	low	medium
Second-stage requirement				
Facultative pond	No	Yes	low-medium	high
Aerated lagoon	Yes	Yes	low-medium	medium
Rotating drum	Yes	Yes	high	low
Activated sludge	Yes	Yes	high	medium

Source: Pescod and Thanh (1976) and Unkulvasapaul (1975)

Treatment costs for representative plants for first- and second-stage requirements are summarized in table 3. Actual treatment costs will vary largely from plant to plant depending upon the design and operation of the production facilities and local conditions, particularly land prices.

Furthermore, effluent treatment costs vary greatly from one installation to another, depending upon bookkeeping procedures.

Economic Impact

Several economic factors were also important in determining appropriate technologies. The factors considered were:

- price
- production
- employment and plant closure
- balance of payments and
- growth.

Potential price increases are based on the additional costs per ton of starch that might be incurred by a plant having to purchase an entire treatment system to achieve the proposed effluent limitations (table 4). These price increases would be less than estimated because the treatment costs do not take into account in-place technology. In addition, part of the costs might be passed on by an increase in the selling price of production wastes, which are used as animal feed.

The potential price effects through the 1970's for segment categories are insignificant except for small second-grade mills. However, even this price increase is dwarfed by variations in the market price, which has increased and decreased annually by as much as 30% and increased by 140% from 1970 to 1974.

The ability of the segments to pass environmental control costs on to the consumer will depend upon future supply/demand balances and substitute products. For the domestic market, the supply/demand balance is expected to be loose through the 1970's. However, there are no competitive substitutes for starch, so it is likely that a small price increase can be passed forward.

Social Consequences

Production effects would vary among the three categories of mills. For first-grade mills, no shutdowns or production curtailments are projected owing to environmental control regulations for either 1977 or 1979 requirements. These larger mills have sufficient return on investment, available capital, and cash flow to finance expected pollution control expenditure through the 1970's. However, if the market deteriorates as it did during 1975, some mills would curtail production for reasons other than pollution control costs.

Large second-grade mills would not shut down with the 1977 requirements. While the owners would not receive any return on their capital investment, they would cover the additional operating costs. However, the seven mills would shut down with the 1979 requirements. In this case, the owners would not be able to cover their operating costs. Closure of these seven mills would decrease total industry capacity by three per cent.

Table 3. Summary of Costs per Representative Plant

Segment	Capital cost $	Operation & maintenance cost $/month
First Stage:		
First grade	6900	40
60 t/day		
Second grade	1100	20
8.4 t/day		
Second grade	300	10
2 t/day		
Second Stage:		
First grade	37 300	2600
60 t/day		
Second grade	7300	300
8.4 t/day		
Second grade	3200	100
2 t/day		

Source: Unkulvasapaul (1975)

Small second-grade mills would probably not shut down with the 1977 requirements, in spite of the fact that the owners would not be able to cover their operating costs. They probably would not shut down because they might be able to reduce operating costs or disregard pollution control requirements. In the latter case, the operating costs are too large to be absorbed by skillful management of the plants. Closure of these mills would decrease total industry capacity by seven per cent.

Table 4. Annual Treatment Costs per Representative Plants[a]

	Cost per ton of starch production	Potential incremental pollution control cost $/ton		Incremental pollution control cost as percent of year end 1975 starch prices	
Segment	$	1977	1979	1977	1979
First grade	145	.10	2.0	<1%	1.5%
60 t/day					
Second grade	150	.15	2.1	<1	1.7
8.4t/day					
Second grade	150	.25	3.3	<1	2.8
2 t/day					

[a] Includes capital recovery and operation and maintenance costs. Assumes no environmental control facilities are in place. Assumes a 20-year life of facilities, 12% interest rate, and 12-month operation.

Both the large and small second-grade mills might close even in the absence of environmental control requirements. Over the past ten years, the number of second-grade mills has decreased by approximately 50%. These mills, particularly the small ones, barely covered their variable costs in 1975.

If pellet producers continue to bid up the price of roots and labor costs increase more rapidly than the selling price of outputs, the second-grade mills could easily be in a situation where they would not cover variable costs. Most likely, this situation would occur some time during the next five years. Thus the environmental control problems caused by second-grade mills might be solved by general economic conditions, which would induce the second-grade mills to cease production.

Similarly, employment effects would vary among the three categories of mills. No adverse employment effects are projected for the first-grade mills because there are no production curtailments foreseen as a result of pollution control. While there are no adverse employment effects associated with large second-grade mills meeting the 1977 requirement, there would be adverse effects meeting the 1979 requirement. As many as 60 employees could lose their jobs if all seven plants close.

Similarly, there are no adverse employment effects associated with small second-grade mills meeting the 1977 requirement, but there would be adverse effects meeting the 1979 requirement. As many as 260 employees could lose their jobs if all 65 plants close.

Thailand's balance of payments would not be adversely affected by the proposed effluent limitations because they would not significantly affect the cost of production for 90% of industry capacity (first-grade mills). This statement is reinforced by the fact that factors other than export price, particularly Japanese tariff barriers, are more significant determinants of Thai starch purchased abroad.

Environmental control expenditures may affect growth by reducing profitability or by reducing the amount of capital available for expansion. This analysis is based on the assumption that, in most cases, the cost of environmental control could be passed on through price increases. Even if the industry (first-grade mills) could not pass on prices, they would expand if there were not excess capacity.

While the 1977 and 1979 effluent limitations would decrease the internal rate of return on investment from 26 to 20%, the rate would still be sufficiently high to attract new capital. This estimate would be low if the industry experiences another year like 1974 in which plant owners apparently repaid their capital investment in one year. Therefore, it is not anticipated that the proposed effluent limitations could deter expansion in a tight supply/demand balance, although in the short run, they might slow down addition to capacity.

Table 5. Current and Proposed Effluent Standards for Thai Tapioca Starch Industry

	Raw waste load		Current		Proposed[a]		
Sub-category	BOD mg/L	SS mg/L	BOD mg/L	SS mg/L	BOD mg/L	SS mg/L	Year
First grade	4500	2000	20-60	30-150	1800	360	1977
Second grade	3500	1000	20-60	30-150	1400	180	1977
(large)							
First grade	4500	2000	20-60	30-150	270	360	1979
Second grade	3500	1000	20-60	30-150	1400	180	1979
(large)							

Source: Unkulvasapaul (1975) and Parker (1971)

[a] These proposed effluent limitations are seen as averages of daily values for thirty consecutive days. There should be a maximum value for any one day, but data to make this estimate were not available at the time of the study.

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Benefits Estimates and Environmental Decision-Making

Excerpted, with permission, from OECD, *Benefits Estimates and Environmental Decision-Making* (Paris, 1992), chaps. 1-4 and 6.

Chapter 1

Introduction

Benefit and damage estimation (BDE) involves the placing of money values on the gains and losses from economic activity. Benefit estimation has a long history in terms of activities such as valuing increases in agricultural productivity induced by water resource projects and time savings and losses in transportation projects, but it is of relatively recent origin in terms of environmental impacts. A number of surveys of both the theory and practice of BDE exist.[1] Still less researched is the way in which BDE is actually used in decision-making. This is the purpose of the current report. The aim is:

- to see how far BDE is actually used in government (central and local),
- what the experience of using it is,
- what the obstacles to its more widespread use might be, and
- and how wider adoption of BDE techniques might be encouraged.

The report builds on previous OECD work, notably a report on the available techniques and the results they have so far produced,[2] and a report on the use of BDE in six countries: USA, UK, Netherlands, Germany, Norway and Italy.[3] The six country studies have been supplemented here with a further OECD questionnaire carried out in 1990 in seven further countries: Sweden, Finland, Greece, Austria, Portugal, Turkey and Japan.

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[1] On the theory, see Freeman, A.M. (1979), *The Benefits of Environmental Improvement*, Johns Hopkins University Press, Baltimore; Johannsson, P-O. (1987), *The Economic Theory and Measurement of Environmental Benefits*, Cambridge University Press, Cambridge. On the practice, see Kneese, A.V. (1984), *Measuring the Benefits of Clean Air and Water*, Resources for the Future, Washington D.C., and Pearce, D.W. and Markandya, A. (1989), *Environmental Policy Benefits; Monetary Valuation*, OECD, Paris.

[2] Pearce and Markandya, in OECD, 1989, *op.cit.*

[3] See Barde, J.Ph., and Pearce, D.W. (1991), *Valuing the Environment: Six Case Studies, Earthscan*, London, 1991.

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Chapter 2

Why Value Benefits?

BDE is controversial. It is important to understand what economists do when they 'value things'. Misconceptions about the purpose and nature of economic valuation account for the major part of the dispute between economists and non-economists.

Value, to the economists, resides *in people*. Value arises whenever a want or preference is satisfied. Value is lost whenever a 'negative want' or 'dispreference' occurs, i.e. there is dissatisfaction. Gains in value are also termed *benefits* and losses in value are termed costs. Values are instrumental, i.e. they are of and in people, *for* things. Traditionally, economists would have reserved this sense of the term 'value' to mean 'value in use' i.e. the capacity of something, when used, to satisfy a want or preference, as opposed to 'value in exchange', i.e. the worth of something in terms of its capacity to be exchanged for something else.[4],[5] As we shall see, the term value in use is now somewhat misleading, since the same type of value—i.e. the capacity to satisfy wants—arises in contexts where use does not occur. A major part of the recent and substantial literature on valuation has been devoted to this 'non-use value' phenomenon. The process of *valuation* is then any procedure which uncovers or elicits instrumental values.

Instrumental value needs to be contrasted with *intrinsic* value which is regarded by ecological philosophers as being *in things*. There is a wide spectrum of opinion as to what class of things possess intrinsic value, as illustrated by the debates about the 'new naturalistic' ethics,[6] especially whether conscious things only have values, or non-conscious things do as well[7]. Typically, debates between advocates of one form of value or the other tend to assume that the pursuit of instrumental value is inconsistent with the protection of intrinsic values. By and large, this is because value in use is incompatible with much intrinsic value: e.g. the

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[4] The distinction between value in use and value in exchange was first developed by Aristotle in his *Politics*, and was elaborated on by Adam Smith in his *Wealth of Nations*. Interestingly, however, Aristotle did not advocate the design of social systems according to the maximisation of value in use. Rather the *common good* could be achieved only by limiting wants and desires. Wants were relevant only in so far as some basic goods—agricultural goods and necessities—were concerned. Thereafter, denial of wants was necessary to achieve the common good. To some extent therefore, Aristotle advocated 'limits to growth', a viewpoint which some environmentalists find attractive to this day.

[5] The 'theory of value' in economics is, however, about the theory of determining value in exchange. Value in use is, of course, essential for exchange to take place, otherwise there would be no incentive for exchange. See Allingham, M. (1982), *Value*, Macmillan, London.

[6] See Turner, R.K., "Wetland Conservation: Economics and Ethics", in Collard, D., Pearce, D.W. and Ulph, D. (1988), Economics, Growth and Sustainable Environments, Macmillan, London.

[7] See Regan T., "The Nature and Possibility of an Environmental Ethic", *Environmental Ethics*, 1981, Vol. 3, pp. 19-34; and Naess, A., "The Shallow and the Deep Long Range Ecology Movement: A Summary", *Inquiry*, Vol. 16, No. 1, 1973, pp. 95-100.

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Table 3. The Use of BDE in Selected OECD Countries

	GRE	JAP	SWE	NETH	NOR	TUR	G	AUS	UK	POR	USA	ITA	FIN
Wide	-	-	-	-	-	-	X	-	-	-	X	-	-
Medium	-	-	-	X	X	-	-	-	X	-	-	X	-
Limited	X	X	X	-	-	-	-	X	-	X	-	-	X
Nil	-	-	-	-	-	X	-	-	-	-	-	-	-

Source: OECD

Table 4. Type of Benefit or Damage Measured+

	FIN	NETH	NOR	SWE	G	UK	GRE	USA	ITA	AUS	POR
User values:											
(a) Direct use											
- market/ shadow prices	X	X	X	X	X	X	X	X	X	X	X
- option values	X	(X)	X	X	X	(X)	-	X	-	X	X
(b) Indirect use											
-ecosystem function	-	(*)	-	X	-	(*)	-	(X)	-	-	-
Non-use values											
- existence	-	(X)	X	X	X	(X)	-	X	-	-	X
- bequest	-	(X)	X	-	X	-	-	X	-	-	-

+Japan and Turkey produced a nil return on this question

Note: All countries indicated expectations of more extensive benefit and damage estimation in the future.

Source: OECD

Table 5. Areas of Application of BDE

	SWE	NETH	NOR	FIN	G	UK	AUS	USA	POR	ITA	JAP
National Damage Estimate	-	X	-		X	-	(*)	X	(*)	-	
Specific Pollution Damage											
-air	(*)	X	X	*	X		-	X	*	-	x
-water	(*)	X	X	X	X	X	-	X	*	X	
-soil/land	-	-	-	(*)	X	(*)	-	X	*	X	-
-toxics	(*)	(X)	-	*	-	-	-	X	(*)	-	-
-noise	-	X	X	(*)	X	(*)	-	(X)	-	X	-
-waste	-	X^{1}	-	(*)	-	-	-	X	*	X	-
-oil spills	-	-	-	(X)	-	-	-	X	*	-	-
-other	-	-	-		sea defence	-	-	-	-	-	-
Resource Concerns:											
-wetlands	-	-	-	*	-	X	*	X	-	-	-
-forests	X	-	-^{2}	(X)	X	(X)	X	X	*	X	-
-coastal zones	-	-	-	(X)	-	-	-	X	(X)	X	-
-wildlife/nature	*	-	X	*	X^{3}	(*)	(X)	X	-	X	-
-fish stocks	(*)	-	X	(X)	*	-	-	-	-	-	-
-recycling	-	X	-	*	-	X	(X)	-	(*)	X	X
Risks:											
-'life'	-	-	-	(*)	-	X	-	X	-	-	
-pollution	-	-	-	*	-	-	-	X	-	-	
-ecological	-	-	-	(*)	-	(*)	-	X	(*)	-	

Source: OECD

[1] agricultural waste

[2] under way

[3] in the near future

Case Study of the Use of Benefit-Cost Analysis in Decision-Making: Lead in Gasoline

Under Executive Order 12291 of 1981 in the USA, government agencies were required to use 'Regulatory Impact Analysis' (RIA) and to adopt regulatory processes that would maximize 'the next benefits to society'. The Order was the first to establish the net benefit objective as the criterion for adopting regulatory processes, although its adoption has been circumcised by existing laws relating to other objectives.

Benefit-cost analysis played an important role in the adoption of regulations concerning lead in gasoline. Ambient lead concentrations were thought to be linked to serious health effects, including retardation, kidney disease and even death. The Environmental Protection Agency conducted a benefit-cost study with the results shown in Table 6.

The regulation involved reducing lead in gasoline from 1.1 grams per gallon (gpg) to 0.1 gpg. The costs of the rule are shown as 'total refining costs.' Refinery costs increase because lead has traditionally been used to boost octane levels in fuel, and other means would have to be found to achieve this. The benefits included:

- improved children's health;
- improved blood pressure in adults;
- reduced damages from misfuelled vehicles, arising from hydrocarbon, NO_X and CO emissions;
- impacts on maintenance and fuel economy.

Children's health. The EPA study found that blood lead levels closely tracked trends in gasoline lead. Medical costs for the care of children would be reduced by reducing lead concentrations, and there would be less need for compensatory education for IQ-impaired children. These savings are shown as 'children's health effects' in Table 6.

Adult blood pressure. Blood lead levels were thought to be associated with blood pressure and hypertension. Medical costs would be saved if these illnesses could be reduced. Moreover, some heart attacks and strokes would be avoided. A value of a 'statistical life' of $1 million was used for the latter. The resulting values show up in the 'adult blood pressure' row of table 6. They are seen to be high because of the involvement of mortality-avoidance in this benefit.

Other pollutants. Reducing lead in gasoline also reduces other pollutants. This is because making unleaded fuel the 'norm' reduces the risk of 'misfuelling'—i.e. using leaded fuels in vehicles designed for unleaded fuels. The mechanism whereby misfuelling is reduced is through the higher cost of leaded fuels at the new low-lead concentration. This deters drivers from purchasing the leaded fuel. As misfuelling is reduced, so emissions of HC, NO_X and CO are reduced. Damage done by these pollutants was estimated by studies of ozone pollution damage (ozone arises from HC and CO emissions), but estimates were also made of the value of the equipment destroyed by misfuelling. The figures appearing in the row 'conventional pollutants' in table 6 are in fact an average of the two methods.

Maintenance and fuel economy. Maintenance costs for vehicles were expected to fall due to reduced corrosive effects of lead and its scavengers on engines and exhaust systems. Fewer engine tune-ups and oil changes would be needed, exhaust systems would last longer. Fuel economy was expected to rise as the new technologies to raise octane levels to what they were previously also increase the energy content of fuels. There would also be reduced fouling of oxygen sensors. Maintenance benefits outweighed fuel economy benefits by around 6 to 1. The totals are shown in table 6.

Table 6. Year-by-Year Costs and Monetized Benefits of Final Rule, Assuming Partial Misfuelling (Millions Of 1983 Dollars)

	1985	1986	1987	1988	1989	1990	1991	1992
Monetised benefits								
Children's health effects	223	600	547	502	453	414	369	358
Adult blood pressure	1,724	5,897	5,675	5,447	5,187	4,966	4,682	4,691
Conventional pollutants	0	222	222	224	226	230	239	248
Maintenance	102	914	859	818	788	767	754	749
Fuel economy	35	187	170	113	134	139	172	164
Total monetised benefits	2,084	7,821	7,474	7,105	6,788	6,517	6,216	6,211
Total refining costs	96	608	558	532	504	471	444	441
Net benefits	1,988	7,213	6,916	6,573	6,248	6,045	5,772	5,770
Net benefits excluding blood pressure	264	1,316	1,241	1,125	1,096	1,079	1,090	1,079

The net benefits from reducing lead in gasoline are seen to be substantial, even if the blood pressure benefits (which dominate the aggregate benefits) are excluded. Indeed, inspection of table 7 shows that the regulation would be worthwhile *even if all health benefits are excluded*. In the event, the blood pressure benefits were excluded from the final decision because the research establishing this link was judged too recent to permit adequate review. The lead regulation was also of interest because of the introduction of a 'lead permits system' to reduce the financial burden on the refining industry. Essentially, this allowed 'lead quotas' to be traded between refiners. Refiners who found it easy to get below the limit were allowed to sell their 'surplus' lead rights to refiners who found it expensive to get back to desirable octane levels without lead. The particular feature of the lead-in-gasoline benefit-cost study that made it a powerful aid to decision-making was the clear-cut nature of the net benefits even when uncertainties about benefits were allowed for. But it was also executed carefully and in comprehensive detail. As Portney (1990)[11] puts it: "It is important to realize that in spite of the difficulties that arise, benefit estimation is a useful input in policy making when used carefully".

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[11] Portney, P., "Air Pollution Policy", in Portney (ed.) *Public Policies for Environmental Protection*, Resources for the Future, Washington, D.C. See also USEPA, EPA's *Use of Benefit-Cost Analysis* 1981-1986, EPA-230-05-87-028, Washington, D.C., August 1987.

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Macroeconomic Modeling Techniques

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Macrosimulation models start with small units, evaluating the effect of a policy change on individual households or businesses, and work up, tracing the effect of those responses on changes in demand, product and prices. In contrast, macroeconomic models work from the top down. A system of aggregate relationships is specified, and the ways in which a policy change may effect one or more important variables in the system are identified.

Macroeconometric models, usually based on some form of Keynesian economic theory, start estimating aggregate variables, such as Gross Domestic Product (GDP) or total employment. They also break the variables down into their component parts. GDP, for example, can be broken down into consumption, investment, imports, exports and government spending. Consumption and investment are in turn linked to such variables as income, interest rates and profits. Relationships between industries are often described by an input/output matrix, and the level of employment is determined by the demand for labour from the productive sectors, and by the amount of labour supplied by various categories of workers. The model may include a financial sector, and sets of estimated equations, to show the effect on prices of changes in production costs and the amount of utilised capacity.

Evaluation of Environmental Regulations in OECD Countries

Summary of Findings

Since the early 1970s, a number of OECD-member countries have been developing macroeconomic modelling capabilities, and using these capabilities to assess the economic impact of their pollution control programmes. These assessments try to quantify the direct and indirect effects that environmental programmes might have on the major macroeconomic variables in each country. The first studies in this area, reviewed in an earlier OECD report[1], were carried out at a time when the economies of most member countries were operating at close to full capacity. They therefore tended to stress the unfavourable short-term effects which

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[1] Source: *The Macro-Economic Impact of Environment Expenditure,* OECD (1985).

pollution control programmes were likely to have on inflation, and on international competitiveness.

The changed economic circumstances prevailing at present in most OECD countries suggest that a somewhat different emphasis may be more appropriate. In addition to the continuing interest in price and balance of payments effects, policy-makers may also wish to know what impact environmental expenditure may have on employment trends and on longer-term growth of productivity and output.

The present report summarizes the results from recently completed modelling in six countries—Austria, Finland, France, the Netherlands, Norway and the United States. A summary of the results, which are displayed in table 1, is given below:

- The effects of increased pollution control expenditures on the growth of output are indeterminate. The range of results suggests that the level of GDP in the final programme year could be either higher (1.5 per cent over 10 years in the case of Norway), or lower (1 per cent over 18 years in the case of the United States), with most results showing intermediate values.
- The effects on inflation would appear to be slightly unfavourable. In virtually all countries, the programmes boost consumer prices; in some cases the increase over the period would be as much as 5 to 7 percentage points, equivalent to an average annual increase of about 0.3 to 0.5 percentage points.
- Conversely, employment is stimulated. With few exceptions, unemployment levels are reduced by pollution-control expenditure, particularly under some variants in the United States, France and, especially, Norway. The counterpart of this result is an implicit worsening of productivity growth (output per unit of labour). This occurs because GDP growth rates are either somewhat lower, or only slightly higher, than they otherwise would have been, while labour input increases because of environmental measures.
- Developments through time suggest that the initial impact of environmental expenditures is more favourable than the long-term effects. In the short-term, increased investment in pollution control equipment boosts output and activity. Over the longer-term, however, lower profits and/or higher prices erode some or most of the short-term gains.

While these various results are of interest in their own right, the main conclusion which emerges from them is that the macroeconomic effects of environmental policies are relatively small. Most of the figures reported—with the exception of some of the results for consumer price inflation—are in the range of a few tenths of a percentage point per year. Furthermore, it is important to recall that these small effects were registered during a period (the 1970s) of peak pollution-control activity, when efforts were directed not only at limiting on-going pollution, but also at cleaning-up the backlog caused by neglect of the environment during the 1950s and 1960s.

This general conclusion on the relatively minor estimated impact also suggests that pollution control measures were not a major cause of the slowdown in productivity growth of the 1970s, as has sometimes been argued. By the same token, environmental measures are not likely to be a major constraining factor in a more expansionary strategy for the 1980s.

Table 1. Effects of Additional Environmental Programmes on Selected Economic Variables

(Range of differences between level with and without environmental programmes)

	Effects on:					
	GDP		Consumer Prices		Unemployment	
	First year	Final year	First year	Final year	First year	Final year
	(percentage points)				(thousands)	
Austria	..	-0.6/0.5	..	0.4/1.7 (a)	..	
Finland	0.3	0.6	0.2	0.2	-3.5	-7.5
France	-	0.1/0.4	-	0.1	-0.2/-1.1	-13.2/-43.5
Netherlands	0.1	-0.3/-0.6	0.2/0.4	0.8/4.3	-1.4/-2.3	-3.8/6.9
Norway	..	1.5	..	0.1/0.9	..	-25.0
United States	0.2	-0.6/-1.1	0.2	5.0/6.7	-80.0	-150.0/-300.0 (b)
Memorandum items (c)						
Italy	..	-0.2/0.4	..	0.3/0.5	..	..
Japan	1.2/2.6	0.1/0.2 (d)	-	2.2/3.8	(lower)	(lower)

(a) GDP deflator.
(b) Partly estimated by Secretariat.
(c) Published in earlier OECD report.
(d) For period as a whole, suggesting negative results for final year.
.. = Not available
\- = Nil

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Benefit-Cost Analysis for the Ismailia Waste-Water Project

Excerpted from R. Luken, "Benefit-Cost Analyses for the Ismailia Waste Water Project", United States Agency for International Development (Washington, D.C., 1987).

Introduction

Statutory Versus Legal Mandates

The usual justification for building waste water treatment facilities is a statutory mandate. Public Law 48 of the Government of Egypt (GOE) requires that domestic waste be treated to meet discharge standards of 40 mg/l of Biological Oxygen Demand (BOD) and 50 mg/l of Total Suspended Solids (TSS). Similarly, Public Law 92-500 of the U.S. requires treatment to meet discharge standards of 30 mg/l of BOD and 30 mg/l of TSS. At least in the case of the U.S., there are exemptions from these standards where holding lagoons are feasible, usually in rural areas, and where ocean discharge is feasible. In these cases the standards are not as stringent because holding lagoons are an adequate form of treatment and ocean discharge usually does not result in serious environmental deterioration.

For many nations, the transition from uncontrolled to controlled discharge of waste water is viewed as a benchmark of progress. Substantial resources are often devoted to this effort, at the expense of other programs, without the benefit of detailed economic and environmental analyses.

Much of the emphasis placed on improved management of human wastes is related to concerns over the relationship between basic sanitary conditions and public health. Economic assessments of the benefits are problematic, due to uncertainties regarding the quantification of health effects and valuation of changes in morbidity and mortality. These problems are compounded in developing countries because of scarcity of data. Nonetheless, sufficient information is available that an attempt at a quantitative economic evaluation is possible.

Methodology

The study examines the economic benefits of building a waste-water treatment plant in Ismailia, Egypt. It first characterizes the environmental situation there with and without the water and waste-water projects and then estimates the potential benefits.

The benefits assessment is conservative. It is only the annual benefits anticipated in 1995 when these facilities will begin operation rather than levelized annual benefits. Levelized annual benefits would account for the growth in benefits over the 30 year life of the projects because it is an average over 30 years rather than benefits in year one of the project. Levelized annual benefits were not calculated because no reasonable data were available to make 30 year projections.

Ismailia Waste-Water Project

Introduction

The city of Ismailia is located on the north and west shore of Lake Timsah, which is an integral part of the Suez Canal. Lake Timsah is a relatively shallow saline waterbody of 12 km^2. The present waste-water treatment plant discharges untreated waste into the West Lagoon area of the lake. The proposed waste-water treatment facility would be a new land disposal system that would eliminate domestic waste-water discharge into the lake.

The population of Ismailia was estimated at 306,000 in 1985 and is projected to reach 470,000 in 1995.

Existing and Proposed Uses of Lake Timsah

Current Uses of Lake Timsah

The lake provides opportunities for recreational swimming, boating and fishing. Swimming beaches are currently on the northwest shore, south shore and north end of the lake. The lake is used for sailing, rowing and power boating with docking facilities concentrated on the north shore. Recreational fishing takes place throughout the lake, west lagoon and the drains entering the system, such as El Mahsama Drain. Total recreation use in 1987 is estimated at 750,000 - 1,000,000 recreation days with 80 to 90% of the users coming from Cairo.

Finfish, shellfish and crustaceans are harvested commercially, providing the main source of income for a number of area residents. The commercial catch in 1965 was 352 t, consisting primarily of mullet (170 t), loot (76 t) and shrimp (59 t), and the value of the catch was LE 763,800 (LE 1986).

The high aesthetic quality of Ismailia is due largely to Lake Timsah. This quality makes passive use such as walking, sitting and relaxing extremely important. The presence of a presidential retreat on the north shore also attracts attention and visitors to the area.

Finally, an important use of the lake system is the topic of this evaluation, namely, as the receiving waters for waste water generated in the area. The waste-water treatment plant discharges to the lake via El

Mahsama Drain. Raw waste water, originating from unsewered areas or overflows in the sewer system, is also discharged to the lake.

Proposed Uses of Lake Timsah

Major studies have outlined specific proposals for the future uses of the Ismailia area and Lake Timsah. These are the Ismailia Master Plan,[1] and the Tourism Development Plan for the Suez Canal Zone.[2] The Suez Canal Authority has also proposed specific future uses for portions of Lake Timsah.

The Ismailia Master Plan proposes a number of uses for the lake which are anticipated to become integral and essential elements in the future development of the city.[3] In general the plan recommends maximum utilization of Lake Timsah to promote domestic tourism and recreation.

The Ismailia Master Plan recommends use of the lake's aesthetic quality through development of walking and sitting areas to enjoy visits of the lake. Development of properties with views of the lake is proposed. This development includes day cabins, hotel sites, casinos, apartments, restaurants, and walking paths on the west bank of Lake Timsah. Potential hotel sites are identified on the west end of Chevalier Island and the west bank of the Suez Canal on the north end of the lake. The expansion of active forms of recreation including swimming, rowing, sailing, and water-skiing is recommended. Also proposed is expansion of the lake's commercial fisheries.

The Tourism Development Plan recommends extensive use of Lake Timsah for recreation and tourist-related activities. The tourism plan recommendations center on international tourism in contrast to the prime consideration given to domestic tourism in the Master Plan. The tourism plan, like the master plan, proposes the west shore of the lake for extensive development. The study calls for an international hotel and beach facilities at this location. The report considers extensive domestic and possibly international tourism and recreational development on the east bank of the lake.

The Suez Canal Authority (SCA) has proposed uses for the Lake Timsah system which could affect existing conditions in the lake.[4] The SCA is presently straightening the navigation channel through Lake Timsah. When this work is completed, the existing channels and portions of the lake will be used as an anchorage for canal traffic. The SCA also

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[1] Culpen and Partners (1976), 'Ismailia Master Plan Study" (Arab Republic of Egypt, Funded by UNDP).

[2] Ismail, Professor Dr. Hassan and Partners, et al., *Tourism Development in the Suez Canal Zone*, (Arab Republic of Egypt, United Nations Development Program, Draft Final Report, 1978).

[3] Metcalf and Eddy , 'Ismailia Waterworks and Waste Water Facilities Master Plan", (Arab Republic of Egypt, Funded by USAID 1979).

[4] Metcalf & Eddy, Vol 6, Appendix Q.

has long-range plans for constructing a new navigation channel which would bypass Lake Timsah. A navigation connection between the lake and the canal would be maintained to allow for ship anchorage in the lake and canal-related maintenance activities.

Water Quality Problems

Past investigations indicate that overall water quality in Lake Timsah is good. However, there are areas with the potential for creating both immediate and long-term water quality problems. Both the in-depth quality survey in 1978[5] and the 1986-87[6] data show several areas with fecal contamination (fecal coliform concentrations in excess of 1,000/100 ml, which is the WHO standard for contact recreation). The area of immediate concern is the northwest shore of Lake Timsah. The north and south shore, as well as the west Lagoon, are all areas with potential water quality problems given the anticipated increase of waste-water discharge.

Economic Evaluation

The economic evaluation is based on anticipated use patterns of Lake Timsah in 1995. One pattern assures building of the waste-water treatment plant and elimination of fecal contamination of Lake Timsah. As a result recreation use and tourism development will occur as anticipated by the Department of Tourism. The other pattern assumes that the plant is not built and that Lake Timsah becomes polluted to the extent that recreation activities and tourism development are discouraged. The economic benefits of the project are the differences between the two patterns.

The potential economic benefits fall into four categories: recreation use, recreation related illness, amenity value and commercial fishing.

Recreation Use

An estimate of recreation benefits must be based on the predicted level and value of recreation activities. The Department of Tourism provided their best estimates of future use of Lake Timsah for recreation. With no significant pollution of the lake, recreation use is projected to be 1,500,000 visitor days in 1995. Without the project, recreation use is projected to be 500,000 visitor days.

To value each user day, two techniques are used. The first is a simple travel cost model. The underlying idea of this technique is to use information on the amount of money and time that people have spent in getting to a recreation site to estimate their willingness to pay for the experience.

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[5] Metcalf & Eddy, Vol 6, Appendix Q.

[6] Governorate of Ismailia, Department of Health, (1987).

The application of the technique here estimates the willingness to pay on the assumption that users of Lake Timsah come from either Cairo or Ismailia. The direct costs for recreationists from Cairo for a day trip to the lake amount to roughly LE 11-12 per user (LE 4-5 for round trip transportation costs[7] and LE 6 for the value of time[8]). The direct costs for recreationists from Ismailia is zero.

The consumer surplus for recreationists without maintaining water quality in Lake Timsah is LE 3,500,000 (table 1). The consumer surplus per visit is LE 7.00. The consumer surplus for recreationists with the maintenance of water quality is LE 16,500,000 (table 2). The consumer surplus per visit is LE 11.00.

Table 1. Lake Timsah Travel Cost Calculations —Without Project

Origin	Visits	Population	Per capita visits	Travel cost
Cairo	450,000	12,000,000	0.04	11.00
Ismalia	50,000	400,000	0.13	0.00
Consumer surplus (LE):		Total	3,500,000	
Consumer surplus (LE):		Per visit	7.00	

Table 2. Lake Timsah Travel Cost Calculations —With Project

Origin	Visits	Population	Per capita visits	Travel cost
Cairo	1,400,000	12,000,000	0.09	11.00
Ismalia	100,000	400,000	0.25	0.00
Consumer surplus (LE):		Total	16,500,000.00	
Consumer surplus (LE):		Per visit	11.00	
1 US $ = LE 2.18 (June 1987)				

An alternative estimate of the value of a day of recreation may be obtained by utilizing estimates derived in the U.S. Several studies have derived reliable estimates of the average consumer surplus of a day of recreational fishing. These values range from roughly $25-to $35 per day

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[7] The round trip travel expenses range from 400-500 piasters (pt) per person. The 400 pt is based on the cost of a round trip bus ticket from Cairo to Ismailia. The 500 pt is based on travelling in a private car for 250 km at 10 pt per km with 5 people in the car.

[8] According to the Department of Tourism, 20% of the Egyptian population takes a vacation and recreation day trips from home. The average household income for this 20% of the population in 1986 is estimated at LE 3,000/year. Thus, the weekly income is LE 58.00 and the hourly income assuming 40 hours, is LE 1.45/hour. Assuming 2 hours travel time in each direction, the value of travel time is approximately LE 6.

($1982) depending on the desirability of the species sought. Evidence on the willingness to pay for swimming are less reliable, but indicators are that a day at the beach is valued at least as highly as a day of fishing.

It would be inappropriate to assert that a typical Egyptian values a beachday as much as an American because the standard of living is significantly different between the two countries.

However, a meaningful comparison can be made by relating leisure values (such as for recreation) to income. In the U.S. average weekly earnings are between $275-$300. Therefore a day of water based recreation is valued at roughly 10% of the weekly gross earnings of the average worker ($30/$287).

A reasonable assumption is that a comparable recreation experience in Egypt is valued at the same rate relative to local earnings. As indicated in an earlier footnote, the average weekly earnings for those likely to participate in recreation activities is LE 58.00. Applying the leisure value income ratio described above, a value of LE 6.10 per recreation day is derived (10.5% x LE 58.00). It is important to note that this value of a day of water contact recreation applies to all users, not just workers. Earnings have simply served as a metric by which to gauge relative values. This value is consistent with the consumer surplus value derived with the simple travel cost method under the without project scenario.

In addition, the recreation benefits should reflect more than the use value to those who recreate in Lake Timsah. There are intrinsic or non-use benefits (existence of resources in pristine conditions and bequest for future generations), due to preserving water quality. In the U.S. several studies have found that total non-use benefits amount to roughly half the recreation benefits. In a developing country such as Egypt, existence benefits are a smaller percentage of the total value of environmental improvement, due to income effects and cultural attitudes. Therefore, a reasonable assumption is that existence/bequest values would equal 10% of the recreation values. Moreover, this value applies only to the recreation benefits associated with the project given that the project would maintain satisfactory water quality in the lake.

In summary, the values for recreation use are estimated at LE 3,500,000 for the without project scenario and at LE 16,500,000 for the with project scenario. The total recreation value for the with project scenario would be slightly higher if existence/bequest values were included in the analysis.

Recreation-Related Illness

An estimate of recreation related illness must be based on the predicted level of morbidity associated with water contact and the value that individuals would pay to avoid the illness. The usual approach to an economic assessment is the indirect estimation procedure that relies on an exposure response relationship and an enhanced cost-of-illness valuation. Such data are not available for recreational related illness in Egypt. However, information is available from the U.S. that may be adjusted for Egyptian conditions and that will give estimates of morbidity and an approximate value to avoid the illness.

Studies about the relationship between water quality and enteric diseases in the U.S. date from the 1950s. The most accepted exposure response relationship relates fecal contamination to acute gastrointestinal (AGI) symptoms, such as vomiting, diarrhea, stomach-ache, and nausea. Health statistics on AGI are usually reported as enteric diseases—typhoid and paratyphoid, hepatitis and dysentery.

In order to estimate the risk of bacterial infection associated with recreational contact, the following assumptions are used:

- The attack rates observed by Cabelli[9] of 16 cases/1,000 marine exposures is increased to 20 cases/1,000 marine exposures because of high level of fecal contamination.
- Fecal concentrations at all recreation areas will exceed the 1,000/100 ml WHO standard for contact recreation.
- All 500,000 recreation days in 1995 will result in some water contact recreation.

An estimate of the potential AGI can be calculated as follows:

$$\frac{20 \text{ cases}}{(1000 \text{ exposures})} x \frac{X \text{ cases}}{(500{,}000 \text{ exposures})} = 10{,}000 \text{ cases}$$

Studies about the relationship between water quality and viral diseases (in this case skin rashes and eye, ear and nose infections) are limited in number and not of the same scientific quality as those for bacterial diseases. Given the limited available data, the Higher Institute of Health in Alexandria suggested that the rate of viral diseases is approximately one-half the rate for AGI.

Given the same general assumptions used for calculating cases of bacterial induced disease, an estimate of the potential rashes/infections can be calculated as follows:

$$\frac{10 \text{ cases}}{(1000 \text{ exposures})} \text{x} \frac{X \text{ cases}}{(500{,}000 \text{ exposures})} = 5{,}000 \text{ cases}$$

The cost-of-illness approach is the usual starting point for determining the benefits of avoiding illness.[10] However, the cost-of-illness

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[9] Cabelli, V.J., A.P. Dufour, L.J. McCabe, and M.A. Levin, "A Marine Recreational Water Quality Criterion Consistent with Indicator Concepts and Risk Analysis", *Journal Water Pollution Control Federation, (1983), Volume 55, Number 10, pages 1306-1314.*

approach understates the benefits of health protection in that it excludes pain and suffering costs. In other words, the cost of illness is a lower bound of the willingness to pay for sustained good health. Several adjustments are made here, however, in an attempt to account for this shortcoming.

First, wage earners suffering a parasitic episode are presumed to miss one week of work, implying an average loss per worker of roughly LE 58.00. Next, this figure is doubled to account for pain and suffering. Based on the Cooper and Rice findings for the U.S., direct (medical) costs for infective and parasitic diseases were roughly 18% greater than earning losses. Such medical expenses undoubtedly would be much lower in Egypt, but until better information is available, it is assumed that LE 68.45 (1.18 x LE 58.00), is the per case cost. This results in a rather liberal total of LE 184.45 per case per Egyptian worker affected (LE 58.00 in lost earnings, LE 58.00 for pain and suffering and LE 68.45 for direct medical expenditures). If one-third of the affected population are workers (including housewives and others who perform tasks for which they do not receive financial reimbursement), and the other two-thirds too young, old or for some reason unable to work, then the average value per case avoided would be reduced to LE 144.30.[11]

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[10] Cooper, B.S. and D.P. Rice, 'The Economic Cost of Illness Revisited", *Social Security Bulletin*, (1976), vol. 39, pages 21-36.

[11] (For non-workers, the value per case avoided would equal LE 58.00 for pain and suffering and LE 68.45 for medical expenditures. A weighted average of this total of LE 126.45 with the LE 184.45 per case per worker yields LE 144.30)

Table 3. Estimated Economic Benefit in 1995 With and Without the Ismailia Waste Water Treatment Plant

Benefit Categores	With Project	Without Project
Quantitative/Qualitative Estimates		
Recreation		
User days	1,500,000	500,000
Illness	Negligible	10,000 AGI 5,000 rash/infection
Amenity Value		
Rental income	Full increase in rental income for 5,000 - 10,000 units	10-25% Decrease in rental income for 5,000 - 10,000 units
Commercial Fisheries		
Net returns	Negligible	Negligible
Monetary Estimates (LE 000)		
Recreation		
User days	16,500	3,500
Illness	2,100	
Amenity Value		
Rental income	12,500 - 25,000	11,250 -18,700
Commercial Fisheries		
Net returns	—	—
Sum	31,100 - 43,000	14,750 - 22,000
Lower Bound Estimate for the Benefits 16,350		
Upper Bound Estimate for the Benefits 21,400		
1 US $ = LE 2.18 (June 1987)		

The benefit per case avoided for skin rashes and eye and ear infections would not include foregone wages because these infections would not result in lost work. Consequently, the value for case avoided is LE 126.45 (LE 58.00 for pain and suffering and LE 68.45 for medical expenditures).

Combining the cases of morbidity for the with and without project scenarios with the values per case avoided provides a basis for calculating a total health benefit for the year 1995. With the project, there would be no more parasitic infections as a result of water contact recreation. Without the project, there would be 500,000 recreation days at the lake. These 500,000 recreation days would result in 10,000 case of AGI and 5,000 case of rashes and infections. The benefit of avoiding these cases is LE 2,236,250 (10,000 case times LE 144.30 for a total of LE 1,555,000 and

5,000 cases times LE 126.45 for a total of LE 632,250). These health damages resulting under the without project scenario should be attributed to the with project scenario as a benefit because they would be avoided if the project were built.

Amenity Values

One direct valuation technique, property values studies, can provide a surrogate measure of the value of environmental amenities. Economists have conducted numerous studies of the influence or absence of pollution levels on the property markets.[12,13] With sufficient market and pollution data and use of appropriate statistical techniques, the property value approach attempts to infer how much people are willing to pay for an improvement or to prevent deterioration in environmental quality. Although data and time are not available to conduct a full scale property value study, a simplified version of the approach is used to infer willingness to pay.

The number of housing units along Lake Timsah is approximately 1,000. The potential number of housing units could be between 5,000 and 18,000 units. In the absence of alarming information about water pollution and adequate infrastructure development, the number of housing units could reach the lower bound estimate of 5,000 and might be as high as 10,000 units by the late 1990s. Approximately 24 million people are projected to live within 150 km of Lake Timsah by the year 2000. Assuming that 20% of these people take weekend vacations and that there are 5 people per household, approximately 1,000,000 households will take vacations and weekend trips. Assuming that one percent of these households maintain second homes on Lake Timsah appears to be reasonable. The approximate value of these housing units, mostly for weekend recreation activities, is estimated at LE 125,000,000 - 250,000,000 (this assumes each unit is valued at LE 25,000). The implied annual rental income is 10% of the market value, giving an annual rental income between LE 12,500,000 and LE 25,000,000.

The with project scenario assumes that all these housing units will be built and that they will achieve potential rental income. The without project scenario assumes that these units would loose between 10-25% of their rental income if the lake becomes too polluted for safe water contact recreation. The housing income would be only LE 11,250,000 to LE 18,750,000. The benefit of maintaining lake water quality would be the difference in rent between the two situations. These benefits are in addition to the recreation days because they reflect amenity values to property owner rather than recreation users.

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[12] Freeman, A. Myrick, III, *The Benefits of Environmental Improvement: Theory and Practice Baltimore (The Johns Hopkins University Press for Resources for the Future, 1979).*

[13] Brookshire, D.S., M.A. Thayer, W.D.Schulze, and R.C.d'Arge, "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches", *The American Economic Review* (1982), vol. 72, pages 165-177.

Commercial Fishing

Commercial fishing in the lake is limited and would not be significantly diminished even if the project were not built by 1995. Water quality in the West Lagoon, the current discharge point of domestic waste, would continue to serve as a large holding basin and should be able to assimilate most of the organic matter, according to the Master Plan for Water and Waste Water.[14]

Cost-Benefit Analysis

All that remains now is to sum the benefits in each category for the with and without project scenarios. The economic benefits in the with project scenario range between LE 31,100,000 and LE 43,600,000; the economic benefits in the without project scenario range between LE 14,750,000 and LE 22,200,000 (table 3). The annual benefits that could be derived from the waste-water treatment project range between LE 16,350,000 and LE 21,400,000.

The annual cost of the project is LE 18,540,000 (this sum includes the full amortization of debt and operation & maintenance). The annual cost is on the high side given the number of conservative assumptions built into the technical analysis. Changing some of the conservative assumptions could reduce the annual costs by approximately 25 per cent. The mid-point estimate of annual benefits, LE 18,875,000, exceeds the annual costs.

The project is justified on economic grounds because there is a postive cost-benefit ratio. The mid-point estimate of annual benefits, LE 18,875,000 slightly exceeds the conservative estimate of annual costs, LE 18,540,000.

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[14] Metcalf & Eddy, Vol 6, Appendix Q.

Further information may be obtained from:

Environment and Energy Branch, UNIDO
Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49

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Learning Unit 7

THE ROLE OF GOVERNMENT IN INDUSTRIAL ENVIRONMENTAL MANAGEMENT

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

Additional Course Material

Video: *Development and the Environment: A New Partnership,* a film by the World Bank

Introduction

Ecologically Sustainable Industrial Development cannot be achieved through the efforts of industry alone. It requires the participation of all sectors of society. Governments play a major role through their laws, regulations, taxation systems and a great variety of other activities. Learning Unit 7 reviews the most important environmental management activities that Governments pursue, discusses how these can be used to promote Cleaner Production and examines the barriers that Governments may encounter in promoting Cleaner Production in developing countries.

Objectives

The specific learning objectives of this unit are as follows:

- To present the rationale for government intervention in industrial environmental management.
- To describe the basic features of a command-and- control regulatory programme.
- To introduce complementary approaches to regulation.
- To discuss innovative measures Governments can take to promote Cleaner Production.
- To recognize the difficulties of Government intervention in promoting Cleaner Production in developing countries.

Key Learning Points

1 Government intervention is necessary to eliminate market and policy failures that encourage excessive resource use and pollution intensity.

2 Government environmental management activities include:

- Establishing regulatory programmes.
- Developing environmental plans and adopting appropriate national policies.
- Collecting environmental data and disseminating information.
- Participating in international environmental agreements.

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3 Traditional command-and-control regulatory programmes require four government activities: establishing standards, issuing permits, monitoring compliance and enforcing regulations.

4 Multimedia command-and-control regulations (those covering air, water and land discharges simultaneously) can promote the least-cost solution to reducing pollution, increase the ability of industry to set priorities, simplify administrative systems and promote more effective cooperation with other policy sectors.

5 Governments can use monetary and fiscal incentives to encourage pollution reduction. Possible programmes include pollution charges, marketable permits, subsidies and deposit refund programmes.

6 Governments can use siting and relocation policies to ensure that industrial activities do not locate in environmentally sensitive areas (high density of human population, critical wetlands, cultural sites etc.) and to encourage industry to locate in industrial estates, where they can benefit from common systems for waste-water treatment and waste disposal.

7 Some of these actions promote Cleaner Production directly, some promote it indirectly; others may actually discourage the introduction of Cleaner Production.

8 Many Governments are formulating national environmental plans and/or policies that integrate industrial development and environmental considerations.

9 To promote the collection of more reliable and consistent environmental data, UNDP and the World Bank are promoting the development of an environmental accounting framework that will be compatible with the national income accounts complied according to System of National Accounts (SNA) of the United Nations.

10 At the international level, Governments have recognized that many environmental problems have regional and global significance, and they have developed several agreements designed to reduce industrial pollution across international borders. These include:

- The Montreal Protocol.
- The Basel Convention.
- The United Nations Framework Convention on Climate Change.

11 Governments need to combine these various actions—sustainable development strategies (based on meaningful environmental data), envrionmental regulation (command-and-control programmes, economic incentives and locational policies), Cleaner Production programmes and international agreements—in a manner that is responsive to their environmental problems and sensitive to their institutions and culture. There is no one combination of actions that is best for all countries.

12 The key issue in developing countries is government ability to implement new environmental programmes. This depends upon many things, including the state of the country's infrastructure, the relative power of government and industry, political priorities and the availability of environmental expertise.

Suggested Study Procedure

1 Take the test in the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.

2 Work through the *Study Materials*, including the *Reading Excerpts* and the video. Prepare answers to the questions and check your answers against those suggested.

3 Read the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

4 Complete the exercises in the *Review*.

Study Materials

The traditional role of Government in environmental management has been to develop and enforce regulations requiring some degree of pollution reduction. Such activities have resulted in a significant reduction in pollution, but the cost has often been very high and many times the regulations have discouraged the use of Cleaner Production techniques. Now, the attention of the international community is turning towards finding ways in which Governments can promote Cleaner Production.

The Environmental Actions of Governments

Pollution intensity increases when organizations that use resources ignore or underestimate the cost of the resulting damage to the environment.

The appropriate role of Governments is to eliminate the market failures and policy failures that cause the difference between what the polluter pays and the full cost of using environmental resources:

- Market failures occur because environmental resources (air, water, soil) are often treated as free goods or as common property and are overutilized or indiscriminately polluted.
- Policy failures occur when Government policies promote the excessive use of resources, which in turn causes environmental damage. Examples include subsidies for energy and water use and tax policies (accelerated depreciation) that favour end-of-pipe technologies over pollution prevention.

Essential activities to be undertaken by Governments in industrial environmental management are as follows:

- Using command-and-control regulations and economic incentives to force industry to internalize the costs of damaging the environment, thereby making the polluter (and ultimately the consumer) pay.
- Developing environmental plans and adopt policies that encourage industry to use environmental and natural resources appropriately without adversely affecting productivity.
- Undertaking or sponsor environmental research.
- Collecting and disseminating meaningful data on industrial pollutant emissions and their effects on human health and the environment so as to create public awareness about the problem and a demand for environmentally benign products and services.
- Participating in international agreements designed to reduce industrial pollution that crosses national borders.

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Command-and-Control Regulation

The role of environmental regulations is to modify industry's behavior in order to reduce the environmental damage associated with industrial production. In environmental jargon, direct regulatory programmes are often called command-and-control programmes.

Effective command-and-control regulatory programmes do four things:

- They establish standards for industry that specify the required pollution control activities or the permitted amount of pollutant discharges.
- They issue permits that specify the environmental requirements for each industrial plant or location.
- They monitor the compliance of industry with the permit requirements. This may be done through self-monitoring by the industrial plant, independent inspections, citizen complaints and/or ambient monitoring.

- They enforce permit conditions with informal, administrative, civil and criminal sanctions. Without enforcement, some industrial plants will not comply with the regulations. If this situation becomes too common, there will be general non-compliance, and the regulatory programme will be ineffective.

Environmental standards may be defined in three ways:

- Technology-based standards require industry to reduce pollutant discharges based on the expected performance of the available technology but do not consider the effects on the environment. Government regulators usually prefer technology-based standards because they are easy to administer. Industry usually finds them too expensive for the results achieved.

- Ambient-based standards require industry to reduce pollutant discharge to the extent necessary to achieve a defined ambient concentration level or condition; they do not consider costs. Government regulators find the procedures to link industrial pollution discharge to ambient standards and also assigning responsibility for violations to individual sources difficult and costly . Industry likes ambient standards because they direct scarce resources to the more serious problems.

- Between these two extremes are benefit-based standards. These require industry to reduce pollutant discharges only to the extent that there would be a reasonable balance between the benefits and the costs of the measures. Government regulators find it difficult to set benefit-based standards because of the need for extensive data collection and analysis. Industry encourages this type of standard.

One criticism of the traditional command-and-control regulatory approach is that its single-medium emphasis (air or water or land) can generate new environmental problems:

- The successful reduction of local air and water pollution problems has often contributed to waste problems on the land; pollutants removed from the air and water have been dumped into landfills and ponds.

- Solving air pollution problems in local areas by building tall stacks (dilution) has led to acid deposition in distant areas. As a result, in the 1990s more countries are expected to make organizational and legislative changes that will enable institutions to adopt a multimedia approach to environmental management.

There are several arguments for a multimedia approach to command-and-control regulations:

- Industry can choose the least-cost solution. Engineers find that an integrated approach to reducing all releases from a factory is likely to be less costly than dealing with releases to each medium.

- Priorities can be set. An integrated approach allows environmental risks to be compared with the costs of pollution reduction. It allows scarce resources to be assigned to the problems with the greatest potential for damage reduction.

- Administrative systems are simpler. An integrated approach requires only one permit covering all media. The follow-up monitoring and enforcement for all media can be done at one time.

- Cooperation with other policy sectors is promoted. An integrated approach makes a convincing argument that all sectors (energy, agriculture, transport and manufacturing) are sources of industrial-related pollution problems and that all relevant ministries must work together to solve these problems.

Imposing command-and-control regulations on an industry is an adversarial process that often involves substantial legal costs and many delays. If industry representatives are willing to cooperate, Governments may be able to negotiate voluntary agreements. A voluntary agreement is a pledge by industry to meet environmental goals acceptable to the Government. Voluntary agreements work best in industrial sectors with relatively few but relatively large firms.

Not all command-and-control regulations or voluntary agreements promote Cleaner Production.

- Technology-based command-and-control regulations that specify end-of-pipe treatment may actually discourage a Cleaner Production approach.
- Command-and-control regulations that allow industry latitude in choosing least-cost solutions are more likely to promote Cleaner Production.

Economic Incentives

Although command-and-control regulation has considerably reduced the amount of some pollutants, it is criticized for being economically inefficient and difficult to enforce. It can lead to distortions in the price structure and the misallocation of resources.

An OECD survey of economic instruments, published in 1989, states that a central feature of such instruments is "the use of monetary incentives or disincentives to improve the environment directly or indirectly".

Economic incentive policies that can reduce pollution include:

- Pollution charges. Governments establish a fee or tax on pollutants but allow the level of pollutant discharge to vary. Common forms of such charges are effluent or emission fees applied to direct pollutant discharge and user charges paid by plants that discharge their wastes into public treatment works.
- Tradeable permits. Governments establish a limit on the level of pollutants that can be discharged with each permit issued. The permits become marketable property rights, tradeable among parties. The price of a permit is allowed to fluctuate according to market conditions.
- Subsidies. Subsidies can take various forms, including grants, below-market-rate loans and accelerated depreciation. Although these inducements provide an economic incentive to reduce pollutant discharges, they violate the polluter-pays principle and, in the case of grants, create a bias towards overbuilding pollutant reduction facilities.

- Enforcement incentives. These are usually fees charged for failing to comply with the conditions in a discharge permit. The automatic assignment of fees avoids time-consuming negotiation with polluters. Non-compliance fees are not true economic incentives in that they are not voluntary, non-coerced actions like those found in private markets.

Economic incentives can:

- Promote least-cost solutions for solving environmental problems.
- Stimulate the development of pollution prevention and control technology and expertise in the private sector.
- Provide Governments with a source of revenue to support pollution prevention and control programmes.
- Provide flexibility in the choice of pollution prevention and control technology.
- Reduce the amount of paperwork associated with environmental regulations.

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Locational Policies

Policies for the siting and relocation of industry should take into account regional balance, the availability of energy and raw materials and local and regional aspirations. Such policies can minimize environmental damage by prohibiting the siting of industry in, for instance, densely populated areas, wetlands and other animal habitats or historical sites.

Locational policies can also minimize environmental damage by encouraging industries, particularly small and medium-size industries, to locate on industrial estates, where it is possible to provide reasonably priced disposal of wastewater with common treatment systems and solid/hazardous wastes with collection and recycling/disposal systems.

Locational policies that promote industrial free zones and export processing zones can require compliance with environmental regulations as a condition for obtaining and retaining operation permits and receiving tax advantages.

Other Policies Towards Industry

Many Government policies other than environmental regulations and economic incentives can be used to encourage environmentally responsive behaviour.

Many Governments are privatizing State-owned industries. Committments to Cleaner Production strategies can be included in the negotiations that precede this privatization. Privatization itself may make it easier to enforce environmental regulations, because environmental authorities often find that they have more legal and political influence over privately owned industry.

A powerful tool for stimulating environmental responsibility is the adoption of stricter liability laws for environmental damages. The spectre of long-term and unlimited liability for products and wastes has spurred many companies to adopt Cleaner Production techniques in order to minimize their future liability.

Many Governments now provide electric power, water and other resources to industry at subsidized prices. This encourages waste and promotes environmental pollution. Simply setting prices to reflect the full cost of these resources can do much to promote Cleaner Production. Ideally, resource prices should reflect not only direct costs but also the costs of environmental damages.

Requiring industry to disclose information about its emissions of pollutants and its generation of hazardous wastes heightens public awareness and creates a powerful stimulus for industry to improve its public image by adopting Cleaner Production.

Many Governments and even NGOs are initiating "eco-labelling" programmes to designate the most environmentally benign products. Eco-labelling is designed to stimulate consumer awareness, encourage the development of cleaner products and provide an objective basis for environmental claims in product marketing.

Ideally, Governments should examine all of their policies towards industry to ensure that they promote Cleaner Production as well as industrial development. In formulating these policies, Governments should do the following:

- Clearly define environmental policy objectives.
- Assess the environmental consequences of existing sectoral policies and development plans.
- Formulate alternative policies and development scenarios at the subsectoral level that would take into account growth, efficiency, equity and ecological sustainability.
- Devise command-and-control regulations, economic incentives and other appropriate policy instruments that would promote Cleaner Production.

Next Steps

1 Read "Making better decisions: information, institutions, and participation", included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 **What are three essential government functions for environmental management?**

2 **What are five main requirements for policy implementation?**

3 **What are three lessons learned from the Japanese success in curbing pollution?**

4 **What are the main advantages of involving local people in the environmental regulation of industry?**

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Answers

1. Setting priorities and formulating policies; coordinating and planning; and regulating and enforcing.

2. A clear legislative framework, an appropriate administrative structure, technicals skills, adequate money and decentralized responsibility.

3. Establishing a national environmental policy framework, negotiating agreements at the local level and allowing flexibility in setting emission levels and promoting self-regulation.

4. They give regulators an understanding of which environmental problems are important, they can help in implementing environmental regulations and they can help resolve conflicts between industry and adversely affected parties.

Next Steps

1 Look over the questions below so that you have some idea of what you want to learn from the video.

2 Watch the video *Development and the Environment: A New Partnership*.

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

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1 How can and do environmental problems undermine the goals of development?

2 What are the environmental priorities in developing countries?

3 What is the primary cause of overexploitation of the environment?

4 How is economic development associated with environmental problems?

5 Why must Governments play a role in environmental management?

6 List some policies that can harness the positive links between environment and development.

7 List some policies that can break the negative link between environment and development.

Answers

1. *Environmental problems undermine the goals of development by offsetting welfare gains with the costs that pollution imposes on health and the environment and by reducing the future productivity of soils, aquifers and ecosystems.*
2. *The environmental priorities are clean water and air, sanitation, the protection of soils and the protection of forests and other natural habitats.*
3. *The primary cause is the undervaluation of some resources like water. The value of other resources, such as metals, minerals and energy, is reflected to a great extent in market prices.*
4. *Some environmental problems are associated with the lack of economic development: inadequate sanitation and clean water, land degradation etc. Others are associated with unconstrained economic development: industrial and energy-related pollution, deforestation due to commercial logging and the overuse of water.*
5. *Governments must play a role in environmental management because very often the market system results in a misallocation of environmental resources (public goods), leading to overutilization and indiscriminate pollution.*
6. *Many policies that are good for the efficiency of the economy are also good for the environment (sometimes called win-win policies). Examples are the removal of energy subsidies, the clarification of property rights, education and the effective valuation of natural resources.*
7. *Some policies are needed to change behaviour even after all the win-win policies are in place (a win-win policy is one that builds on the positive links between development and the environment and at the same time breaks the negative links). These policies include targeted regulation and incentives, improved knowledge of environmental and economic trade-offs and accountable institutions.*

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Government Actions to Promote Cleaner Production

Government actions can encourage Cleaner Production, either directly or indirectly, or they can discourage it. When reviewing environmental management policies and programmes, it is important to examine whether they will provide incentives to adopt Cleaner Production techniques.

Government actions that directly encourage Cleaner Production include:

- Laws and regulations that assign priority to pollution prevention over end-of-pipe treatment.
- Negotiated environmental compliance procedures that encourage waste minimization.
- Full pricing of energy, water and raw materials.
- Privatization of public-sector enterprises, or at least privatization of their management.
- Providing information on waste minimization techniques.
- Funding of Cleaner Production demonstrations.
- Government procurement of cleaner products.

Government actions that, by requiring pollution reduction, indirectly encourage Cleaner Production include:

- National strategies for sustainable development (Agenda 21) that realistically address industry as well as other sectors.
- Effective environmental regulatory programmes (standards, permits, monitoring, compliance and enforcement activities with sufficient technical and financial support).
- An appropriate balance between centralized and decentralized regulatory activities.
- Economic incentives applied to pollutant discharges.

- Multimedia (air, water and land) rather than single-medium permitting of individual industrial sources.
- Publication of information on the release of pollutants by individual industrial facilities (pollutant release inventories).
- Publication of data on the effects of pollutant discharges on human health and the environment.

Government actions that discourage Cleaner Production include:

- Subsidies for the use of energy, water and other resources.
- Tax concessions (e.g. rapid depreciation) for waste-treatment investments.
- Import restrictions that favour indigenous end-of-pipe technology.

Questions

1 How does the full pricing of energy or water promote Cleaner Production?

2 How do multimedia permits encourage Cleaner Production?

3 How does privatizing State-owned enterprises promote Cleaner Production?

Answers

1. When resources are priced at their full cost, there is more incentive to conserve them and a greater penalty on waste.

2. Multimedia permits allow industry the most flexibility in determining how to reduce pollution.

3. Privately owned enterprises tend to be more efficient and less wasteful because they have a greater motivation to make a profit and are subject to the external disciplinary force of the market.

Sustainable Development Strategies

Many developed and developing countries are preparing national sustainable development strategies (often called action plans or policy plans). Some were started a few years ago and others are being initiated as a result of countries preparing national reports for UNCED.

The purpose of a national sustainable development strategy is to integrate environmental considerations into a nation's overall economic and social development plans and to promote a comprehensive and consistent national environmental policy.

Some of the central elements of a national sustainable development strategy are the following:

- Quantitative targets, e.g. a reduction of particulate emissions to a certain number of tonnes.
- Dates on which these targets will be met.
- Specified actions on the part of all sectors (agriculture, transport, industry, utilities, construction, commerce etc.).
- Financial and economic implications of the specific actions.
- Clarification of the roles and responsibilities of Government ministries and of central versus local or provincial levels of Government in monitoring and enforcing specific actions.

As an example, the National Environmental Policy Plan for the Netherlands includes the following:

- Environmental problems, with trends extrapolated.
- Principles of environmental management, including polluter pays and pollution prevention.
- Environmental goals for the year 2010, with quantified targets.

- Alternative scenarios for meeting targets and their economic implications.
- Principal features of the policy for 1990-1994 with regard to the major environmental issues such as climate change, acidification, eutrophication and toxic chemicals.
- Specific actions required of target groups, including agriculture, transport, industry and consumers.

Next Steps

1 Read "Highlights of the Dutch National Environmental Policy Plan", included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 As described in the National Environmental Policy Plan of the Netherlands, what are the five levels of pollution that affect each other?

2 Explain the major goals of the Plan at the global level.

3 Explain the major goals of the Plan at the local level.

4 What negative environmental impacts of traffic and transport were identified in the Plan?

5 What are the main proposals of the Plan for the energy sector?

Answers

1. Local, regional, fluvial, continental and global.

2. There were two: stopping the growth of the production of climate-influencing substances and stopping, before the year 2000, the emission of substances that damage the ozone layer.

3. Sharp reductions in emissions of hazardous substances and in noise and odour production.

4. Traffic and transport have negative consequences for the landscape and nature and also account for a large share of the consumption of energy and raw materials.

5. There were four main proposals:
Public information and subsidies to stimulate energy conservation and the use of renewable energy sources.
Establishment of systems of environmental concern in energy firms.
Reduced emissions of sulphur dioxide and nitrogen oxides from electric power plants.
Increased cogeneration of electricity and heat.

National Accounts

To identify polluters and assess improvement or deterioration in the environment, a country needs reliable and consistent data. Data on current emission levels and ambient conditions is necessary if a Government is to develop an efficient strategy for meeting environmental objectives.

Currently, data in most developing countries are collected in a piecemeal manner. Leading research centres and institutions like UNDP and the World Bank are proposing that environmental data be put into an accounting framework compatible with the national income accounts compiled according to the System of National Accounts (SNA) of the United Nations.

There are two approaches to preparing national environmental accounts, one in physical terms and the other in monetary terms. The advantage of the physical approach, as exemplified by Norwegian and French efforts, is that is it easier to implement and does not require the monetary valuation of environmental goods and services. The advantage of the monetary approach is that it contains more information; however, it is difficult to implement and there still remain conceptual issues to be resolved.

The Statistical Office of the United Nations is attempting to integrate these two approaches in a System for Integrated Environmental and Economic Accounting. The proposal starts with the well-established SNA and adds a separate system to account for natural resources and the environment.

This effort is important from a Cleaner Production perspective because it is attempting to provide a better estimate of the progress in achieving sustainable development. It suggests that a welfare measure of sustainable development should be adjusted to account for defensive measures against pollution, the monetary value of environmental damages and the depreciation of man-made and environmental capital.

In any one country, whether it is environmental degradation or the depletion of natural assets that is causing the greater economic loss depends on many cultural, political, economic and industrial factors.

Next Steps

1 Read "Accounting for environmental effects at the national income level", included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 Give two criticisms of GDP as a measure of welfare or national prosperity.

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2 What are the advantages and disadvantages of the physical and the monetary approach to preparing national environmental accounts?

Answers

1. Natural assets are not valued and their loss entails no charge against current income. Remediation expenses are accounted for as increases in national income and products despite the fact that they should be considered as a maintenance cost to society rather than as social progress.

2. The physical approach is easier to implement and does not require the monetary valuation of environmental goods. The monetary approach contains more information, but it is difficult to implement and still some issues remain unsolved. It can also be linked to other SNA accounts.

International Government Agreements

Some environmental concerns can be resolved only by concerted action on the part of several or many nations:

- Some concerns are regional in nature because several countries share a common resource and one country's action affects other countries. Examples of transboundary pollution are acid rain and the managment of international rivers or regional seas.

- Other concerns are global in nature because all countries share the atmosphere and the deep oceans and their actions affect, to some extent, the global resources. Examples of such problems are global warming owing to the emission of greenhouse gases and thinning of the ozone layer owing primarily to the emission of CFCs.

Resolving international environmental issues is more complicated than resolving national environmental issues, for two reasons:

- The international legal system differs from national legal systems in that there is no central authority, no central monitoring body and no central court to enforce agreements.

- International solutions to global and regional environmental problems must accommodate large variations in the balance of the benefits and costs to different countries and in their ability to pay these costs. Thus, for rich countries to secure action on problems mainly of concern to them, they must begin to pay the poor countries to take actions.

Several recent international agreements are directly related to Cleaner Production. The Vienna Convention and the Montreal Protocol both deal with the depletion of the ozone layer, the Basel Convention deals with the international movement of hazardous wastes, and the United Nations Framework Convention on Climate Change aims to stabilize worldwide emissions of greenhouse gases.

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The Vienna Convention for the Protection of the Ozone Layer (1985) is a general agreement on information exchange and research on ozone-depleting substances. Its follow-up, the Montreal Protocol on Substances that Deplete the Ozone Layer (1987), sets limits for the production and consumption of the damaging CFCs and halons in order to curb levels of chlorine and bromide reaching the stratosphere and damaging the ozone layer. Some important features of the Montreal Protocol are as follows:

- The Montreal Protocol calls for periodic reviews of production and consumption targets. Three reassessments have taken place: the London Amendments (1990), the London Adjustments (1991) and the Copenhagen Amendments and Adjustments (1992). Amendments add new ozone-depleting substances and require a new ratification by each country. Adjustments change the scope, timing and amount of control for already regulated substances and occur as a result of a simple decision of the Parties.

- The ozone-depleting substances now controlled are CFCs, halons, carbon tetrachloride, trichloroethane and methyl bromide.

- The Parties agreed in London to eliminate completely the production and consumption of CFCs and halons by January 2000, with a 50 per cent cut by January 1995 for both these substances and an 85 per cent cut by January 1997 for CFCs. Carbon tetrachloride should be phased out by the year 2000, with an 85 per cent cut by January 1995. Trichloroethane has a slightly more lenient phase-out schedule (because of widespread use), with a 30 per cent cut in 1995, a 70 per cent cut by January 2000 and a full phasing out by 2005. The Parties agreed in Copenhagen to add methyl bromide to the Protocol and to freeze production at 1991 levels by 1995. In addition, they agreed that industrialized countries would phase out halons, used in fire-fighting, by January 1994 instead of January 2000; trichloroethane, used in cleaning metals, by January 1996 instead of January 2000; HCFCs, a less damaging substitute for CFCs, by 2030 and carbon tetrachloride by January 1996 instead of January 2000.

- Developing countries with a consumption of the originally controlled substances (five CFCs and halons) of less than 0.3 kg per capita (the "Article 5" countries) are given a 10-year grace period to comply with control measures.

A specific multilateral fund was added in 1990, through which non-Article 5 countries (developed countries) are obligated to pay the incremental costs for Article 5 countries to eliminate the use of ozone-depleting substances.

- No Party to the Protocol is allowed to sell any of the controlled substances to a non-Party country or to import them from such a country.
- Chemicals that are imported in ready-made products, e.g. in aerosol cans or air-conditioning equipment, are not counted against a country's target. In other words, it is the country where these products are produced that is responsible for finding alternatives to controlled substances.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) aims to control the transboundary movement and disposal of hazardous wastes. It has five main goals:

- To minimize the generation of hazardous wastes.
- To reduce transboundary movements of hazardous wastes.
- To achieve self-sufficiency in hazardous waste disposal at national levels.
- To create a system of informed consent between waste exporting and importing countries before wastes are shipped.
- To end all exports and imports of hazardous wastes to or from non-Party States unless some other bilateral agreement exists.

The United Nations Framework Convention on Climate Change (1992) aims to stabilize greenhouse gas concentrations at a level that would prevent dangerous interference with the world's climate. Some important provisions of the Convention are as follows:

- All countries are to prepare inventories of emissions and to formulate, implement, publish and regularly update programmes containing measures to mitigate climate change.

- Developed countries "shall adopt policies [which limit] anthropogenic emissions" and report to the Conference of Parties detailed information on these measures "with the aim of returning [emissions] individually or jointly to their 1990 levels".
- Developed countries are committed to meeting the "agreed full costs" of analysis and publication of developing country abatement programmes.
- Developed countries are committed to meeting the incremental costs of developing country emission stabilization programmes as agreed with donors, initially through the Global Environmental Facility.

According to the *International Environment Reporter* on 12 August 1992, "Despite these uncertainties [funding and emission targets], the clear statements of funding responsibilities, the emphasis on the need to adopt policies and the interim 'goal' which must be revisited make the commitments section much stronger than the Vienna Convention ..., which left almost everything to the Montreal Protocol..., signed two years later".

Next Steps

1 Test your comprehension of the information by answering the questions that follow.

2 Compare your answers with those suggested.

Questions

1 Explain why some environmental problems can be resolved only by international government actions.

2 Give some examples of international pollution.

3 What environmental problem does the Montreal Protocol address?

4 What are the main goals of the Basel Convention?

Answers

1. *Some concerns are regional in nature because several countries share a common resource and one country's action affects other countries (e.g. acid rain). Others are global in nature because all countries share environmental resources (e.g. the atmosphere).*

2. *Acid rain and other air pollutants migrating across national boundaries.*
   Shipments of hazardous wastes between countries.
   Pollution of rivers that flow through many countries.
   CFCs destroying the ozone layer.
   Greenhouse gases contributing to global climate change.

3. *Destruction of the earth's ozone layer by CFCs and other pollutants.*

4. *To minimize the generation of hazardous waste, to reduce transboundary movements of hazardous waste and to achieve self-sufficiency in hazardous waste disposal at national levels.*

Barriers to Effective Government Action

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One barrier to effective government action is a political economy characterized by the following conditions:

- A rich and powerful segment of society that benefits from exploiting natural resources and polluting environmental resources. This segment often impedes the setting of economically appropriate prices for water, energy and raw materials and the enforcement of enviromental regulations.
- Urgent, short-term financial needs that distract Governments from making and adhering to long-term commitments needed to resolve environmental issues.
- Public sector industries that waste water, energy and raw materials, causing high levels of pollution, and that are exempted from environmental regulatory requirements.
- Military installations and agriculture that are exempted from environmental regulations.
- A poorer, disadvantaged and vulnerable segment of society that suffers the most from environmental degradation but lacks the political influence to bring about change.

Another barrier is information gaps and deficiencies caused by the following constraints:

- Limited data on the nature and extent of environmental degradation (physical indicators of resource depletion as well as air, water and land pollution).
- Limited understanding of the proximate and underlying causes of, and hence feasible remedies for, environmental degradation.
- Insufficient measurement of economic losses resulting from environmental degradation.

Another barrier is an ineffective public sector characterized by:

- An inability to formulate policies that require setting priorities, coordinating activities and resolving conflicts.
- An inability to translate policies into laws and build administrative structures to carry out the laws. One of the difficulties is a shortage of skilled manpower owing to poor salaries in the public sector and an overall absence in the country of the necessary professional skills; another is insufficient financial resources.
- An inability to decentralize and delegate responsibilities to local levels of government, which are usually in the best position to carry out specific duties. There is an even greater shortage of financial resources and skilled manpower at this level.
- An inability to overcome strong regional governments.

Another barrier is a business community that is not supportive of Cleaner Production, for the following reasons:

- The business community is not convinced of the financial and socio-economic advantages of reducing environmental degradation.
- Even where it is convinced, capital is scarce and expensive, which precludes Cleaner Production changes that are financially attractive but require an initial investment.
- Most industrial enterprises are small and lack the information and skills to carry out changes.

Next Steps

1 Read "Barriers to ecologically sustainable industrial development", included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

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Questions

1 What are some of the four main barriers to effective government actions to promote Cleaner Production?

2 What are the difficulties of achieving ESID in developing countries?

Answers

1. Adverse political-economic circumstances;
Information gaps and deficiencies;
An ineffective public sector;
A reluctant business community; and
Limited capacity to absorb Cleaner Production processes owing to the lack of technical and scientific capacity.

2. All the barriers mentioned above plus indebtedness, which results in shortages of capital needed to finance Cleaner Production processes.

Additional Suggested Readings

This concludes the study section of Learning Unit 7. For additional information on Government actions to promote environmental management, you may refer to the following sources.

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Case Studies

Next Steps

1 Think about the questions raised in each of these *Case Studies* and prepare answers to the questions, preferably working in a small group.

2 Compare your answers with those suggested.

Case Study 1: Industrial Monitoring

You are visiting a national environmental management authority and observe that they do not have data on pollutant discharge from large industrial sources. When you suggest that a monitoring programme is an essential part of a successful environmental regulatory scheme, the national en- vironmental management authority says that it does not have the necessary trained manpower or the equipment for such an effort. What three suggestions could you make?

Answer

The authority could apply to the United Nations and to bilateral agencies for support for a training programme and for equipment for the more routine analyses. It should ask the group in the country with the best monitoring programme (there usually is at least one that has received significant support from external donors) to provide a training course in data acquisition and processing. Alternatively, it could require that industry monitor itself, reporting to the national authority and verifying its samples with an independent body at least once a year.

Case Study 2: Air Pollution Tax

Given the current interest in economic incentives, a parliament proposes to institute a tax on conventional air pollutants. What do you think would be the reactions of the national environmental authority and of industry associations? How would you respond to their reactions?

LU7

Answer

Environmental authorities would object. They usually prefer a regulatory regime that requires the installation of equipment, because in this regime, there is a visible sign of environmental management. It would also object that such a tax would allow for the release of toxic air pollutants. Industry would object because it would see the tax as just another form of taxation that puts them at a competitive disadvantage.

A reply to the environmental authority would be that it could experiment with such a tax system in one area of the country to see how it would work, limiting it to conventional pollutants, such as dust and SO_X and maintaining emission limits for toxic pollutants. Also, it should be pointed out that a regulatory regime requires more enforcement. A reply to industry would be that funds collected should be used to subsidize loans for the installation of pollution control equipment and for pollution prevention programmes.

Case Study 3: Sustainable Development Strategy

The head of an environment authority opposes the preparation by the Government of a national sustainable development strategy similar to the Dutch National Environmental Policy Plan. He or she says that the authority is in and of itself able to ensure environmental quality in the country. What is your response?

LU7

Answer

You could start out with one of the main themes of Our Common Future*: many countries now recognize that environmental management authorities cannot by themselves achieve environmental goals and that the leading forces of development (agriculture, industry, transport) must take a proactive role in environmental protection.*

You should document the magnitude of the environmental problems caused by these sectors and point out policy failures, such as the subsidized (or even mandatory) use of pesticides, which is unnecessarily degrading water quality, and subsidized electricity prices, which are causing industry to use more electricity than needed and thermal power plants to generate more pollution than necessary.

Case Study 4: Environmental Reporting

A ministry of environment has issued a new regulation requiring large companies to report annually on their use of resources (water, raw materials) as well as all discharges to air, water and soil. What do you think will be the reaction of industry and the public to this requirement? How might the ministry respond to these reactions?

LU7

Answer

Industry will object that such reporting is too time-consuming and would not produce any useful results. You could point out the experience in other countries, where industry was surprised by the results of the inventory and as a result instituted cost-saving measures that are cutting down on the use of resources and pollutant discharges.

The public will not object at first but will react adversely when they find that they are being exposed to any high levels of pollutants. The ministry should prepare a public outreach programme explaining that even though there are pollutant releases, they are not violating health standards (if that is the case.

Case Study 5: Enforcement Against Small Businesses

The chairman of a national environmental management agency has received complaints from a community in which 90 small tanneries are generating obnoxious levels of water pollution. When the chairman approaches the small tanners, they say they cannot afford to install pollution control equipment and that in any case there is no space in their plants for such equipment. How would you advise the chairman to proceed in this situation?

LU7

Answer

You could suggest that the chairman should contact the tanners' association and propose the building of a common waste-water treatment facility that would collect and treat the wastes from all the tanneries. Common waste-water treatment facilities have several advantages: they entail very low cost for any one tanner, they solve the space problem and they need to use household organic wastes to work properly. The last-mentioned advantage would allow the tanners to make a positive contribution to the neighborhood by offering to treat household wastes. UNIDO can provide designs for several common waste-water treatment facilities in developing countries.

In addition, the chairman could point out to the tanners the economic advantage of recovering the chromium that they are now discharging. Several tanneries in developing countries have installed chromium recovery units that have a financial payback period of less than two years.

Case Study 6: Enforcement Against Government-Owned Enterprises

In response to severe adverse international publicity, the government of a large city in a developing country resolved to enforce strictly the existing environmental regulations for the discharge of hazardous waste into the harbor. The river and harbor area had been severely polluted for over 20 years by discharges from chemical factories owned by the city government. The companies protested vigorously and suggested that if the regulations were now enforced, the factories would have to close, causing a loss of production, a loss of thousands of jobs for city workers and a loss of profits for the city government. What do you think the city government did?

LU7

Answer

Short-term enforcement was recognized as unrealistic. Longer-term planning was initiated. The city arranged with the companies to discharge only at night and only when the tide was going out. Thus, no public pollution discharge was evident.

Case Study 7: State-Owned Enterprise

The chairman of the national environment authority is threatening a State-owned fertilizer plant with legal action if it does not control its NO_x emissions. Why do you think that the plant is resisting the request of the chairman and what suggestions might you make to him?

Answer

The State-owned fertilizer plant must sell its product at a fixed price that does not cover its variable cost of production, so it does not have the funds to install the necessary pollution control equipment. The chairman should work instead with the ministry that is setting the price of fertilizer in order to make the funds available for environmental management. He or she should ask the fertilizer plant to investigate pollution prevention options as a means of reducing NO_x emissions, because such measures tend to be less costly than pollution control measures.

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Review

Test ✓

The following test will help you review the material presented in this Learning Unit.

1 The concept of market failures in environmental management refers to

a. State ownership of enterprises
b. Subsidies for energy use
c. Accelerated depreciation for pollution control equipment
d. Treating environmental resources as free goods

2 An example of policy failure in environmental management is

a. Absence of environmental laws
b. Subsidies for water use
c. Absence of a national environmental action plan
d. Subsidies for building municipal waste-water treatment plants

3 One essential environmental management activity that needs to be undertaken by Governments is

a. Support for environmental NGOs
b. Tax credits to industry for installing pollution control equipment
c. Collection and dissemination of environmental data
d. A ministerial appointment for the head of the environmental management agency

4 An effective command-and-control regulatory programme requires

a. Issuing discharge permits
b. Monitoring compliance
c. Enforcing permit conditions
d. All of the above

5 Ambient-based environmental standards require industry to

a. Install the best practicable technology
b. Conduct environmental compliance audits
c. Reduce pollutants to meet water quality standards
d. Inform workers of the level of pollutants in a factory

6 A multimedia approach to environmental management means

a. Using both command-and-control regulations and economic incentives
b. Documenting pollution problems with a video film
c. Using both self-monitoring and independent inspections to ensure compliance
d. Simultaneously regulating pollutant discharges to air, water and soil

7 Economic incentives include all of the following except

a. Effluent taxes
b. Marketable permits
c. Corporate income taxes
d. Deposit refund schemes

8 Economic incentives can

a. Promote least-cost solutions
b. Provide flexibility in pollution control technology
c. Stimulate the development of technology
d. All of the above

9 An essential component of a national sustainable development strategy is

a. Funding environmental research
b. Signing of international protocols
c. Reducing pollutants in all sectors (agriculture, industry etc.)
d. Qualitative targets to be met at some unspecified time

10 One limitation of the United Nations System of National Accounts is that they do not include data on

a. Exports and imports
b. Government spending
c. Environmental damages
d. Consumption

11 One approach to including the depreciation of environmental capital in the System of National Accounts is based on

a. Quantitative estimation of resources
b. Ecological mapping
c. Qualitative descriptions of environmental damages
d. Aerial photographs

12 International solutions to global environmental problems are difficult because of

a. Lack of data on the concentration of pollutants
b. Absence of pollution control laws
c. Lack of data on the effects of pollutants on the environment
d. The inability of developing countries to meet the costs of proposed solutions

13 The Montreal Protocol calls for

a. Information exchange on ozone depletion
b. Research on ozone depletion
c. Prior approval for the transboundary shipment of hazardous wastes
d. Limits on the production and consumption of ozone-depleting substances

14 A Government action that directly encourages Cleaner Production is

a. A national strategy for sustainable development
b. Thje provision of economic incentives
c. Negotiated environmental compliance that allows for innovation
d. Issuing multimedia environmental permits

15 A Government action that indirectly encourages Cleaner Production is

a. Establishing environmental regulatory programmes
b. Government procurement of clean products
c. Issuing policy statement that assigns priority to pollution prevention
d. Information dissemination about low- and non-waste technologies

Answers

1-5 d b c d c
6-10 d c d c c
11-15 a d d c a

Some Ideas to Think About

The following are some additional questions raised by the *Study Materials*. Take some time to think about them. If possible, work in a small group and try to achieve consensus.

1 Should one locality in a developing country have lower environmental standards than the rest of the country?

2 Should a developing country accept toxic and non-toxic waste from a developed country as a source of foreign exchange?

3 Why are legal environmental standards sometimes not enforced in some developing countries?

4 Should one country reprocess and dispose of hazardous waste for another country? How do you justify your viewpoint?

5 Should a developing country have lower environmental standards than a developed country?

6 A major new development project for heavy industry would create severe environmental impacts, but the Government is unconcerned and wants to proceed very rapidly. What issues should UNIDO raise?

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Reading Excerpts

Making Better Decisions: Information, Institutions, and Participation

Excerpted, with permission, from The World Bank, *World Development Report 1992: Development and Environment* (New York, Oxford University Press, 1992).

The principles of sound environmental policy do not conflict with development objectives. Why, then, are wise policies frequently the exception? A principal reason is that such policies often mean the withdrawal of entrenched 'rights'—to pollute or to use resources—that tend to benefit the wealthy and influential, often at the expense of the poor. Effective governmental action is also hampered by incomplete information, uncertainty, and weak regulatory powers.

In implementing change, governments must make the best use of their scarce administrative capacity. To do so requires, first, improved information and analysis to inform priority-setting and policy design; second, responsive and effective institutions suited to the administrative traditions of the particular country; and, third, greater local participation in policymaking, monitoring, and enforcement. The benefits of public participation frequently outweigh its costs.

This chapter asks why governments find it so hard to develop and implement wise environmental policies. Guidelines for environmental management are easier to describe than to put into practice, so that, in both industrial and developing countries, there is a gap between policy and performance. For example, many middle- and low-income countries set environmental standards that are unrealistically high and then fail to enforce them. In some countries serious environmental problems are apparently ignored, while in others decisions are often based on the lobbying clout of industry or of environmental activists rather than on balanced analysis. Sometimes public investments proceed with little or no attention to environmental impacts, while others are thwarted by NIMBY ("not-in-my-backyard") campaigns that hamper dispassionate analysis of the benefits and costs of alternative measures.

The Political Economy of Environmental Degradation

Governments face many pressures in making environmental policy. Conflicting interest groups lobby noisily, public opinion demands action on the most dramatic rather than the most important issues, and Governments even find it difficult to curb their own damaging behavior. Building constituencies is an important part of the solution to these pressures.

Redistributing Environmental Rights

People benefit from being able to use environmental resources without paying for them, and removing these benefits has direct distributional consequences. Often, those who have been enjoying the benefits are the wealthiest and most politically powerful members of society. Taking away their rights to pollute or to exploit resources can be politically painful and will often require compromises. Second-best policies are not desirable, but if well implemented, they are often preferable to unenforced 'perfect' policies. Chile's new fishing law (Box 1.1) is an example.

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Whereas the rich are often good at protecting their positions, the poor—whether they be slum dwellers in Manila, Lagos, or Rio de Janeiro, pastoralists in East Africa, or artisanal fishermen in Peru and Indonesia—tend to play little part in the environmental debate. Yet they usually bear the brunt of environmental degradation. They may be the ones to suffer most when forests that once provided free fuel are logged or when factories pollute rivers. Unlike the better-off, they lack the means to defend themselves—by switching to other fuels, say, or by boiling polluted water. Thus, the poor generally have the most to gain from effective environmental policies. Governments must represent the interest of those without a voice, including the urban poor and ethnic minorities.

Crisis-Driven Policymaking

Even when environmental cause and effect are well understood by scientists, individuals may make perverse judgments about relative risks when setting priorities. People are more concerned about cancer and nuclear accidents than about many known health problems. Overreaction to environmental disaster is also common. Dramatic images of oil spills or leaking toxic wastes have captured public attention and played a powerful role in initiating policy change. Less attention has been paid to the insidious, chronic problems of exposure to high levels of particulates or to unsatisfactory drinking water—environmental problems that may put many more lives at risk.

The use of the dramatic or photogenic to garner popular support and donations is common. Many environmental activists have found these to be powerful metaphors for broader environmental concerns. The danger remains, however, that priorities can be distorted. Governments must

Box 1.1 Chile's New Fishery Law

Chile has one of the five largest fishing industries in the world. In 1990 exports of fish and fish products totaled more than $900 million, making the sector second only to mining as a foreign exchange earner. Managing the open-access fisheries has become more difficult as additional investment in the fishing sector has led to overfishing. The Chilean government has responded with a new law (*Ley de Pesca*) designed to prevent overexploitation and the collapse of any one fishery by regulating access to the different species being fished. Since any management scheme would imply some restrictions on the fish catch, the law became the subject of public debate. The evolution of the law illustrates some of the constraints on making environmental policy.

Three main regulatory systems were considered in designing the new management scheme: global quotas, individual transferable quotas (ITQs), and limits on individual boats and their gear. The final version of the law combines open access (within an overall quota), selected controls on boats, and a licensing scheme that is to be phased in gradually after the third year and is based on a percentage of the total catch.

The new law is an improvement over the previous situation of completely open access without restrictions on the catch. It was not possible, however, to implement a strict ITQ system—the preferred approach from the standpoint of both sustainable management and the economic viability of the fishermen. Fishing companies in the north opposed the inclusion of ITQs in the law. They preferred open access within overall quotas, which would allow them to switch their boats from a declining fishery to another area. Many fishermen saw any catch restriction as a zero-sum game in which they stood to lose.

The new fishery law is an important step that demonstrates that a compromise solution is frequently better than none. Its implementation will have to be monitored carefully. Chile is receiving assistance from the Nordic countries and the World Bank in strengthening its capacity to monitor and analyze the fishing industry.

make sober determinations of the relative importance of different environmental problems and set priorities in an informed, cost-effective manner.

Difficulties in Self-Regulation

In many countries the public sector owns the most-polluting industries and controls important natural resources. Instead of performing better on environmental criteria than private enterprises, state-owned enterprises tend to be less efficient, to use more resources, and to produce more wastes. The public sector is also notoriously bad at policing itself. The environmental problems of Eastern Europe and the former USSR. clearly demonstrate this. Being both poacher and gamekeeper does not work, especially when public agencies are responsible for such essential but massive tasks as waste-water treatment or solid waste disposal.

Creating a greater separation between the regulator and the regulated is one option. The establishment of semiautonomous regulatory bodies, or the use of independent commissions to regulate such natural-resource matters as interprovincial water allocation, the fish catch, or logging policies, helps depoliticize decisions and creates greater responsibility for self-regulation. Privatization with appropriate regulation can also help; in the United Kingdom when water companies were privatized, they came under tighter government scrutiny.

Building Constituencies

If governments are to challenge established polluters or reallocate existing rights to resources, they need to build on and promote wider support for good environmental policies. Much evidence suggests that the basis for such support already exists, having been stimulated sometimes by particular environmental issues, sometimes by a powerful book (such as Rachel Carson's *Silent Spring*) or an expert report. As voters, protesters, and consumers, people in many countries show a similar interest in environmental causes.

'Green' political parties have appeared in a number of countries, and increased activism by non-governmental organizations has made governments and public institutions more accountable for their actions. Environmental causes frequently cross established political divides. Indeed, even in countries where conventional political participation is discouraged, the environment may be one area in which governments are willing to allow and respond to popular protest. It is no accident that the move toward more democratic forms of government has coincided with the worldwide increase in popular environmental awareness.

The behavior of consumers and producers is also changing. In many countries people are willing to recycle, to think about using energy and materials more efficiently, and to alter their consumption patterns. Companies often respond by using the environment as a selling point. 'Green labeling', increased use of recyclable and biodegradable packaging, and more energy-efficient technology are most common in industrial countries, but the same trends are appearing in some developing countries. Businesses sometimes argue that environmental measures will diminish competitiveness or lead to loss of jobs, but they are usually wrong. Business is increasingly realizing that it can take actions which yield both environmental and economic benefits. For example, *Changing Course* (Schmidheiny 1992), a report prepared by the Business Council for Sustainable Development in anticipation of UNCED, forcefully advances the idea that good environmental management is also good business.

Given the multitude of environmental problems and political pressures, governments must conserve their scarce administrative capacity. To develop good environmental policies, they need informed analysis based on accurate information. They also need to improve the way bureaucracies make and enforce decisions. To implement policies, they need to build popular support and encourage local participation. These are the themes of the next sections.

Improving Knowledge and Understanding

Ignorance is an important cause of environmental damage and a serious impediment to finding solutions. This principle holds for international negotiators and poor households alike, as is illustrated by the global damage done to the ozone layer by CFCs and the serious implications of indoor air pollution for family health. It is necessary, first, to know the facts; second, to determine values and analyze the benefits and costs of alternative measures; and, third, to ensure that information is available to inform public and private choices.

Establishing the Facts

Frequently, especially in developing countries, decisions are made in the absence of environmental information. Collecting basic data can be expensive, but the rewards are usually high. Although different countries have different needs, there are some general guidelines. For example, the discussion in chapter 2 suggests some priorities for monitoring pollution and waste problems:

- Quality and availability of drinking water and sanitation facilities
- Exposure to ambient air pollutants, especially particulate matter and lead, in urban areas
- Fecal coliform and heavy metals in rivers and lakes
- Indoor air pollution from the burning of biomass
- Hazardous wastes and pesticides in selected 'hot spots'.

Essential management information on land use and natural resources needed for improved management of these resources includes:

- Data on soils, from surveys and experiments in each agricultural zone
- Rate of depletion and quality of groundwater in threatened aquifers
- Changes in forest area and data on harvesting and replanting
- Data on fish harvest and wildlife depletion in vulnerable areas
- Damage to coastal and wetland resources.

Efforts are being made to help countries with environmental monitoring and to compile internationally comparable data. The Global Environmental Monitoring System (GEMS), managed by UNEP, has activities related to air and water quality in 142 countries. Monitoring of urban air quality began in 1974. Most of the cities report on concentrations of sulfur dioxide and suspended particulate matter, both important air pollutants. Unfortunately, the amount of financial help has so far been inadequate, and thus the coverage and quality of data are weaker than is desirable.

Given limited resources, it is better to concentrate on the most significant pollutants and to limit collection points to the numbers that can be accurately monitored. In the late 1980s Poland was reported to be regularly monitoring river pollution at more than 1,000 sites. Even if all the samples collected were properly analyzed, the gain in knowledge about river quality over that attainable with a system of 100-200 monitoring points would not justify such an extensive system.

Valuing Resources and Analyzing Benefits and Costs

Ending well-entrenched but environmentally damaging practices is difficult enough for governments when the damage is readily quantifiable. When environmental damage threatens health or jeopardizes economic output, it is relatively easy to point to the benefits of changes in policy. But as previous chapters have stated, some environmental values—important to poor and rich people alike—are not only unmarketed but also intangible. The more difficult it is to quantify the benefits of preserving these values, the harder it will be for policymakers to weigh the gains from conservation against the quick profits from resources degradation or pollution. However, more sophisticated methodologies are now making it possible to estimate the value of less-tangible environmental benefits.

In many cases local analysis of costs and benefits can build on international experience. Researchers in Bangkok, in analyzing the health impacts of pollution, tested local data against what had been learned in other countries about the links between exposure to pollutants and health. They found that the greatest threats to health were particulate matter, lead and microbiological diseases. Other environmental problems that traditionally receive a great deal of attention—contamination of groundwater and surface water; air pollutants such as sulfur dioxide, nitrogen dioxide, and ozone; and disposal of hazardous wastes—were much less dangerous. (In fact, the gravest threats were at least 100 times more serious than the lowest risks.) This information was used to develop cost-effective pollution control policies.

Improving Information and Education

Environmental education based on careful analysis can add rationally to the environmental debate. Publication of annual reports on the environment is increasingly common. When the public has a well-informed grasp of environmental issues, there is a better prospect of developing positive rather than purely defensive policies. Without such knowledge, people tend to focus on causes of death (for example, technological hazards and nuclear accidents) that are sensational and are caused by somebody else, and to worry less about the probability of death from causes that are less dramatic and often under an individual's own control, such as cigarette smoking and wood fires. The work of independent research institutes—such as the Thailand Development Research Institute—can help to modify people's views.

Communities are increasingly bombarded with a variety of environmental information and need sources of information that they can trust. Independent commissions can help to depoliticize decision-making by analyzing thorny environmental issues and producing recommendations for policy action. Box 1.2 illustrates how some of these bodies have contributed to the development of the consensus required for policy decisions on such complex topics as global warming, pollution control and urban planning. Independent commissions can also audit public agencies and so make them more accountable.

The most important effect of improved information and environmental education is to change behavior. Well-informed citizens are in a better position to put pressure on governments and on polluters and are more likely to accept the costs and inconveniences of environmental policies. The results can be dramatic. In Curitiba, Brazil, a combination of an energetic mayor, a committed municipal government, and an informed and involved public have led to many environmental innovations and an improved quality of urban life in this city of 2 million. Public transport is used by most of the population, green spaces have been expanded, recycling is widely practiced and industrial location and product mix are carefully chosen to minimize pollution.

Changing Institutions: Making the Public Sector More Responsive

Given that the scarcest government resource is frequently not money but administrative capacity and that political pressures make environmental policymaking particularly difficult, governments must think carefully about what they do and how they do it. The 'what' of environmental management consists of setting priorities, coordinating activities and resolving conflicts and creating responsible regulatory and enforcement institutions. The institutional response to these tasks—the 'how' of the equation—includes developing legislations and administrative structures, providing needed skills, ensuring funding and donor coordination and implementing decentralization and devolution.

Essential Government Functions

Setting Priorities and Formulating Policies

Since all countries face multiple environmental problems, governments must set priorities on the basis of informed analysis so that they can

Box 1.2 Independent Commissions and Improved Environmental Analysis

Governments have often used independent panels of experts (sometimes constituted as special commissions) to investigate contentious policy issues. In recent years environmental issues have increasingly been referred to such bodies. The procedure has a number of advantages.

- It relieves, at least temporarily, the pressure for an early decision.
- It facilitates open debate, sometimes through public submissions or hearings, without committing the government to adopt any of the recommendations that may emerge. Scientific disagreement can be clarified and the public educated.
- It allows a number of scientific disciplines and interest groups to be brought together. A consensus is more likely to emerge if the commission is chaired by an independent person rather than by a government representative.

There have been several interesting examples of the use of this approach.

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On global issues. In 1990 the Enquete Commission on Preventive Measures to Protect the Earth's Atmosphere presented a comprehensive report to the German Bundestag. The commission, which was made up of scientists and representatives of the country's main political parties, made specific recommendations not only on national energy policy but also on international measures.

In the United States, Congress asked the National Academy of Sciences to review available evidence on global warming and evaluate policy options. The report, issued in 1991, recommended that even though the effect of global warming on the United States was uncertain, selected low-cost actions to reduce greenhouse gas emissions should be initiated.

On national priorities. Industrial companies have occasionally used expert panels to help prepare national environmental strategies. The United Kingdom has had a Royal Commission on Environmental Pollution since 1970. Members serve as individuals, not as representatives of organizations or professions, and are appointed for at least three years. The commission is empowered to request documents and even to visit premises. Over the years it has produced 15 reports, most of which have influenced policy. For example, following the 1983 report on lead, the lead content of gasoline was reduced and unleaded fuel was introduced.

On specific environmental issues. Governments increasingly finance independent 'think tanks,' such as the Thailand Development Research Institute, which analyzes a wide range of issues, including environmental topics. Sometimes governments use interagency task forces to examine discrete issues. In Hungary a group evaluated a proposed hydropower dam on the Danube; in Mexico a task force will analyze the use of economic instruments to control pollution and manage natural resources.

make the most efficient use of scarce administrative and financial resources. Frequently, better environmental policy is more important than more environmental policy. In many developing countries top priority must be given to environmental impacts on health and productivity. Actual priorities will depend on the average level (and distribution) of income. In highly urbanized countries such as Argentina, Korea and Poland, air and water pollution in cities will be priorities. In more rural economies, as in many Sub-Saharan African countries, parts of Central America, and India and Bangladesh, land, forest, and water management may well have top priority.

The distribution of impact is important. Wealthier city dwellers, who can protect themselves against unsafe water, may lobby governments to assign higher priority to air pollution, which affects rich and poor alike, than to ensuring a safe water supply. Yet water investments may have a much larger immediate health benefit.

National environmental action plans are proving useful tools for setting priorities. Plans are being drawn up for a number of African countries and have already been completed for Lesotho, Madagascar, and Mauritius. The experience of Burkina Faso with such a plan (box 1.3) demonstrates the importance of building consensus and the will to act.

Coordinating and Planning

Once priorities have been determined and appropriate policies designed, implementation of policies and the resolution of conflict become important. Environmental policy often cuts across the normal bounds of bureaucratic responsibility. Whether it is watershed management to protect a new dam, allocation of a region's water resources among competing users, or the complex problem of managing a city's air quality, many different actors must be brought together. Agencies need to collaborate and some machinery for resolving conflict is needed. Although there is a natural bureaucratic tendency for governments to respond to intersectoral conflicts by setting up regional bodies, these organizations have rarely been successful in the past because they are inevitably at odds with strongly established, sectorally organized government bureaucracies.

A common problem with environmental issues that cross normal bureaucratic demarcation lines is the absence of an effective mechanism for coordinating the work. In Sao Paulo, Brazil, the metropolitan area has a planning agency, while the state has agencies with responsibilities for environmental protection, water, and sanitation. A consequence of divided responsibilities is that programs for controlling industrial pollution have not been integrated with investments in waste-water treatment and the sanitation master plan has not been sensibly implemented. (For example, treatment plants have been constructed, but not the needed interceptor and trunk line sewers.)

If regional environmental planning is to be successful, countries need flexible management frameworks that encourage the actors to "think globally, act sectorally." In rural areas resource analysis and planning should be done at the level of the individual watershed or irrigation scheme, even if line ministries take responsibility for implementation. In cities the management of air and water pollution requires a strong mechanism for intersectoral planning and coordination. For example, Santiago and Mexico City recently established special organizations for planning pollution reduction strategies to be implemented by line agencies for the wider metropolitan areas; in Mexico City the commission will include part of the state of Mexico as well as the federal capital. In Jakarta the work of several intersectoral groups has led to the relatively successful implementation of a program to protect the metropolitan area's ecologically sensitive watershed by shifting growth away from the south, where the watershed is located, and toward the east and west of the city.

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Box 1.3 Setting Priorities in Burkina Faso

Improved environmental management requires a commitment from both the government and the wider public. The recent experiences of Burkina Faso in developing a national environment action plan illustrates how the process itself can be an essential component in creating awareness and building the political will needed for action.

When Burkina Faso began to develop its plan, the process was based on a series of previous national meetings synthesized by local consultants in commissioned reports. These resulted in the identification of several key program areas: developing environmental management capability at all levels, improving living conditions in rural and urban environments, focusing on environmental management at the village ('micro') level, addressing key national ('macro') resource issues and, in support of all these, managing information on the environment.

With the aid of funding from a number of bilateral and multilateral organizations, including the World Bank, the entire process took about three years and cost about $450,000. A national seminar was held to debate the draft plan and to set priorities in preparation for approval by the Cabinet in September 1991. A meeting was planned for mid-1992 at which donors were asked to pledge support for specific projects that make up the action plan.

The main lesson from Burkina Faso is that by working with the government and local participants, it was possible to develop a plan that incorporates the work of those who will have to implement it. Although it might have been quicker and cheaper to produce the plan using international consultants, the plan would not have been a Burkinabe product and would probably have joined other 'external' products on a bookshelf instead of resulting in action.

Regulating and Enforcing

Agencies, chronically short of money and manpower, need to devise cost-effective ways of implementing policy. One way is to give citizens more power to challenge polluters, whether public or private. For example, public environmental agencies may give local communities or voluntary organizations substantial responsibility for implementing or monitoring programs. This approach can be formalized through the legal system. In the Clear Air Act of 1970 the U.S. Congress authorized private citizens to seek injunctions (and in some cases financial penalties) against companies that violated the terms of their operating permits, thus making environmental enforcement no longer the exclusive responsibility of the government.

Enforcement may be bolstered by making more use of the private sector or of nongovernmental groups. Many governments now hire private companies and technical consultants to perform environmental assessments, collect and analyze data, undertake monitoring and inspection and provide specialized advice. Mexico City, for example, is implementing air pollution control measures through private vehicle-inspection stations and is considering using private laboratories to analyze air and water samples.

Community groups can play an important role in enforcement. In India an 'environmental audit' procedure has been developed for the 500-megawatt Dahanu Thermal Power project, currently under construction. The authorities in charge of pollution control plan to distribute to local communities and NGOs summaries in nontechnical language of the results of environmental monitoring. Community groups can then check emissions against legal standards and seek redress in the courts if necessary.

The success of such approaches will depend partly on how freely information about polluting activities is available. Sometimes simply obliging large polluters to publish information about specific emissions will have some effect on behavior. Legislation in the United States now requires some 20,000 plants to make public information on their annual emissions of 320 potential carcinogens. Public disclosure can also help focus the attention of senior management on emissions and the opportunities for reducing them and can supplement official monitoring with public and community oversight.

The Institutional Response

Policymaking has frequently outpaced administrative capacity to analyze and implement policies. Laws are multiplying, and often the result is a large number of contradictory regulations that are beyond the capacity of governments to enforce. The situation, in addition to doing little for the environment, breeds skepticism about laws in general and government commitment to the environment in particular and may encourage corruption. It is essential to close the gap between making and implementing policy. That means reforming the way the machinery of government handles environmental issues.

When the World Bank expanded its lending for environmental purposes in the 1980s, it was clear that the public sector was often unable to deliver the expected results. The World Bank and member governments therefore began drawing up comprehensive country environmental action plans. These plans take into consideration both the legal and the administrative frameworks in countries as diverse as Brazil, Poland and the Philippines (box 1.4). Experience with the plans has shown that there are five main requirements for successful policy implementation: a clear legislative framework, an appropriate administrative structure, technical skills, adequate money and decentralized responsibility.

Enacting Legislation

Laying the legal foundations for environmental management frequently necessitates the repeal of outdated law and the codification of new concepts. If the laws are to be effective, detailed regulations, without which most laws are only general principles, also have to be developed. New environmental provisions need to be integrated into existing government procedures or into traditional local law. In Chile one of the first steps taken by the new National Environment Commission (CONAMA) was to review existing legislation and prepare a comprehensive environmental law. This law and a companion law implementing requirements for environmental assessments, both now under consideration, will provide a rational framework for environmental management.

Building Administrative Structures

Institution building is a long-term business. It depends on local conditions, political factors and the availability of manpower and money. Frequently, it is easiest to build on existing institutions. In practice, the structure of environmental administration matters much less than the ability to get the job capacity to set priorities, coordinate and resolve conflicts and regulate and enforce. Countries will allocate these roles differently; for instance, coordination and conflict resolution might be undertaken by an independent executive agency, by an interdepartmental committee, or by a small politically and technically astute group in the office of the president. The key is clear statutory powers combined with the authority to resolve intragovernmental disputes and the ability to provide continuity when administrations change.

Institutional arrangements that have been found to be helpful include:

- A formal high-level agency that can provide advice on policy and monitor implementation. Examples are IBAMA in Brazil, the Federal Environmental Protection Agency (FEPA) in Nigeria, and the State Environmental Protection Commission in China.

- Environmental units in the principal line ministries that can provide the central unit with technical expertise and monitor those environmental policies that the ministries are responsible for imple-

Box 1.4 The Gap Between Policy and Implementation

In a growing number of borrower countries World Bank assistance for national environment plans includes help with institution building. Here are some examples of attempts to reduce the gap between policies on paper and results on the ground.

The Brazil National Environment Project, a $117 million loan signed in mid-1990, is designed to strengthen the institutional and regulatory framework and promote better management of biological resources. In support of the first three-year phase of Brazil's National Environmental Program, the project finances the strengthening of national conservation units; improved environmental management of threatened eco-systems in the Pantanal, the Atlantic Forest, and the Brazilian coast; and reinforcement of IBAMA (Brazil's national environmental agency, the executing agency for the project) and state environmental agencies. The loan provides support for staff training, equipment, better technical information and legal and technical assistance; improvement of regulations and technical guidelines for environmental management; and environmental education. Implementation of the project has been delayed by fiscal and management problems. The slow start highlights the need to strengthen management capability of executing agencies before they can effectively undertake project implementation.

Building environmental institutions is a key concern in Eastern Europe. The Poland Environmental Management Project, approved in April 1990, was the third World Bank loan to Poland and the first for environmental activities. The purposes of the $18 million loan include strengthening environmental management, introducing consistent standards and enforcement, improving monitoring and regionalizing environmental management. The government has identified the most polluted areas and has told the 80 worst industrial polluters to improve their environmental performance at once. At the same time, government task forces are revising the regulatory system and designing a national environmental monitoring strategy.

In the Philippines a loan and credit package totaling $224 million, approved in 1991, will promote policy reform and strengthen institutions. The loan contains provisions to help protect biodiversity in the country. Since the largest threats to biodiversity are encroachment by land-hungry farmers and illegal commercial logging, the project supports more sustainable patterns of resource use by small farmers in exchange for secure tenure rights and improves the enforcement of logging regulations, partly by strengthening the regional and local offices of the Department of the Environment and Natural Resources. The loan also supports the design of a network of protected areas and provides resources to manage 10 priority areas.

menting. Oversight, from a public health perspective, of general environmental quality (especially air and water) is frequently carried out by the ministry of health, and the management and conservation of natural resources may be spread among government units responsible for agriculture, forestry, fisheries and parks and wildlife.

- Regional and local environmental units that allow local implementation and monitoring and feed information back to the national government (see below).

Closing the Skills Gap

The public sector in many developing countries is short of qualified staff at all levels. The necessary skills may exist but may not be attracted into the public sector because the salaries are well below the market rate. Environmental agencies are therefore condemned to being outstaffed by the private firms they are charged with regulating or may be forced to rely for expertise on expensive temporary consultants. Some countries have found ways to mitigate this problem. In Latin America, for example, foundations and institutes financed by non-governmental sources sometimes undertake both policy analysis and resource management.

Another common problem is an imbalance of professional skills. In some countries the agencies are dominated by engineers and contain few natural or social scientists; in other countries the reverse is true. But environmental management requires a mix; natural or biological scientists to manage renewable resources, social scientists—economists, sociologists and anthropologists—to identify problems and formulate policies and engineers to design solutions.

Economic analysis is particularly important to (and frequently absent from) the dialogue between those responsible for environmental management and those in charge of the budget, planning and economic policy. An environmental economics unit in the ministry or agency responsible for economic planning and public finance can fill this role by assessing budgetary allocations, ensuring that economic incentives are consistent with environmental objectives and helping to strike an appropriate balance between environmental and economic goals in determining development priorities.

Obtaining Funding

Environmental agencies have not yet firmly established their place in the competition for scarce government funds. Given the secondary importance usually attached to environmental management, budgetary allocations are sometimes insufficient and highly variable. When money runs out, the effect may be disproportionately damaging. For instance, if a shortage of cash means that enforcement of water pollution regulations has to be suspended, the consequent damage to groundwater and surface water can be substantial. If a national park goes unprotected during a dry

Box 1.5 Japan: Curbing Population While Growing Rapidly

Japan's post-war reconstruction brought about both rapid economic change and major environmental problems. In the 1960s, when it was still a middle-income country, Japan began to invest heavily in control technology to combat severe air and water pollution, largely from industrial sources. Expenditures for pollution control by large firms peaked at more than 900 billion yen in the mid-1970s before declining to 400 billion yen or less by 1980. Japan is now enjoying the benefits of its investment: between 1970 and the late 1980s emissions of sulfur dioxide decreased by 83 percent, emissions of nitrogen oxide by 29 percent and concentrations of carbon monoxide by 60 percent. Similar advances were made in improving water quality. These results were obtained through stringent governmental regulations and negotiations between industry and communities to define solutions that could be fine-tuned to varying local requirements. An estimated 28,000 such agreements are now in force.

Three lessons from the Japanese experience may offer useful guidance to today's middle-income countries:

Establish a national policy framework. The initial legal framework, established by the Diet, included the Basic Law for Environmental Pollution Control (1967), the Air Pollution Control Laws (1967 and 1970), and the Water Pollution Control Law (1970). These laws define responsibilities and divide them among government at various levels, private firms, and individuals, thereby encouraging decentralization.

Negotiate agreements at the local level. The open negotiation of agreements between polluting industries, local authorities, and citizens' groups often led to emissions considerably lower than the minimum required by law.

Allow flexibility in setting emissions levels and promote self-regulation. Since industries were often located in the middle of residential areas, firms were very sensitive to local environmental concerns. The negotiating process allowed emissions levels to be tailored to local conditions and also encouraged self-regulation by industry, thus fostering the idea of good corporate citizenship.

season because of lack of funds, poachers may quickly undo what has taken years to achieve.

Environmental administration can often be improved even within a tight budget. But an environmental agency needs a core of skilled technical staff, as well as laboratories and other monitoring devices, to do its job properly. In some countries more money is becoming available as environmental management is accepted as an important national objective. Economic instruments—fines for polluters, charges for permits to use forests and fisheries, entrance fees for parks and protected areas and so on—can help to pay for enforcement and administration.

Donors, including development banks and multilateral societies, are often reluctant to finance what is needed most—improved operation and maintenance of fledgling national environmental administrations. Rather, they seek to make specific investments that tie up scarce local staff. Sometimes contributions come in the form of technical assistance and other tied aid, which does not necessarily strengthen local capabilities, and sometimes the donor community floods local officials with well-meant but unorchestrated offers of assistance. Finally, most donor-funded projects are relatively short-term and small scale. What is needed most is longer-term reliable funding, especially for institution building and research.

Decentralizing and Delegating

Once national priorities have been set, it is often cost-effective to solve problems at the local level. Many governments therefore pass day-to-day responsibility to local bodies. This approach was used successfully in Japan (Box 1.5) and is being increasingly applied in other countries. In China, for example, the actual work of environmental protection takes place mainly at lower levels of government. The provinces are responsible for carrying out national policy set by the State Environmental Protection Commission. All provinces and municipalities and most counties now have environmental policy committees headed by a vice governor or vice majistrate. China's network of environmental policy commissions headed by a vice governor or vice majestrate. China's network of enforcement protection bureaus (EPBs) that answer to local environmental protection agencies thus consist of the central units and about 2,400 EPBs, which together employ more than 16,500 people.

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In Nigeria, a federal state, most policy is implemented at the state level. Over the years the states have monitored their environmental problems through their administrative systems, which include representation from local governments. Local capacity, however, has been weak. The 1988 decree establishing Nigeria's FEPA encourages the establishment of local environmental protection bodies, but most have only limited capacity to carry out their responsibilities for environmental management. If decentralization is to work, it must be accompanied by a transfer of finance. Otherwise a policy vacuum is created: the center sheds responsibilities, but local agencies are ill equipped to take them up.

Some countries have made specific allocations to local administrations for environmental investments. China and Colombia, for example, have passed national laws that permanently assign a percentage of the income from hydropower sales to local governments for watershed protection, environmental education, soil protection and environmental training programs for municipal officials. In others emissions fees serve as local sources of finance. The Municipal Environmental Protection Bureau of Tianjin, China, has created an industrial pollution control fund financed by emissions fees mandated under national legislation. Revenues are used to finance investments in control and treatment at individual enterprises.

Investments in decentralized treatment of industrial waste water increased the treatment rate from 35 to 46 percent between 1985 and 1990.

Involving Local People

Many environmental problems cannot be solved without the active participation of local people. Few governments can afford the costs of enforcing management programs that local people do not accept. Participation can also help with afforestation, wildlife conservation, park management, improvements in sanitation systems and drainage and flood control. Local people can provide the manpower and knowledge for dealing with the aftermath of environmental disasters, and local knowledge of genetic diversity has led to breakthroughs in crop production.

Participatory approaches offer three main advantages:

- they give planners a better understanding of local values, knowledge and experience;
- they win community backing for project objectives and community help with local implementation; and
- they can help resolve conflicts over resource use.

Drawing on Local Values, Knowledge and Experience

People's views of their environment strongly influence how they manage it. Even when attitudes toward the natural world do not achieve the sophistication described in box 1.6, few cultures view natural resources as worth nothing more than their cash value in the marketplace. Only if environmental programs reflect local beliefs, values, and ideology will the community support them.

The belief that traditional knowledge of the environment is simple and static is changing rapidly. More and more development projects are taking advantage of local knowledge about how to manage the environment. For example, people in the tropical rainforests in the Amazon and Southeast Asia have accumulated a valuable understanding of local ecosystems, and African pastoralists, such as the Maasai and Samburu of Kenya, are able to exploit apparently marginal savannahs (see box 1.6). Building on these strengths requires great care, expertise and patience. But development projects that do not take existing practices into account often fail.

A particularly costly instance of neglecting local practices occurred in Bali, Indonesia. For centuries the traditional Balinese irrigation calendar had provided a highly efficient way of making the most of water resources and soil fertility and of controlling pests. When a large internationally financed agricultural project tried to replace traditional rice varieties with high-input imported varieties, the result was a sudden increase in insect

Box 1.6 Indigenous Values and Knowledge of Land and the Environment

Many of the world's remaining indigenous people—estimated to number over 250 million in more than 70 countries—take a view of nature that differs strikingly from conventional attitudes. A study commissioned for this Report analyzes the attitudes of three groups of indigenous peoples: the Quichua-speaking Amerindians in the rainforests of eastern Ecuador, the Maasai and Samburu nomadic pastoralists of Kenya, and the indigenous swidden (slash-and-burn) farmers in the upland areas of the Philippines. The study concluded that many indigenous people view land not as a commodity to be bought and sold in impersonal markets but as a substance to be endowed with sacred meanings, embedded in social relations and fundamental to the understanding of the groups' existence and identity.

Tribal Filipinos see land as a symbol of their historical identity: an ancestral heritage to be defended and preserved for all future generations. According to the Episcopal Commission on Tribal Filipinos,

> *They believe that wherever they are born, there too shall they die and be buried, and their own graves are proof of their rightful ownership of the land. It symbolizes their tribal identity because it stands for their unity, and if the land is lost, the tribe too shall be lost.*
>
> *Ownership of the land is seen as vested upon the community as a whole. The right to ownership is acquired through ancestral occupation and active production. To them, it is not right for anybody to sell the land because it does not belong to only one generation, but should be preserved for all future generations.*

Like many indigenous people, the surviving tribes of the rainforests of South America drew on traditional knowledge and practices to make a living in fragile environments. The study observes,

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pests, followed by declining crop yields. A subsequent project built on the indigenous production system has been much more successful.

Sometimes local knowledge can be applied in other parts of the world. Vetiver grass has been used for centuries in the hilly areas of Tamil Nadu and other parts of India as cattle fodder and as a hedge plant to conserve soil and moisture. Experience from the Kabbalama Watershed Development Project in 1987 prompted the World Bank to support the use of vetiver in countries as diverse as China, Madagascar, Nepal, Nigeria, the Philippines, Sri Lanka and Zimbabwe. The costs of vetiver are one-fifteenth those of soil conservation systems that rely more

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> *Quichua forest management is often overlooked and unappreciated by outsiders who are unfamiliar with it, in part because the methods that they use to alter the course of forest succession are technologically simple (consisting of axe and machete and a vast array of knowledge), and also because the forest that regrows is diverse and complex and hard to distinguish from undisturbed mature rainforest. The lowland Quichua achieve this effect by altering the mix of species that regrow in their agricultural clearings...(The result is) a patchwork of habitats of different ages in different stages of succession and with a varying blend of useful resources.*

In most countries legal recognition and practical protection of the customary land and territorial rights of indigenous people are limited or non-existent. Pastoralists in Africa face particular problems in maintaining access to their traditional pastures. An example is the case of the Maasai and Samburu of Kenya. At one time the Kenyan government hoped to set up group ranches as a way of increasing beef exports while retaining collective management. Recently, the government has promoted the privitization of these ranches, asserting that corporate land tenure impedes rational land management. The Bank study notes that Maasai elders regard private land ownership as an 'alien concept' and express fears that "subdivison may lead to a disastrous change of lifestyle for the Maasai people".

The only source of income for the Maasai people is livestock. Their culture provides them with a system in which they can preserve the arid and semi-arid areas...in such a way that certain areas are put aside in periods of drought in order to keep grazing areas in good condition. Although lately it has become more difficult to do, it still works within and among group ranchers, especially where upgraded cattle breeds are introduced. However, in the fragile (semi-) arid areas it might even become impossible to keep livestock on an individual basis on small plots; it will also irrevocably lead to soil erosion, overuse of resources, and desertification.

heavily on engineering. However, local management practices—embedded as they are in specific culture—are not always so transferable.

Improving Project Design and Implementation

Projects are more successful if they are participatory in design and implementation. A review of thirty completed World Bank projects from the 1970s found an average rate of return of 18 percent for projects that were judged culturally appropriate but only 9 percent for projects that did not include mechanisms for social and cultural adaptation. A more detailed study of 52 USAID projects similarly found a strong correlation between participation and project success, especially when participation took place through organizations created and managed by the beneficiaries themselves.

The contrasts between environmentally beneficial projects designed on participatory principles and those that fail to include participatory designs can be striking. Haiti's top-down afforestation program, plagued by high sapling mortality rates on forest department lots and by conflicts with villagers, consistently fell short of tree-planting targets. Starting in 1981, an alternative approach was tried. NGOs helped to provide trees that were selected by farm households. The result was dramatic: instead of the 3 million trees on 6,000 family farms originally planned, 20 million seedlings were planted on the farms of 75,000 families who voluntarily joined the program.

Ideally, both local communities and the responsible agencies gain from participation, as the experience of the National Irrigation Authority (NIA) in the Philippines illustrates. Early involvement of community groups in planning construction and in finding ways to avoid the silting of channels and drains has brought about better maintenance of irrigation works and higher agricultural yields. Users have also been more willing to pay for the NIA's services.

Growing numbers of countries are devising partnerships with local people to provide municipal environmental services. In Accra sanitation services in low-income areas have improved greatly since NGOs and local entrepreneurs have been allowed to operate improved community pit latrines. Desludging and disposal are carried out by the city's central waste management department. This division of responsibility has proved more effective than attempting to operate a completely centralized sewerage system that had fallen into disrepair. In Jakarta neighborhoods organize the collection of solid wastes by collecting monthly dues that are used to buy a cart and hire a local garbage collector. At least once a month, one volunteer from each household assists in collecting garbage and cleaning the neighborhood drainage system. The wastes are taken to a transfer station. There they are picked up by municipal authorities—a task that is gradually being contracted out to private companies. This combination has allowed Jakarta to achieve an 80 per cent waste collection rate—high by developing country standards.

Resolving Local Conflict

Properly planned participation eases resolution of the conflicts inherent in environmental decision-making. When mechanisms for resolving conflicts exist, people may be less likely to overuse natural resources out of fear of losing their access to them. All too often, top-down rules that govern access to natural resources appear arbitrary and unfair. Many governments are changing resource allocation rules to reduce conflicts between authorities and local communities and to set up procedures for resolving disputes among competing claimants to resources.

When large infrastructural investments—dams, irrigation facilities, roads and ports—are planned, listening to public opinion and local NGOs at an early stage is a good way to avoid trouble later on. If this is not done, community opposition can gather momentum and delay or stop the project. A good environmental assessment should clarify potential environmental and social impact, propose mitigative measures and present the costs and benefits of alternatives.

A particularly difficult challenge for conflict resolution is posed by projects such as dams, highways and some types of wildlife reservations that change land use and lead to involuntary displacement and resettlement. Rarely have local views been consulted to any extent in making such an investment decisions or, until recently, in planning resettlement programs. This omission has led to inefficiency, as well as injustice; traditional resettlement has turned out to be needlessly slow and expensive. Governments and donors now broadly agree on several principles:

- project designers should explore ways of minimizing resettlement;
- resettlers' living standards should be as good or better than before resettlement;
- compensation for lost assets should be paid at replacement costs; and
- communities should be encouraged to participate in all stages of resettlement planning and implementation. Examples from Mexico and Thailand illustrate this new approach (box 1.7).

The Limitations and Costs of Participation

Public participation has its drawbacks. Extensive participation, especially when information is inadequate, can delay decisionmaking. Communities with political influence sometimes reject proposals to construct facilities such as waste disposal centers on the most suitable sites because of the impact on local property values, aesthetics or safety. Making compensatory payments for local use and giving communities control over how the project is sited and designed can defuse opposition.

Participatory approaches tend to be expensive. Consultation requires plenty of staff and time, and government agencies, already short of funds, may cut corners. If they do, the most remote and marginal—and often the neediest—communities will be the ones to suffer.

The extra net expense of seeking participation need not be large, however. In the Philippine example described above, the additional cost for the community organization program was about $25 a hectare, but savings in construction costs—largely as a result of information provided by farmers—brought the net increase down to less than $2.50 a hectare. The outcome was a better irrigation system with higher utilization and higher revenues. Increased participation was clearly cost-effective.

Box 1.7 Reforming Resettlement through Participation: Mexico and Thailand

Resettlement of people displaced by large hydroelectric dams has typically been the extreme case of nonparticipatory planning. But experience with two recent projects in Mexico and Thailand illustrates how participation can help with issues as difficult as involuntary displacement and resettlement.

The 200-meter dam at Zimapan, central Mexico, and the 17-meter Pak Mun dam on the Mun River in Thailand are at the core of two World Bank-assisted projects designed to provide urgently needed clean energy. But the national benefits of the dams meant little to the nearly 25,000 people who would be displaced. Nor was previous experience in either country encouraging; new housing and compensation for lost assets had proved no substitute for submerged farmland and uprooted communities. It was not surprising that resettlement proposals were greeted with skepticism and opposition.

In both countries the impact of resettlement was taken into account when the dams were designed. In the case of Pak Mun a review of technical options showed that locating the dam slightly upstream and lowering its height would reduce the number of people to be resettled from approximately 20,000 to fewer than 2,000. Detailed resettlement plans that followed the World Bank's guidelines were prepared to help the affected farmers recover their lost livelihoods.

Under repeated prodding by NGOs and community groups, the energy company began working with the affected communities on improving its approach to resettlement.

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A potential disadvantage of participation is that decentralization of decision-making can easily reinforce the power of local elites. In these cases strong supervision is needed to overcome local conflicts.

When projects involve voluntary provision of labor, participatory approaches can widen income differentials. This often happened with community woodlot programs in India in the 1970s and early 1980s. In many of these projects, despite an approach ostensibly built on village participation, poor villagers commonly found their time and labor were welcomed but that the benefits went disproportionately to wealthier villagers who made a smaller contribution. More thought was needed on ways to ensure that participatory approaches are able to balance the claims of different groups.

How Participation Can Be Improved

How can the large benefits of participation be realized while minimizing the costs? Community organizations often require strengthening through

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Although the problems remain, sharing information about resettlement alternatives, preparing meetings and publications to inform resettlers of their rights and entitlements, and providing farmers with good-quality replacement farmland are important steps in improving the resettlement program.

To implement the resettlement policy for Mexico's Zimapan project, the parent company set up a unit that reported directly to the company's president. The unit included anthropologists, technicians, economists, architects, and social workers, all of whom were to live in the affected villages, help identify local concerns and resettlement preferences, and provide a channel of communication between the villagers and the company. As villagers in Zimapan organized, they repudiated the local administration and elected their own much tougher council to manage the negotiations on compensation and resettlement. Farmers have been active in selecting and supervising designs for replacement housing, and the company has purchased farms that will improve their incomes and living standards.

In neither case has participation in resettlement planning led to the disappearance of opposition—that was not the purpose. Indeed, opposition remains strong and confrontational encounters between the company and antidam organizations still occur. Nevertheless, in both projects pressure for more active participation by local people has led to significant improvement in what will always be a difficult process. Participation has allowed the people most adversely affected by the projects to be actively involved in directing the course that resettlement will take.

technical assistance, management training, and gradually increased levels of responsibility. Several measures can enhance participation.

Use of Indigenous Institutions

Indigenous institutions (such as the *subak*, or traditional water users, in Bali) that are already involved in managing natural resources can be useful, particularly when decisions on land use have to be made. Where such institutions do not exist, it is often necessary to create them. All too often, however, user groups have been legislated into existence rather than built on existing social foundations. User groups can be effective only when they enjoy broadly based local support.

Use of Local Voluntary Organizations

Among the strengths of community groups and NGOs are their ability to reach the rural poor in remote areas and to promote local participation; their effective use of low-cost technologies; and their innovativeness. They work best when they complement the public sector but may also have an important 'watchdog' function, thereby influencing public policy. The disadvantages of NGOs include generally a weak financial base and administrative structure and limited technical capabilities. Many NGOs are small and by themselves cannot be expected to cover large populations. The challenge is to retain the NGO's expertise and energy while simultaneously enlarging their financial and administrative bases.

Increased Access to Information

Many countries now support local involvement in environmental impact assessments. But if such consultations are to be effective, the people who are involved need to be well informed. Some ways to achieve that are

- to share information with local communities at the early stage of identifying a project,
- to discuss local worries with the affected communities,
- to allow public comments on background studies,
- to encourage public comments on the draft environmental assessment, and
- to include hearings and comments in the final document. The World Bank expects its borrowers to arrange public discussion of environmental assessments prepared for the projects it finances.

Institutional Reforms

The attitudes of bureaucracies often thwart the benefits of local participation. Forestry departments, for example, generally see as their mission protecting trees from people. Wildlife conservation agencies (sometimes justifiably) fail to distinguish between local communities and game poachers. Often, the institutional units that have the best relations with the local communities are themselves on the margins of their own agencies. Most technical agencies lack the skills to foster participation. High priority should therefore be given to increasing the organizational weight of units that specialize in participation, to hiring professional staff trained in the social sciences and to providing institutional incentives for participation.

Policies for mitigating the worst effects of pollution and degradation without sacrificing development are available. Although such policies may appear simple and logical, no one should underestimate the political difficulties entailed in implementing them. As this chapter has argued, governments can reduce those difficulties by introducing well-designed administrative structures for making and implementing environmental policy and by carefully building constituencies of support.

Highlights of the Dutch National Environmental Policy Plan

Excerpted, with permission, from Ministry of Housing, Physical Planning and Environment, *Highlights of the Dutch National Environment Policy Plan: A Clean Environment: Choose It or Lose It* (The Hague, 1991).

Drastic Intervention

The state of the environment is extremely serious. In spite of improvements in certain areas, the situation as a whole is continuing to deteriorate. It would be irresponsible to delay drastic measures any longer. Radical decisions, which will affect everyone, are unavoidable. Not only the improvement of environmental quality, but also the very survival of mankind is at stake. Unless we set a different course quickly and resolutely, we are heading for an environmental catastrophe. The only way to avoid it, is to lay a basis now for sustainable development.

In the National Environmental Policy Plan (NEPP), the Dutch Government sets out how and with what resources it intends to enter this struggle. The NEPP also makes clear the contribution to sustainable development which are expected from every group and sector in society. It is no longer enough for the government to issue laws and regulations which must then be complied with. A positive, active attitude on the part of everyone in society is indispensable to the realization of a clean environment.

This requires a firm foundation. It is important, then, that the NEPP has been drafted jointly by four ministries (Housing, Physical Planning and Environment, Agriculture and Fisheries, Transportation and Public Works, and Economic Affairs), in consultation with the target groups which must ultimately implement the policy.

The NEPP contains concrete measures for the period 1990-1994, but it focuses emphatically on the long term. It sets out the course to be followed by environmental policy until 2010. This is the first time such a long-term course has been charted. Never before were there enough possibilities and information available to make such a plan. Of course, the NEPP cannot work out in detail everything that must be done a quarter of a century from now. So it is being revised every four years. The concrete measures are being elaborated every year in an "Environmental Programme".

Concern of Tomorrow

"If we want to remain the norms for environmental pollution, then reductions of 70-90 percent are required. This is beyond the capacity of most of the end-of-pipe technologies that we know about".

An ominous statement but a solidly grounded one. It was taken from the summary of the well-known report "Concern for Tomorrow" which was published in late 1988. This study has received a great deal of attention and deservedly so. Never before has there been such a complete, scientifically based picture presented of the long-term environmental developments that we can expect in the Netherlands. Numerous universities and institutions contributed to the research.

The report presents the environment as a system of reservoirs and natural cycles of all sorts of substances which circulate within and between these reservoirs. Intervention by man has disrupted many of these processes profoundly. In order to promote understanding of the system and of the consequences of these disruptions, "Concern for Tomorrow" distinguishes five levels of scale: local (the development environment), regional (the landscape), fluvial (the basins of rivers and coastal seas), continental (air and ocean currents), and global (the higher air layers). Each level has its "own" problems, yet they all affect each other. Local problems can contribute to problems at "higher" levels. And conversely, global problems have effects all the way down to the local level. The higher the scale level, the longer it takes before these problems become clear. But also, the more difficult it is to do something to counter them and the longer it is before such counter-action has an effect.

Acid rain provides a good example. Warnings regarding their risks appeared as long ago as the last century. In the 1960's when energy consumption had increased sharply, acidifying substances (especially sulphur dioxide) were already causing health problems at the local level (respiratory disorders). In response, people began to build taller stacks. And the result was that the acidifying substances were precipitated hundreds of kilometers away, for example in Scandinavia, where they made lakes unlivable for fish and other organisms. However, it was a long time before reports about this phenomenon were taken seriously. By then, all kinds of other consequences had become clearly visible: dead trees, and damage to agricultural crops, buildings and cultural property all over Europe. The problem, then, had been lifted from the local to the continental level, which has not made it any easier to solve.

The environment can tolerate a certain amount of rough handling, but continuous overburdening exhausts its capacity to recover. And the longer and more intense the assault on the environment's health, the longer and more difficult is recovery. Exactly the same as with someone wounded or ill who goes too long without treatment.

The growth in scientific and technical knowledge since the Industrial Revolution, about 200 years ago, has made it possible for mankind to make use of ever increasing amounts of natural resources. We assume that these resources, the formation of which took a very long time, are inexhaustible. And we take too little account of the negative environmental consequences in the long term. Examples:

- Deforestation is consuming the "reservoirs" of centuries in a short time;
- Soil erosion and peat depletion are exhausting "reservoirs" of millennia at a rapid pace;
- The formation of fossil fuels (oil, gas, coal and lignite) and mineral raw materials (such as metals) required tens to hundreds of millions of years, but current consumption is racing through the existing reserves at an incredible speed.

This rapid exhaustion is accompanied by enormous amounts of pollution, which are affecting essential aspects of the composition of the atmosphere, soil and water in a harmful way. What the consequences of this will be is to a large degree still unknown. This is also true for the consequences of massive extinction of plant and animal species. But there are enough signals to warrant sounding the alarm, to have "Concern for Tomorrow".

Brundtland: Towards Sustainable Development

Concern about the future quality of the environment is not limited to our country. In 1987, before "Concern for Tomorrow", the important report "Our Common Future" was issued by a special United Nations commission. This commission consisted of individuals from both "developed" and "Third World" countries. "Our Common Future" is also referred to as the "Brundtland report", after the commission's chairwoman, the current Prime Minister of Norway, Mrs. Gro Harlem Brundtland. The report concludes that the most significant threat facing humanity is development characterized by increasing numbers of poorer people and simultaneous deterioration in environmental quality. Projections indicate that the world's population will double in the near future. Ninety per cent of that growth will occur in the poorest nations (and 90 per cent of that will be concentrated in already overpopulated cities). What will this mean to the economy? Industrial production has already grown fifty-fold during this century; 80 per cent of this growth has occurred since 1950.

What will the expected five-fold or even ten-fold growth in economic activity mean for the environment, which is not becoming larger but is becoming increasingly dirty? Acid rain, the hole in the ozone layer, the "greenhouse effect", the enormous erosion of fertile agricultural land, and the extinction of plant and animal species are only some of the numerous threats that "Brundtland" records.

The commission makes the important observation that the environmental, development and energy crises are all part of a whole. None of these crises can be resolved unless solutions are also found for the others. The solutions are dependent on one another.

Based on this, "Brundtland" formulates the goal of sustainable development: development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The commission notes that world ecology and world economy are becoming increasingly tightly interconnected. But the perspective has also changed. We used to look with concern at the detrimental effects of economic growth on the environment. Now it is high time to concern ourselves with the disastrous consequences for the economy of environmental destruction.

In order to promote both global justice and environmental protection, the Third World must be granted the opportunity to grow economically— in an environmentally responsible manner. An important facet in this is the creation of fair international trade conditions.

Drastic measures are also needed in the energy area. Economic growth must be coupled with increasingly lower energy use. Ultimately, according to the Brundtland report, current energy use in the industrialized nations must be reduced by 50 per cent. The "Third World", however, has a right to substantial growth in its energy use in view of its enormous economic disadvantage. The developed world must—in its own interest—play a role in meeting the challenge of sustainable, environmentally responsible production.

Drastic measures are also needed to curb the rapid growth in population. "Brundtland" notes, too, that a more equitable distribution in welfare can provide part of the solution.

The Dutch National Environmental Policy Plan

The reports mentioned above indicate, then, that it is high time for rigorous measures. They form the basis and the point of departure for the National Environmental Policy Plan (NEPP). The NEPP is a strategic plan directed at the long term: 1990-2010.

It sketches the main features of the environmental policy which the government believes is necessary in order to be able to achieve sustainable development.

The NEPP notes that the nature of environmental problems is that they are becoming increasingly larger in scale.

In years gone by, the problems involved were largely local and regional (noise, odor, local water pollution and so forth); now we are also confronted with global problems such as the hole in the ozone layer and the greenhouse effect.

And where the damage used to be limited to health effects and impacts on nature, nowadays the essential social and economic functions of the environment are at stake. As environmental problems become larger scale and more fundamental, the realization of solutions requires more effort, more money and more time.

Some effects will never be able to be undone: the extinction of plant and animal species, the loss of the tropical rain forests, and the desolation of certain regions (desertification).

According to the NEPP, the causes can be traced to:

- the breaking open of cycles;
- the more intensive use of energy;
- the emphasis on quantity, leading to neglect of quality considerations in production processes and products.

Environmental problems are also rolled off constantly to other people, other places and the future. It starts out small (neighbourhood noise, emptying car ashtrays on the street, dog litter), but at the other end of the spectrum there is raw materials waste, the pollution of areas from Alaska to Antarctica, the dumping of chemical waste in the Third World.

This roll off leads to sizable "environmental loans" on a worldwide scale. The current generation is consuming huge amounts of energy and other raw materials, leaving (chemical) waste belts behind everywhere, destroying fertile regions, chopping down unique rain forests, heating up the atmosphere, creating a hole in the ozone layer. All of this poses serious dangers to the pursuit of sustainable development.

How will the NEPP turn this disastrous development around? To begin with, the following well-known premises will be adhered to in initiating and assessing new developments:

- stand still principle: environmental quality may not deteriorate;
- abatement at the source: remove causes rather than ameliorate effects: these source-oriented measures are determined on the basis of effect-oriented norms (the goal determines how stringent the measures must be);
- polluter pays principle;
- application of best practical means in abating pollution (preventing unnecessary pollution);

- carefully controlled waste disposal;
- internalization: motivating people to good environmental behaviour.

The core of the new approach which must lay the basis for sustainable development is:

- closing substance cycles (including product life-cycle management): the chain from raw material through production process to product and waste must contain as few "leaks" as possible which cause energy and raw material losses and environmental pollution;
- conserving energy, together with improving the efficiency and utilization of renewable energy sources (solar, wind and water power);
- promoting the quality of production processes and products.

In addition to controlling detrimental environmental effects as such, the NEPP also wants to reduce the chances of negative effects occuring (risks). The norms being established to that end will take into account the health of people, environmental functions and nature values.

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Major Goals for Each Level of Scale

Globally, the growth in concentrations of climate influencing substances must be brought to a halt by 2010 (and that in substances which damage the ozone layer sooner). To this end, emissions of carbon dioxide must be reduced by 90 per cent in the industrialized nations (assuming an equitable distribution in per capita emissions among the world population).

The emission of substances which damage the ozone layer must be stopped completely before 2000. Decreases in the area of tropical rain forests must be halted well before 2000.

For the time being the Netherlands is striving to stabilize $C0_2$ emissions in 2000 on the 1989/1990 level. In addition industrialized countries will in due time possibly decide on joint, substantial reductions of CO_2 for the first coming decades of the next century.

Continentally, reductions on the order of 80 or 90 per cent are needed in emissions of acidifying substances, certain hydrocarbons and poorly or non-degradable substances (such as heavy metals, certain hydrocarbons, pesticides). These reductions are necessary, *inter alia*, for the conservation and recovery of healthy forests.

Fluvially, measures are needed to preserve and restore safe drinking-water supplies without high costs for purification, swimming water, fish cultivation, and fresh and saltwater ecosystems with their characteristic animal species such as seals, otters, badgers, salmon and pike.

In order to achieve these goals, emissions of eutrophying poorly or non-degradable substances must be reduced by 90 percent. Measures are also needed to reduce the change of calamities on or near rivers and at sea.

Regionally, substantial reductions (70 to 90 percent) in emissions of acidifying, eutrophying and poorly degradable substances must also take place before 2010. The quantity of waste (*inter alia* through reuse) must decrease by 70 to 90 percent.

Extra measures are needed to preserve dunes and meadows on peat soils, for which the Netherlands bear a special responsibility. The chance of large-scale accidents in factories and during transportation of hazardous substances must be reduced to the point where the risks are acceptable.

Locally, sharp reductions are also needed in emissions of environmentally hazardous substances and in noise and odor production. These reductions must improve the quality of the daily living environment.

Measures

As already noted, measures at the same source are to be preferred to measures which ameliorate negative affects. After all, an ounce of prevention is worth a pound of cure. There are three kinds of source-oriented measures:

- Emission-oriented: emissions of pollutants and waste production can be reduced with extra equipment ("end-of-pipe" techniques); the production process itself does not change;
- Volume-oriented: less raw materials are used and fewer products are made as a result of policy measures; the production process itself does not change;
- Structure-oriented: production and consumption processes are changed structurally (for example, through more economical or cleaner technologies).

The kind of measures required (emission, volume or structure-oriented) depends on the nature of a given environmental problem as well as on the objective to be achieved. In general, the emphasis will continue to be on emission-oriented measures during the period until 1994. However, these measures will not be sufficient to achieve the goals set.

A disadvantage of using extra equipment is that it does not really contribute to sustainable development: cycles are not closed; often even more energy is used; and no contribution to improved product quality is made.

Structural source-oriented measures offer better prospects, but their development and implementation usually require a lot of time. As a consequence, volume-oriented measures may also be needed in the period until 2010.

The NEPP also formulates goals for achieving sustainable development with the help of structural measures jointly referred to as integrated life-cycle management:

- Considerable savings in use of raw materials (20-30%) by 2010 (through more economical use and better utilization of wastes); in 2010 the use of renewable raw materials (wood, agricultural products) must be at a level which makes renewal sustainable;
- The use of finite energy supplies in 2000 may not exceed its current level; in industrialized countries conservation of several tens of percents must be realized in 2010;
- The pursuit of quality improvement must double the length of time that raw materials, capital goods and products remain in the economic production and consumption cycle and they must be reusable as raw materials in their waste phase.

Needed: Time, Economic Support and Instruments

Instruments and measures are needed in order to be able to achieve the objectives described above and they must be affordable. It also takes time to institute the necessary measures. These, then, are the basic ingredients for a good environmental policy.

In principle there is a very broad set of instruments available to the government. First of course, are legislation and regulations. Adequate control of compliance with these laws and regulations ("enforcement") is then essential for the credibility and effectiveness of the environmental policy promulgated.

Strict adherence to a principle such as the polluter pays (including a detailed system of environmental liability) is also an efficient instrument which at the same time provides an incentive effect. This is just one of the numerous financial possibilities which the government can use in stimulating environmentally friendly behaviour. Fiscal measures are another of those financial possibilities.

Internal corporate systems of environmental concern can also play a positive role in prompting firms to integrated and "internalized" environmental behaviour.

Setting environmental standards for products and promoting or requiring the provision of clear product information can help to encourage environmentally aware choices in a more general way. Environmental public information can create the right "acceptance framework" for all these measures.

Influencing the development of technology is also an important instrument of environmental policy. Many environmental problems can be solved through prevention "on the drawing boards". Such an approach is not only more elegant; it is also less expensive. It requires governmental efforts in the areas of research, schooling, increasingly strict standard setting, public information and, of course, financing, among others.

Three scenarios have been analyzed to provide insight into costs of the environmental policy desired. Current environmental policy is continued increase from Dfi. 7 billion (in 1985) to Dfi. 16 billion in 2010. This is then 2 per cent of Gross National Product (GNP).

Scenario II is based on the maximum introduction of emission-oriented measures. Such a policy would incur annual costs of Dfi. 26 billion in 2010, which would amount to about 3 per cent of GNP.

Scenario III reflects an environmental policy which not only includes emission oriented measures, but also focusses on a fundamental, structural approach to problems with an eye to sustainable development. In the first instance, this is the most expensive scenario with annual costs of about Dfi. 57 billion.

However, these costs are offset by "compensating effects": fewer emission oriented measures are required. Energy conservation, for example, is not only good for the environment but it also generates financial savings.

The total compensating effect could amount to Dfl 20 billion annually based on current trends in the development of fuel prices. If energy prices will rise, this figure could add up to 30 billion.

In this case just described, the following structural measures, among others, would be taken:

- far-reaching energy conservation; less car driving, more public transportation;
- fewer beef cattle, but a greater yield per animal;
- efficient use of raw materials and their recovery from waste in industry and agriculture as well as in households;
- product quality improvement.

"Concern for Tomorrow" concludes that structural changes or reductions of production and consumption are needed. A start towards making these changes must be made during the period 1990-1994. Implementing them, however, will take time.

The most urgent problems, therefore, must be ameliorated now through maximum utilization of the existing technical means. In the meantime, the instruments of environmental policy must ensure that technological development, investments and consumption expenditures move in the direction of the structural changes desired.

Further, the Netherlands will strongly urge the other EC countries, in any case, to take the same environmental measures.

After all, most environmental problems are international in character. And distortion of competition must also be prevented as much as possible.

The Main Elements

Environmental policy can be divided into a number of themes. Certain measures are needed in each theme.

Climate change is a new theme. Carbon dioxide emissions must be reduced in order to control the heating up of the atmosphere (and with it the "greenhouse effect"). The objective for 2000 is that carbon dioxide emissions may not increase above their 1990 level.

This requires limiting energy use among other things. In particular traffic, heating systems and electricity producers will have to contribute to this. Even more extreme measures are needed until 2010, especially in an international context.

A complete elimination of CFC emissions is necessary in order to leave intact the protective ozone layer around the Earth.

Acidification will have to be abated largely with numerous emission-oriented measures during the coming years. Examples: three-way catalytic converters on cars, extra fuel gas desulfurization at coal-fired power plants, working manure directly under the soil and large-scale manure processing. The measures must ensure that healthy forests can grow, in any event on the richer soils, in the year 2000.

In order to reach that goal, not only emission-oriented measures but also effect-oriented measures will be needed in forests and nature areas. To be on the safe side, deposition in the areas should not exceed 400-700 "acid equivalents" per hectare per year. On a level of deposition of 1400 acid equivalents the most serious effects acidification can be avoided. The NEPP sets an interim objective for the year 2000 of a maximum of 2400 acid equivalents.

Eutrophication is a problem that is caused mainly by industry, agriculture and animal husbandry. With respect to agriculture, the NEPP is aiming for structural measures which must ensure a "fertilizer balance".

No more phosphate and nitrate may enter water and soil than can be absorbed again via natural processes. To give a concrete example: this means that groundwater must satisfy the standards which apply to the preparation of drinking-water.

And because policies still have not resulted in adequate reductions in surface water eutrophication (over fertilization) despite great efforts, installations to remove nitrate and phosphate from waste water must be constructed at sewage treatment plants.

Diffusion of substances in the environment also receives a great deal of attention in the NEPP. The current policy is being continued and intensified. A "screening test" is being introduced for new substances in order to be able to asses their possible risks in an early stage and to take measures.

This can, moreover, contribute to a "products policy": products as such will also be assessed on their environmental aspects in the future. A great deal of attention is being devoted to controlling the diffusion in the environment of "priority", especially harmful substances such as cadmium and solvents. In cooperation with industry, preventive and process integrated measures will be taken to this end. This policy must ensure that no more unallowable risks exist in 2000.

Disposal is the theme directed at reducing waste generation and at environmentally responsible processing or recycling of that waste which is still generated. The concrete goal for 2000 is that only a maximum of twelve million tons will be dumped or incinerated and that waste which is produced in the Netherlands will also, in principle, be processed here. This will require very sizable efforts. Concrete and drastic plans will have to be drawn up and implemented jointly with private industry.

Such plans must be made in the short term for used oil, building and demolition waste, halogenated hydrocarbons, bottom and fly-ash from coal-fired power plants, shipping waste, purification sludge and hospital waste. Supplementary measures will be taken if implementation of the plans falls behind the objectives. Possibilities include raising dumping tariffs gradually and a more stringent permitting policy.

Disturbance pertains to odor, noise nuisance and risks. The current policy in this area will be continued. This means that structural measures will be taken in addition to effect-oriented measures such as the construction of biofilters and noise walls. In a number of cases process integrated measures will be able to prevent odor as will, for example, zoning of industrial sites and "quieter" motors can reduce the noise load. The concrete policy goal for odor in the year 2000 is that the number of dwellings at which "odor nuisance" is suffered must be no greater than 750,000. The number of people experiencing noise nuisance in 2000 may be no higher than it was in 1985.

The chance of accidents involving industrial installations and transportation of hazardous substances must be reduced considerably by 2000 to an acceptable level.

Dehydration-policy is aimed at extensification of groundwater use to avoid drying out of soils on local or regional levels of scale. Dehydration is caused by supplying the large demands for water of domestic use, industry and agriculture. Aims are set on limiting the area showing signs of dehydration to the 1985 level. Water use should then be in balance with the capacity of the sources.

In the *anti-squandering policy* the environment is considered as stocks. Aims for the year 2000 are set on inventorising environmental resources (such as raw materials, energy, clean water and fertile soils) and making a strategy on environmental resources management. Feedback at the source will be developed. This means that necessary conditions for closure of substance cycles, energy extensification and quality improvement have to be realized as soon as possible.

Target Groups

No matter how well a policy is thought out and written down, it must, of course, be implemented or else nothing happens. The target group policy, therefore, also has a central place in the NEPP: much is expected from agriculture, traffic and transport, industry (particularly the chemical industry), the energy sector, the construction branch, and drinking-water, waste and environmental production firms as well as from research institutes and organizations in society.

The NEPP is introducing consumers as a new, extremely important target group. All segments of society will be asked to make large efforts. The environmental problems warrant that. The following section presents a number of the concrete NEPP goals for each sector in the year 2000.

Agriculture

The agriculture sector has managed to achieve tremendous growth in productivity during recent years, both per hectare and in an absolute sense. The new challenge awaiting this sector is to maintain this accomplishment, but in an environmentally friendly way. Several of the concrete accomplishments which are being asked of this sector are:

- Reducing ammonia emissions in 2000 by 70 per cent (relative to 1980);
- Balanced fertilization with phosphorus and nitrogen in 2000 (via physical regulation, levies on fodder and fertilizer and working with minerals balances);
- A 50 per cent drop in use of pesticides in kg active substance by 2000;

- Experiments with screening firms and setting up manageable systems of environmental concern;
- Improvement of manure acceptance in arable farming by way of quality certification;
- Construction of manure processing plants with a joint capacity of 20 million tonnes by 2000;
- Intensification of research into sustainable agricultural methods (integrated cultivation systems, optimal utilization of manure and fodder etc.).

Traffic and Transport

The mobility of people and the transportation of goods have increased dramatically during recent decades.

In addition to numerous other effects, this has also had substantial negative consequences for landscape, nature and environment. Traffic and transportation are also accounting for an increasingly large share of the consumption of energy and raw materials.

This development must urgently be diverted. The NEPP considers the following measures, among others, to this end:

- Reducing emissions of nitrogen oxides and hydrocarbons from passenger cars by 75 per cent and those from trucks by 35 percent in the year 2000 (relative to 1980);
- Controlling the increase in carbon dioxide emissions; a 10 percent reduction must be reached by 2010;
- Equipping passenger cars with three-way catalytic converters;
- Using no more harmful substances in vehicles;
- Recycling raw materials used for 85% in the waste stage;
- Taking structural measures (such as bringing residential and work areas closer together again) to reduce the need for mobility;
- (Partly as a result) realizing a shift in the modes of transportation used: more use must be made of bicycles for distances of 5 to 10 km; the train must play a more important role for longer distances (up to 200 km). The train must "win ground" from the airplane for distances between 200 and 1000 km;
- Expanding and improving bicycle routes and public transportation; stimulate their use via, among other things, reward instruments and influencing the price mechanism (road-pricing, fiscal measures).

Industry

Industry is also a very important target group of the NEPP. However, it is difficult to describe in a few words precisely what is expected from this group since numerous, extremely different kinds of firms are involved. In broad outline, what is expected of them is that they thoroughly investigate the environmental aspects of their own operations. "Internal environmental concern" is becoming an important pillar of policy.

Sulfur dioxide emissions must in any event be reduced by 80 per cent in the year 2000. The reduction percentages for nitrogen oxides and volatile organic compounds are 45 and 45-60 respectively. Emissions of phosphorus and nitrogen into water must be halved by 1994. Waste "production" must also decrease substantially. Reuse will have to play an important role in this.

The chemical industry will play a major role in achieving these objectives. Not only is it a very large industry in the Netherlands, but it is also one which uses large quantities of hazardous substances.

Reducing the chance of serious accidents is thus also an NEPP objective in which the chemical industry must play a major part.

The energy sector will not only benefit from improved efficiency by saving money but it also reduces pollution and contributes to the fight against the "greenhouse effect".

Important concrete objectives include:

- Electric power plants will have to have achieved an 85 percent reduction (relative to 1980) in their sulfur dioxide emissions by 2000. The reduction percentage for nitrogen oxides is more than 50;
- Construct 900 MWe of cogeneration capacity before 1994 and another 1500 MWe before 2000;
- Establish systems of environmental concern in energy firms;
- Public information and subsidies to stimulate more energy conservation and the use of renewable energy sources.

Building Trade

The construction sector uses large quantities of raw materials, the reserves of which are usually not inexhaustible. Their extraction, moreover, often has major impacts on nature and landscape. The construction method and the choice of raw materials to a large extent determine the energy use and the environment in and around developed areas.

And finally, the demolition of abandoned buildings, roads etc. generates waste which can, in turn, be a burden on the environment. For all these reasons the NEPP also focusses on the construction and demolition sector. Among the things being asked are:

- Doubling the recycling of construction and demolition waste by the year 2000;
- Replacing materials whose extraction or use has serious environmental impacts;
- 25 per cent energy conservation in heating systems;
- Construction quality such that risk limit values are not exceeded in the indoor environment;
- Improving the training of and transfer of information to employees, contractors and consumers;
- Providing environmentally friendly products through the do-it-yourself branch;
- Developing environmental yardsticks, stimulating experiments, improving national government buildings.

Waste Processing Firms

The waste problem receives a great deal of attention in the NEPP — both prevention of waste production and recycling and reusing waste that is generated. Separate collection of recyclable waste components and hazardous waste can play a useful role in this.

The dumping of waste must decrease considerably. In the long term, moreover, all dumping sites must satisfy stringent environmental standards. A larger share of the waste must be incinerated; the heat generated must be put to use.

The disposal structure must be improved in order to bring these goals within reach. The same thing applies to the waste problem as to energy: everyone, every sector of society has a responsibility here.

The NEPP expects *drinking-water companies* to expand their role as environmental firms. Drinking-water quality, after all, is crucial to human health.

They must, therefore, remain vigilant for threats to the quality of their raw material-surface and groundwater. Groundwater reserves must remain well protected through the expansion of protection regions among other things. Water conservation must be undertaken by industry and agriculture and central partial water softening must be introduced.

A contribution from *environmental production firms* is expected in the area of the development and introduction of structural process integrated measures and the transfer of relevant information.

Societal organizations (including environmental organizations, labor unions and employers' organizations, women, youth and senior citizen organizations) will be asked to contribute to the NEPP goals. Environmental organizations fulfill an indispensable "antenna function" for environmental policy and play a major role in recommending ideas for structural measures. They have an important function in consiousness raising, education and the provision of public information. Labour unions and employers' organizations have an important task in setting up and expanding internal corporate systems of environmental concern. But the other organizations can also make significant contributions by adopting objectives in the fields of environment and sustainable development.

Consumers

In addition to all of these target groups, consumers as a target group have a special position. This is a target group to which everyone belongs. Environmental awareness in consumers has, therefore, a large carry over effect. Whoever acts in an environmentally friendly way at home is also more likely to do so at work or in other contexts.

A concrete example of what is expected from consumers is that they store all of their small chemical waste, tin, glass and paper separately for waste collection by the year 2000. Their electricity consumption must decrease considerably. Cars will have to be driven much less in 2000 than they would have been without directed development. Consumers are, of course, also affected indirectly by (the effects of) environmental measures being taken "elsewhere" (for example, in agriculture or in the area of traffic).

There is, then, an enormous environmental task awaiting each of the target groups mentioned, who together form the whole of Dutch society. In many cases the efforts required will not be easy. But they are necessary. Otherwise we will be behaving ourselves like people who are at a party in someone else's home, plundering the refrigerator and the wine cellar, demolishing the garden and the interior, and just walking away from the mess.

The earth is not our property. We just have it on loan from our children.

There are abundant opportunities and possibilities for sustainable development. What the issue boils down to is that we have the daring, creativity and political will to take advantage of them.

Barriers to Ecologically Sustainable Industrial Development

Excerpted from UNIDO, "Issues in support of ecologically sustainable industrial development", *Proceedings of the Conference on Ecologcally Sustainable Industrial Development Copenhagen, Denmark, 14-18 October 1991* (PI/112), pp. 15-16.

Common to both developed and developing countries are barriers to the achievement of ESID. These encompass information gaps and deficiencies, scientific, technological, professional and related institutional capacities to support the process of transition to ESID, as well as political and economic obstacles to its implementation.

Information deficiencies include limitations of data on the nature and extent of environmental degradation (physical indicators of resource depletion, as well as air, water and land pollution); limited understanding of the proximate and underlying causes of, and hence feasible remedies for, environmental degradation; and insufficient measurement of economic losses resulting from environmental degradation.

Most of the problems cited above may be more acute in some developing countries where government activity is constrained by urgent, short-term financial needs. The gathering and dissemination of information and applied research do not receive sufficient attention. Consequently, Governments have inadequate information on the nature, magnitude, causes and consequences of environmental degradation; furthermore, because of low economic and technological capacities of their countries, they often lack access to non-commercial and non-profit technical information to deal adequately with pollution-related problems.

Obstacles to ESID-related measures are numerous. Heading the list of such obstacles are conflicts between short-term economic costs and long-term economic benefits of environmental protection. Regulatory and monitoring capacity and skilled personnel may not be sufficient for dealing with new problems. Small and medium-scale industries have limited information and lack the skills and capital needed to implement Cleaner Production processes. Political and social constraints often limit the setting of economically appropriate prices for water, energy and raw materials. States may ignore the consequences of industrial activity that result in damage begin done outside of their borders. Finally, the poor, disadvantaged and vulnerable tend to suffer most from environmental degradation, but lack the political influence required to bring about the introduction of remedial measures.

Obstacles to the implementation of ESID-related measures are intensified in developing countries. Weak institutional capacity, particularly the ability to implement and coordinate programmes, and shortages of skilled personnel are major problems in developing countries. Even if existing industry wanted to invest in more environmentally sound technologies, it would often be faced with financial constraints. The scarcity and high cost of capital may preclude importing those technologies, even if the investments are economically justified. Lastly, a sizeable portion of the population lacks the awareness, education and experience needed to deal with environmental problems, and the few non-governmental organizations (NGOs) that are involved in such matters lack political influence.

More importantly, developing countries are faced with particular difficulties in achieving ESID. One barrier can be in part traced to their indebtedness, which results in shortages of capital needed to finance Cleaner Production processes. Another is their limited capacity to absorb Cleaner Production practices, which is attributable in part to their lack of technical and scientific capacity. A third is the potential risk of new non-tariff barriers emerging as a side-effect of new environmental measures that, in effect, close markets to exports from developing countries. Keeping markets open to manufactured products from developing countries will provide such countries with better conditions for the repayment of debts to developed countries.

Accounting for Environmental Effects at the National Income Level

Excerpted, with permission, from *Environmental Accounting: Current Issues, Abstracts and Bibliiography* (United Nations publication, Sales No. E.92.II.A.23), chap. VII.

Environmental issues in national income accounting reflect many of the same concerns as corporate accounting. Those who seek to improve accounting for the environment at the corporate level can learn from the attempts to adjust national accounts to reflect environmental costs.

The United Nations System of National Accounts (SNA), first developed in the 1950s, is cited by economists as one of the major social inventions of the century. The SNA is followed by many countries in developing their national economic statistics. Economic decisions are often made on the basis of resulting gross domestic product (GDP) statistics or other measures of national income. However, such measures largely ignore the productive role of natural resources. Critics of policy-making based on SNA measures assert that integration of the environment into economic indicators is of great importance, since the lack of systematic, integrated environmental indicators is likely one reason why such factors are given little emphasis in economic decision-making.

There are numerous criticisms of GDP as a measure of welfare or national prosperity. The two most frequent criticisms related to the environment involve the scarcity of natural resources and the consequences of environmental damage. First, although man-made assets are valued as productive capital and are depreciated against income; natural assets are not so valued, and their loss entails no charge against current income. A country could exhaust mineral resources, cut down forests, erode its soils, pollute its aquifers and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these assets disappeared. Rapid economic growth from exploitation of resources results in illusory income gains and permanent losses in wealth.[1]

Second, while environmental damage is not included as a cost to national income, remediation expenses are accounted for as increases in national income and products, despite the fact that such outlays should

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[1] Repetto, R., "Wasting assets: the need for national resource accounting", *Technology Review* (Cambridge, Massachusetts) 93(1):38-44, January 1990.

be considered as a maintenance cost to society rather than social progress.[2] The national income treatment of clean-up expenses is inconsistent if they are expended by Government, industry or individuals.[3]

Political and economic leaders have recognized the need to improve national income reporting. The United Nations' World Commission on Environment and Development (Brundtland Commission) declared in 1987 that economic development must take full account in its measurements of growth of the improvement or deterioration in the stock of natural resources.[4]

Several countries have experimented with production of environmental national accounts. Germany has established physical accounts for energy supply and use.[5] In France, general principles and methods of natural resource accounting, and pilot accounts, have been produced both on the national and corporate level, but practical implementation has not yet been achieved.[6] Italy produces environmental statistics and is working on an accounting system. Japan has calculated a measure of net national welfare for 1955-1985, which subtracts the costs of remediation of pollution above certain standards.[7] Norway has published physical environmental accounts annually since 1978.[8] Other countries and international organizations have also experimented in producing environmental statistics or accounts. A case study of Indonesia reduced GDP growth from 7.1 per cent using traditional methods to 4.0 per cent for 1971-1984, using environmentally adjusted accounts, a depletion rate of 14 per cent of GDP.[9] A study of Costa Rica indicated a depletion rate of natural resources which totalled 5.7 per cent of GDP.[10]

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[2] Bartelmus, P., "Accounting for sustainable growth and development," *Structural change and economic dynamics* (Oxford) forthcoming

[3] Repetto, R., "Wasting assets: the need for national resource accounting." *Technology Review* (Cambridge, Massachusetts) 93(1):38-44, January 1990.

[4] World Commision on Environment and Development (WCED), *Our Common Future,* Oxford and New York, Oxford University Press, 1987.

[5] Leipert, C., and Simonis, U. E., "Environmental damage—environmental expenditure 1: statistical evidence on the Federal Republic of Germany", *The Environmentalist* (Middlesex, United Kingdom) 10(4):301-309, 1990.

[6] Theys, J., "Environmental accounting in development policy: the French experience", *Environmental accounting for sustainable development,* Ahmad and others (eds.) Washington, D.C., The World Bank, 1989. p. 40-53.

[7] Uno, K., "Economic growth and environmental change in Japan—net national welfare and beyond", Tsukuba, Japan, Institute of Socioeconomic Planning, University of Tsukuba, 1988.

[8] Norway, Central Bureau of Statistics, *Natural resource accounting and analysis: The Norwegian experience,* 1978-1986. By Alfsen, K.H., Bye, T., and Lorentsen, L. 32p.

[9] Repetto, R., "Wasting assets: the need for national resource accounting", *Technology Review* (Cambridge, Massachusetts) 93(1):38-44, January 1990.

[10] Bartelmus, P., "Accounting for sustainable growth and development", *Structural change and economic dynamics* (Oxford) forthcoming

The emphasis in most countries has been on information regarding physical quantities, rather than information provided in money terms. However, the United Nations has been reviewing the SNA for several years, in part to incorporate environmental concerns. The present revision of SNA will not include major revisions; it will recommend linked satellite accounts to deal with environmental issues. No consensus has yet been reached on the optimal ways to reflect environmental concerns in the SNA.

Further information may be obtained from:

Environment and Energy Branch, UNIDO
Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49

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Learning Unit 8

SOURCES OF INFORMATION ON CLEANER PRODUCTION

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

Additional Course Materials

Floppy disc: MICRO-METADEX$^{\text{PLUS}}$ and ICPIC case studies

Introduction

Learning Unit 8 introduces various sources of information that you may use to obtain further information about Cleaner Production. As you might imagine, there is a wealth of information available from UNIDO and UNEP, from other international organizations, from NGOs such as industry associations and environmental organizations and from national organizations.

Objectives

The specific learning objectives of this unit are as follows:

- To introduce a variety of sources of information relevant to Cleaner Production issues, including organizations, contacts and databases.
- To provide practice in using UNIDO and UNEP databases that provide industry-specific information about Cleaner Production.

Key Learning Points

1 UNIDO information on industry and technology is available through the Industrial and Technological Information Bank (INTIB).

2 INTIB has developed an Energy and Environment Information System (EEIS).

3 INTIB maintains a database on energy and environmental issues for industry called Referral Database on Energy and the Environment (REED).

4 The UNIDO book *Industry and Environment: A Guide to Sources of Information explains how to organize a search for environmental information.*

5 The Industry and Environment Programme Activity Centre (IE/PAC) of UNEP maintains a database and enquiry service on Cleaner Production, the International Cleaner Production Information Clearinghouse (ICPIC).

6 ICPIC issues several publications, including a quarterly newsletter, *Industry and Environment*, a biannual newsletter, *Cleaner Production* and many technical reports on Cleaner Production.

7 The World Industry Council for the Environment (WICE) was initiated by the International Chamber of Commerce to raise environmental awareness and concern on the part of industry in both developed and developing countries. It published the book From Ideas to Action: Business and Sustainable Development and issues a quarterly newsletter.

8 The International Network of Environmental Management Organizations (INEM) is a global network of independent business organizations devoted to environmental education and problem solving. It publishes a bulletin every two months.

9 The Business Council for Sustainable Development was set up to present a global business perspective on sustainable development at the United Nations Conference on Environment and Development (UNCED). It produced the book *Changing Course: A Global Business Perspective on Development and the Environment, and continues to be a source of environmental information.*

10 The United States Environmental Protection Agency (USEPA) maintains the Pollution Prevention Clearinghouse, offers many publications, including the free monthly newsletter *Pollution Prevention News*, and supports a pollution prevention research branch that is producing a series of industry-specific pollution prevention guidance manuals (16 to date).

11 Several other international and national institutions and professional associations, described in the *Study Materials*, also provide information on Cleaner Production.

12 Given such a large mass of information, the key to an effective search is to define the query carefully.

Suggested Study Procedure

1 **Take the test in the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.**

2 **Work through the *Study Materials*, including the *Reading Excerpts*. Prepare answers to the questions and check your answers against those suggested.**

3 **Work with the demonstration data sets in the *Case Studies*.**

4 **Complete the exercises in the *Review*.**

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Study Materials

Obtaining information about Cleaner Production is largely a process of sorting through the almost endless variety of sources that are available to you. UNIDO, UNEP and many other organizations maintain databases that you can tap. There are books, periodicals, newsletters, bulletins and special reports available on just about any topic imaginable, from the general to the very specific. You can, for example, read the book *Changing Course*, which offers a global business perspective on development and the environment. Or, for very specific information, you can search the Industrial Development Abstracts (IDA) database of UNIDO for pollution prevention opportunities for a given application such as textile dyeing and finishing.

This Learning Unit first introduces you to sources of information within UNIDO and UNEP IE/PAC. It then briefly describes some of the other information sources available to you. While it is impossible to present an exhaustive list of all the available information sources, the discussion should at least familiarize you with a broad range of sources that you may consult. It then suggests an approach that you might use in organizing a search for specific types of information. It concludes with sample data searches based on databases available from UNIDO and UNEP.

Recommended Starting Points

Where you first turn to for information should depend on your purpose. You may want to learn more about Cleaner Production. You may want to keep up with the latest news about Cleaner Production. Or you may want to search for detailed information about a special topic.

If you simply want to broaden your understanding of Cleaner Production, we recommend the following books:

- Schmidheiny, S., *Changing Course: A Global Business Perspective on Development and the Environment* (Cambridge, Massachusetts, MIT Press, 1992).
- Willums, J.O., and U. Goluke, *From Ideas to Action: Business and Sustainable Development* (Oslo, International Environmental Bureau, 1992).
- Smart, B., ed., *Beyond Compliance: A New Industry View of the Environment* (Washington, D.C., World Resources Institute, 1992).
- Winter, G., *Business and the Environment* (Hamburg, McGraw-Hill, 1987).

If you want to keep up to date with the latest developments in Cleaner Production, we recommend that you subscribe to, or at least read regularly, the following periodicals:

- *Environmental Awareness Bulletin*, issued monthly by UNIDO.
- *Cleaner Production*, issued twice a year by UNEP.
- *Industry and Environment*, issued quarterly by UNEP.
- *Pollution Prevention News*, issued monthly by USEPA.
- A WICE newsletter to be issued quarterly.
- *Pollution Prevention Review*, published by Executive Publishers.
- *Journal of Cleaner Production*, published by Butterworth-Heinemann.

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If you want to carry out a detailed search, you will first want to think carefully about your information needs. You can then draw on any of the information sources mentioned. In most cases, we suggest that you begin your search by contacting INTIB at the address and telephone numbers listed below.

Sources of Information

United Nations Industrial Development Organization

Once you are ready to begin your information search, you can look to a myriad of sources. One of your first should be UNIDO. You can direct questions to INTIB, the Industrial and Technological Information Bank of UNIDO:

INTIB
UNIDO
P.O. Box 300
A-1400 Vienna
Austria

Telephone: (43-1) 21131/3705
Fax: (43-1) 230 7584
GE QUICK-COMM:
AAQ0001IB@UNIDO
EARN/BITNET:
pkepp@unido1.bitnet

INTIB draws on many sources of information, all of which can be used on your behalf; some of them are available for your use directly in the field.

- The Referral Database on Energy and Environment (REED) of INTIB contains industrial environmental information input by UNIDO staff from, *inter alia*, publications, other specialized databases, conference notifications and directories. REED is used by INTIB staff at Vienna to respond to your questions.

- The Industrial Development Abstracts (IDA) database of INTIB is a major source of information on UNIDO industrialization activities in developing countries. Environment-related projects are included. Much of the work is unique and unpublished elsewhere. The IDA database contains over 22,000 fully indexed abstracts of UNIDO documentation, including major studies and reports, technical assistance reports and proceedings of expert working groups, workshops and seminars. Copies of the reports in the IDA database are available on paper or microfiche. For use in the field, subsets of the database, including search software, are available on floppy disc for IBM-compatible PCs. One subset is specifically on UNIDO projects with environmental components.

- INTIB has special arrangments with several commercial databases on industry- and environment-related issues. Subsets of Metals Abstracts (METADEX), Engineered Materials Abstracts and the Materials Business File containing information on Cleaner Production and other environmental issues relating to the metallurgical and plastics/ composites industries are available for use in the field. Search software is included. Sample METADEX records are included on the floppy disc accompanying this Learning Unit. Contact INTIB for further information.

INTIB issues monthly the *Environmental Awareness Bulletin, an informal bulletin highlighting industry-related environmental activities. For information, write to the Editor, Environmental Awareness Bulletin,* c/o INTIB, UNIDO. The INTIB quarterly newsletter, *INTIB Net,* also contains environment-related news items from time to time.

INTIB has developed an information network of over 80 national and 4 regional focal points in direct contact with INTIB at UNIDO headquarters. These focal points promote the diffusion of industrial and technological information within their own countries or regions. An international referral system is being established whereby queries received by the focal points will be redirected to a wide range of well-targeted sources of industrial and technological information. The sources will respond directly to the requestor. For a list of the focal points, write to INTIB.

To improve the availability of information on clean technology and ecologically sustainable industrial development to small and medium-size industries in developing countries, INTIB has established the Energy and Environment Information System. In participating countries, INTIB will select an institution with proven capabilities in information management and good links with industry to serve as a primary contact point. Other organizations that are in close touch with small and medium-size industries will serve as secondary contact points. INTIB is discussing details with institutions in 24 countries. A list of participating countries can be obtained from INTIB.

UNIDO has prepared a number of publications in the environment area. These include *Proceedings of the Conference on Ecologically Sustainable Industrial Development* (Copenhagen,

1991) and the book *Industry and Environment: A Guide to Sources of Information.* Another UNIDO publication on Cleaner Production of particular interest is *Energy Conservation in Industry, the first in the INTIB Energy and Environment Series. Contact INTIB for further information.*

UNIDO, the World Bank and IE/PAC are jointly developing pollution prevention and abatement guidelines for a number of industrial sectors. The first publications in the series cover the cement, textiles, chlor-alkali, leather tanning, pulp and paper, iron and steel, copper and nickel, aluminium, petroleum refining, pesticides, fertilizers and cane sugar manufacturing sectors; they will become available in early 1994. The target audience for these guidelines is project personnel in investment and development institutions as well as individuals who wish to familiarize themselves with the key environmental aspects of a specific industry sector.

Next Steps

1 Read about the UNIDO Energy and Environment Information System, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Look over the sample page of the *Environmental Awareness Bulletin*, also included in the *Reading Excerpts*.

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What is the main source of information on UNIDO industrialization activities in developing countries?

2 What does the IDA database contain?

3 What are some of the barriers facing an information system that targets small and medium-size industries in developing countries?

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4 What is the target group for EEIS?

5 How will the EEIS project reach out to small and medium-size industries?

Answers

1. Industrial Development Abstracts (IDA).

2. The IDA database contains over 22,000 abstracts of UNIDO documentation, including major studies and reports, reports resulting from UNIDO technical assistance activities, reports and proceedings of expert working groups, workshops and seminars and publications in series.

3. Small and medium-size industries in developing countries do not want to pay for information, the information available is not relevant to their problems or they lack modern communication equipment.

4. Small and medium-size industries in developing countires.

5. Through a network of secondary contact points (trade associations, chambers of commerce etc.) organized around a primary contact point in the country.

United Nations Environment Programme

The Industry and Environment Programme Activities Centre (IE/PAC) of UNEP in Paris was created in 1975 to help industry and Governments to incorporate environmental critieria into industrial development. It maintains an on-line information clearinghouse, produces several publications related to Cleaner Production and conducts training activities around the world. For information on all the services, products and publications described below, contact IE/PAC at the address given.

The computerized on-line International Cleaner Production Information Clearinghouse (ICPIC) of IE/PAC contains message centres, bulletins providing the latest news about Cleaner Production worldwide, a calendar of events (conferences, training seminars and workshops), a case-study database with over 600 entries, descriptions of country and corporate Cleaner Production programmes and a bibliographic database holding hundreds of Cleaner Production document abstracts. ICPIC is accessible free-of-charge to anyone by telephone/modem connection. For information on how to access this database, contact IE/PAC at its Paris address. Sample ICPIC records are included on the floppy disc included with this Learning Unit.

IE/PAC publications include the following:

- A quarterly review, *Industry and Environment*, which reports examples of environmentally sound management in industry.
- A biannual newsletter, *Cleaner Production*, which provides news of activities related to Cleaner Production.
- Various technical reports and documents, such as *Climate Change and Energy Efficiency. Other UNEP reports of interest include Tanneries and the Environment: A Technical Guide* and *Audit and Reduction Manual for Industrial Emissions and Wastes.* The last two were produced jointly with UNIDO.

IE/PAC training activities related to Cleaner Production include workshops and seminars that are organized at the request of Governments, industry and academia. One of its recent training projects is a Cleaner Production Programme in China, requested by the Chinese Environmental Protection Agency and sponsored by the World Bank.

To facilitate the collection and dissemination of information and to provide continuing input on the direction of its Cleaner Production programme, IE/PAC maintains a number of working groups. These include industry working groups for leather tanning, textiles, metal finishing, pulp and paper and biotechnology as well as working groups on data management, education, policies and strategies.

Inquiries may be directed to:

UNEP IE/PAC Tour Mirabeau 39, Quai André Citroën F-75739 Paris, Cedex 15 France	Telephone: (33-1) 44371450 Fax: (33-1) 40588874
UNEP P.O. Box 30552 K-Nairobi Kenya	Telephone: (2542) 621234 Fax: (2542) 226886

Next Steps

1 Read selections from the brochure *ICPIC*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Look over the sample pages *Industry and Environment* and *Cleaner Production*, also included in the *Reading Excerpts*.

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 List some publications of IE/PAC.

2 Who can request training activities related to Cleaner Production from IE/PAC?

3 What does ICPIC contain?

Answers

1. *The periodicals* Industry and Environment *and* Cleaner Production *and the book* Climate Change and Energy Efficiency.
2. *Governments, industry and academia.*
3. *A message centre, bulletins, calendar of events, case studies, programme summaries, on-line bibliography, directory of contacts and topical conferences.*

World Industry Council for the Environment

The World Industry Council for the Environment (WICE), which replaces the International Environment Bureau, was created in 1993 at the initiative of the International Chamber of Commerce. It represents the interests of over 90 of the world's leading companies committed to improving environmental policy and dedicated to the principles of sustainable development.

The core of the WICE programme is the activities of its task forces, which bring together academic and corporate experts on themes such as environmental reporting, energy efficiency in industry and technological cooperation.

WICE has two objectives: to promote cost-effective and sound science-based policies and to be a catalyst for change within corporate environmental management.

WICE has close links with Governments and intergovernmental organizations and publicizes business achievements in environmental management.

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A free quarterly newsletter is available from WICE. It contains editorials, position papers, in-depth analyses and research information on enivonmental topics addressed by WICE task forces.

Inquiries may be directed to:

WICE
40, cours Albert 1er
F-75008 Paris
France

Telephone: (331) 49 53 28 91
Fax: (331) 49 53 28 89

Next Steps

1 **Look over the sample page of *WICE Newsletter*, published by WICE, included in the *Reading Excerpts* at the end of this Learning Unit.**

International Network for Environmental Management Organizations

The International Network for Environmental Management Organizations (INEM) was established in 1991 as a global federation of national and regional non-profit business associations fostering environmental management and sustainable development. It has members and affiliates in 19 countries on four continents.

The *INEM Bulletin*, published quarterly, shares information about INEM affiliate activities and reports on issues of interest to members. It is available free to INEM members and to governmental and intergovernmental organizations.

The INEM environmentalist management book *Business and the Environment* contains extensive check-lists and references to organizations and information sources. It has been published by the European Community in several languages including English, French, German, Mandarin and Portuguese and also in Danish, Swedish, Norwegian, and Russian.

Inquiries may be directed to:

INEM
Bahnhofstr 36
22880 Wedel/Holstein
Germany

Telephone: (49-4103) 84019
Fax: (49-4103) 13699

Next Steps

1 **Look over the sample page of the *INEM Bulletin*, included in the *Reading Excerpts* at the end of this Learning Unit.**

Business Council for Sustainable Development

The Business Council for Sustainable Development was established in 1990 to present to UNCED a global business perspective on sustainable development. Its report to UNCED, Changing Course, published in 1992, contains a number of examples of eco-efficiency and technology cooperation by companies.

The Council is an independent group of leaders of major corporations around the world, representing a broad spectrum of business sectors and balanced between developed and developing countries. Members serve in a personal, not a corporate, capacity.

The Council aims to provide business leadership as a catalyst for change towards sustainable development by working with policy makers to create the conditions business needs to contribute effectively; helping make business a respected partner in policy development and implementation; promoting a clear understanding of sustainable development in the global business community; and encouraging business to develop goals and actions for sustainable development within their current profit/loss criteria and in the context of present/future international agreements, governmental policies and fiscal measures.

The Council's current work programme includes the examination of policy and the development of projects, with the focus on two key concepts: eco-efficiency (i.e. the corporate goal of increasing value added while minimizing resource use and pollution), and technology cooperation (i.e. partnership to transfer clean technologies, along with training and education, from companies that have them to companies that need them).

The Council also proposes to establish an innovative public/private partnership group with the IFC, UNDP and UNEP to facilitate specific eco-efficient projects involving technology cooperation. Through its current policy and project work, the Council is a continuing source of information on Cleaner Production.

Inquiries may be directed to:

BCSD
Route de l'Aéroport 10
CH-1210 Geneva
Switzerland

Telephone: (41-22) 7883202
Fax: (41-22) 7883211

Other International Organizations

The International Register of Potentially Toxic Chemicals (IRPTC) is a cooperative research and information centre of WHO, ILO and UNEP. IRPTC provides a database, a newsletter and many publications that set standards for acceptable exposure to such potentially hazardous chemicals as have been adequately researched (10,000 out of 80,000).

IRPTC
Case Postale 356
CH-1219 Châtelaine, Geneva
Switzerland
Telephone: (41-22) 9799111
Fax: (41-22) 7973460

WHO has information systems and publications that promote environmental health considerations in economic and development activities. Topics include occupational health, pollution control, water supply, sanitation, environmental planning and rapid assessment of waste by industry.

WHO
Ave. Appia
CH-1211 Geneva
Switzerland
Telephone: (41-22) 7912111
Fax: (41-22) 7910746

In addition to its many publications, ILO maintains a database on hazardous chemicals used by industry and an information service in its occupational health department.

ILO
CH-1211 Geneva
Switzerland
Telephone: (41-22) 7996111
Fax: (41-22) 798-6111

OECD is active in environmental economics, management and research and has many publications. It has a programme on technology and the environment that focuses on the promotion of cleaner technology.

OECD
2, rue André Pascal
F-75775 Paris, Cedex 16
France
Telephone: (33-1) 45248200
Fax: (33-1) 45248500

The Centre for Our Common Future publishes a number of useful works, notably a monthly newsletter, *The Network*, that monitors and reports on follow-up activities to UNCED.

Centre for Our
Common Future
Palais Wilson
52, rue des Paquis
CH-1201 Geneva
Switzerland
Telephone: (41-22) 732-7117
Fax: (41-22) 738-5046

The World Resources Institute has several publications that are relevant to Cleaner Production concerns.

World Resources Institute
1709 New York Ave. NW
Washington, D.C. 20006
United States
Telephone: (202) 638-6300
Fax: (202) 638-0036

All these organizations normally respond to requests for information by fax, post or telephone.

International Professional Associations and Selected Commercial Periodicals

The International Association of Water Pollution Research publishes *Water Research* (monthly), *Water Science and Technology* (monthly), *Water Quality International* (quarterly), *IAWPRC Yearbook Conference Proceedings* (series) and a variety of Association scientific and technical reports. It holds biennial international conferences and sponsors the activities of over 30 specialist working groups.

IAWPRC
1 Queen Anne's Gate
London SW1H 9BT
United Kingdom
Telephone: (44-71) 222-3848
Fax: (44-71) 222-1811

The International Union of Air Pollution Prevention Associations publishes *IUAPPA Newsletter* (quarterly), *IUAPPA Handbook* (biennial), the book *Clean Air Around the World* and the proceedings of its congresses. It holds triennial international cleaner air congresses as well as regional conferences and maintains an information and advisory service.

IUAPPA
136 North St.
Brighton BN1 1RG,
United Kingdom
Telephone: (44-273) 26313
Fax: (44-273) 735802

The International Association for Clean Technology was founded in 1987 to promote the research and application of cleaner technology and methodology. It has published two books, *Hazardous Waste Management* and *Industrial Risk Management and Clean Technology*, as well as *The International Journal of Clean Technology and Environmental Sciences* (quarterly) and a quarterly newsletter. It also convenes workshops and congresses to demonstrate the technical, environmental and economic aspects of Cleaner Production.

IACT International Secretariat
Rechte Wienzeile 29/3
A-1040 Vienna
Austria
Telephone: (43-1) 56-74-87
Fax: (43-1) 31-41-82

The World Federation of Engineering Organizations was founded in 1968 to advance the profession of engineering and to foster cooperation between engineering organizations throughout the world. It publishes a newsletter (semi-annual) and the proceedings of its biennial general assemblies and organizes congresses and seminars on various engineering topics, including environmental engineering.

WFEO
1-7 Great Georges Street
London SW1P 3AA
United Kingdom
Telephone: (44-71) 222-7512
Fax: (44-71) 222-0812

Pollution Prevention Review is published quarterly by Executive Enterprises. It contains articles on pollution prevention submitted by specialists and managers in industry, pollution prevention consultants, members of the research and university communities and employees of concerned state and federal agencies.

Executive Enterprises, Inc.
22 West 21st Street
New York, N.Y. 10010-6990
United States
Telephone: (212) 645-7880
Ext. 248

The *Journal of Cleaner Production* is an international journal published in January, April, July, and October by Butterworth-Heinemann. It contains interdisciplinary research papers on practical stragteies to eliminate or reduce pollutants at the source.

Butterworth-Heinemann Telephone: (44 865) 310366
Linacre House Fax: (44 865) 310898
Jordan Hill
Oxford, OX2 8DP
United Kingdom

Depository Libraries

National, university and local libraries may have information on Cleaner Production. Many of them throughout the world receive copies of United Nations publications and have an obligation to make them available on request and to respond to inquiries. They can also often search in international databases for specialized information.

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Extensive environmental information is also available from Governments, international organizations, sectoral and non- sectoral industry associations, professional associations, universities, trade unions, NGOs and publishers as well as from commercial vendors of databases and information services.

Next Steps

1 Test your comprehension of the information by answering the questions below.

2 Compare your answers with those suggested.

Questions

1 What is INEM?

2 What is the task of the Business Council for Sustainable Development?

3 Do you now know the names of some publications that focus on the prevention of air pollution?

Answers

1. *The International Network for Environmental Management is a global federation of national and regional non-profit business associations fostering environmental management and sustainable development.*
2. *The Business Council for Sustainable Development was established to present to UNCED a global business perspective on sustainable development and to stimulate the interest and involvement of the international business community. It is made up of business leaders from developed and developing countries.*
3. IUAPPA Newsletter *(quarterly)*, IUAPPA Handbook *(biennial) and* Clean Air Around the World.

United States Environmental Protection Agency

USEPA is one of the few national environmental agencies to operate with a specific legislative mandate to promote pollution prevention. The Pollution Prevention Act of 1990 established as national policy an environmental management hierarchy that sets pollution prevention as the option of first choice. In support of this programme, USEPA actively supports the transfer of technical information on pollution prevention and an extensive pollution prevention research effort.

The Office of Pollution Prevention and Toxics of USEPA, at Washington, D.C., publishes a free monthly newsletter, *Pollution Prevention News*, which describes pollution prevention initiatives throughout the United States. In addition, it published *Pollution Prevention 1991: Progress on Reducing Industrial Pollutants* and *1993 Reference Guide to Pollution Prevention Resources*, an annual guide (portions of the latter are contained in the *Reading Excerpts* at the end of this Learning Unit).

The Pollution Prevention Clearinghouse of USEPA is dedicated to reducing or eliminating industrial pollutants through technology transfer, education and public awareness. It contains technical, policy, programmatic, legislative and financial information on source reduction and recycling efforts in the United States and abroad. It is a free service of USEPA and is accessible by personal computer, telephone hot line or post (see *Reading Excerpts* for information on how to access this service).

The Pollution Prevention Research Branch of USEPA, at Cincinnati, Ohio, supports an extensive research effort. It is publishing a series of industry-specific pollution prevention guidance manuals (13 to date) and environmental research briefs. Every six months it publishes a report on its current projects.

USEPA and many state agencies and local governments in the United States produce fact sheets covering a wide range of topics.

Inquiries may be directed to:

PPIC
USEPA
401 M St. SW, PMA-211A
Washington, D.C. 20460
United States

Telephone: (202) 260-1023
Fax: (202) 260-0178

Next Steps

1 Read the selections from *1993 Reference Guide to Pollution Prevention Resources*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Look over the sample page of *Pollution Prevention News*, also included in the *Reading Excerpts.*

3 Test your comprehension of the information by answering the questions below.

4 Compare your answers with those suggested.

Questions

1 Which publication provides the best overview of pollution prevention information resources available in the United States?

2 What is the PPIC?

3 What are some industry-specific sectors covered by USEPA pollution prevention guidance manuals?

4 What is the name of the USEPA generic waste reduction manual?

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Answers

1. 1993 Reference Guide to Pollution Prevention Resources.

2. The Pollution Prevention Information Clearinghouse (PPIC) is a free, non-regulatory service of USEPA and consists of a repository, a telephone reference and referral service and a computerized information exchange system.

3. The 13 manuals published to date cover such sectors as auto repair, commercial printing and fabricated metal industry.

4. Facility Pollution Prevention Guide.

Additional Suggested Readings

This concludes the study section of Learning Unit 8. For additional readings on sources of information about Cleaner Production, you may refer to the following:

Allaby, M., ed., *Dictionary of the Environment*, 3rd rev. (London, Macmillan Reference Books, 1988).

ILO, *Environmental Management* (Geneva, 1992).

North, Klaus, *Environmental Business Management: An Introduction*, Management Development Series No. 30 (Geneva, International Labour Office, 1992).

Porteous, A., *Dictionary of Environmental Science and Technology* (Milton Keynes, Open University Press, 1991).

UNIDO, *Industry and Environment: A Guide to Sources of Information* (Bollschweil, Germany, Grüb, 1991).

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Case Studies

Next Steps

1 The *Case Studies* for this Learning Unit consist of sample data searches using the ICPIC and MICRO-METADEX^{PLUS} databases both of which are contained on a single IBM-compatible floppy disc.

2 Follow the instructions on the following pages and do the exercises.

3 Compare your results with those suggested.

Case Study 1: Cleaner Production Cases from ICPIC

These user instructions and exercises are for 16 case studies on Cleaner Production drawn from the ICPIC file of machine-readable information and contained on the floppy disc. As the ICPIC file is not a database but consists essentially of lists of text records, regular database search strategies cannot be used. INTIB has prepared this floppy disc in a simple ASCII format, which can be used with an IBM-compatible PC. As an aid to the user in navigating the text, a small programme has been included to allow searching for text strings.

User Instructions

Ensure that you are in the DOS working environment.

Place the disc in the A or B floppy drive.

At the screen prompt (either **A:** or **B:**), type **LOOK**, which will present the text file for viewing and press carrriage return **(CR)**.

The PgDn and PgUp keys will scroll through the text a screen at a time. The up and down arrow keys will do the same, but only one line at a time.

To look for a string of text, press **F,** which will trigger the command line at the bottom of the screen with the prompt *Find.*

Then type the string (not case-sensitive) that you wish to find, e.g. solvent, and press **CR**. The first line that contains this text string will be highlighted, with the string itself in a more distinctive colour.

To view further occurrences of the string, press **PF3 (F3)**. This can be repeated until the message *Text not found* appears.

Alternatively, return to the top of the file by pressing **Home** to view another term.

At this point, press **CR** to return to the command level.

The help key (**PF1** or **F1**) presents additional features that may be utilized.

Press **ESC** when finished with the file.

Note that the text file is structured according to the following format:

1.0 Headline

2.0 SIC/ISIC code

3.0 Name and location of company

4.0 Clean technology category

5.0 Case study summary

6.0 Economics

7.0 Cleaner Production benefits

8.0 Obstacles, problems and constraints

9.0 Date study performed

10.0 Contacts and citation

11.0 Keywords

12.0 Assumptions

13.0 Peer review

Keywords

Exercises

The following exercises are intended to show how you can move about in the text file by using simple string searches. Return to the top of the file before starting each exercise by pressing Home.

LU8

1 Are there case studies on electroplating in the sample data set? (Hint: find occurrences of the string **electroplating**.) Result: five case studies.

2 How many case studies in the sample data set relate to textiles? (Hint: find the string **textile**.) Result: two case studies.

3 Is chrome waste included in any of the case studies? (Hint: find the string chrome waste in any field.) Result: two case studies.

Case Study 2: Sample Records from MICRO-METADEX^{PLUS}

These user instructions are for the sample records from MICRO-METADEX^{PLUS}, a machine-readable source of technical and business information on recent developments in environmental technology in the fields of metallurgy, plastics and composites. Approximately 30 items on waste minimization procedures relating to plating bath wastes have been selected for this disc by staff of INTIB. The records, including abstracts, have been loaded into Micro-ISIS read and print database application, which can be used with an IBM-compatible PC.

User instructions

Ensure that you are in the DOS working environment.

Place the disc in the A or B floppy drive.

At the screen prompt (either **A:** or **B:**) type **ISIS**.

At the prompt *Please enter your ID*, type **DEMO.**

Choose S, which calls the search facilities.

Choose **T** from the search facilities menu, which presents a dictionary of search terms.

At the prompt *Key*, either press **CR**, which starts the dictionary at the beginning, or type any letter or string of letters (e.g. **chrome**), which starts the dictionary at that point.

Select a term by pressing **S.** The term will be highlighted. Additional terms may be chosen by moving the cursor to the term and pressing *. This procedure will select an item from the database in which both terms appear.

Type **X** once and the search procedure will be started with a statement of the question posed.

Press **CR** and the question will be run against the database. If there is a result, it can then be displayed. If further dictionary support is required, press **T** to repeat the search formulation process, starting from "at the prompt key..."

Type **D** to display the results, which will appear in short form.

Type **U** to call up different display options. Move the cursor to **JOURN** and press **CR**, followed by **D** again. The search result will be presented in a standard abstract journal format.

To see the second screen of multi-screen entries, press **CR**.

Type **X** until the DOS prompt appears to exit the application.

These instructions give only a quick overview of the information on this demonstration disc. The full application allows a much wider range of search options, including the ability to combine or to specify a relation between several terms (full Boolean logic).

The following access points (indexes) are available to use in searching. Sample questions are provided to allow you to test the application. The database can be searched using prefixes, which indicate the position of a term in the record, or single words, which can appear in several different positions in the record. The prefixes are as follows:

AF = Author affiliation
DA = Date of abstract
DP = Date of publication
JD = Date of journal
JN = Name of journal
LA = Language of document
MT = Main term
NC = Name (initials) of author
NM = Name (family) of author
SC = Subject category
ST = Secondary term
ZZ = Abstract code

The content of the prefix fields may consist of individual words or strings of words. For example, to search for the term **plating bath wastes** as a main term, the appropriate prefix must be used: MT=plating bath wastes. *No spaces should be used before or after the equals sign.*

Alternatively, all three words can be searched separately without using a prefix. For example, search for the terms **plating** or **wastes**. If this option is chosen, you should be prepared to find the word(s) occurring anywhere in the record, such as in the title of an article or of a meeting, as well as in a prefixed field.

Exercises

1 Do any of the items in the database include mention of cadmium? (Hint: find if the word cadmium occurs in any of the fields indexed in this sample database by typing **cadmium** after the prompt *Key.*) Result: six items.

2 How many items in the sample database are primarily on the topic of copper plating? (Hint: find copper plating used as a main term: MT=copper plating.) Result: five items.

3 Are there any items in the database written by M.F. Szabo? (Hint: search for Szabo as a family name in the author index: NM=Szabo.) Result: one item.

4 Are there any articles in the sample database from the journal *Metal Finishing*? (Hint: search the index under name of journal: JN=Metal Finishing.) Result: two items.

5 Is there any material in the sample database in the German language? (Hint: search in the language index: LA=German.) Result: seven items.

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Review

Test

The following test will help you review the material in this Learning Unit.

1 A printed source of environmental information from UNIDO is

a. INTIB
b. *Industry and Environment: A Guide to Sources of Information*
c. REED
d. ICPIC

2 TheUNIDO information system that supports a network of 80 focal points around the world is operated by

a. INTIB
b. IE/PAC
c. REED
d. ICPIC

3 Data on UNIDO's energy and environment-related industrialization activities in developing countries are obtained from UNIDO via

a. METADEX
b. Industrial Development Abstracts
c. Energy Technology Clearinghouse
d. ICPIC

4 Data on environmental economics are best obtained from

a. UNIDO
b. OECD
c. UNDP
d. World Industry Council for the Environment

5 The name of the UNEP on-line pollution prevention clearinghouse is

a. PPIC
b. Awareness and Preparedness for Emergencies at Local Level (APELL)
c. ICPIC
d. Energy and Environment Information System

6 The acronym IE/PAC stands for

a. Industry and Environment Pollution Action Centre
b. Intensive Environmental Preventive Action Control
c. Initiatives in Environment Prevent Active Coordination
d. Industry and Environment Programme Activity Centre

7 A database available from UNIDO that contains information on metallurgy and the environment is

a. INTIB
b. REED
c. METADEX
d. ICPIC

8 A United Nations-sponsored source of data on hazardous chemicals and health is

a. INTIB
b. IRPTC
c. International Occupational Safety and Health Information Centre
d. REED

9 One source of information for setting up a national environmental management association for enterprises is

a. World Environment Centre
b. Business Council for Sustainable Development
c. INEM
d. WICE

10 A source for training materials in hazardous waste management is

a. IE/PAC
b. INEM
c. ICC
d. UNIDO

11 In a remote area of a developing country, the first United Nations source of industrial environmental information should be

a. IE/PAC
b. USEPA
c. INTIB focal point
d. UNIDO Environment Coordination Unit

12 The key problem with getting environmental information is usually

a. Time
b. Relevance
c. Cost
d. Availability

Answers
1-5 b a b b c
6-10 d c b c a
11-12 c b

Some Ideas to Think About

Take some time to think about the following questions.

1 Which of the sources of information described in this Learning Unit are most accessible to you?

2 Do you have access to a PC with modem?

3 Does your nearest UNIDO office subscribe to any of the periodicals mentioned?

4 Do you know of any government offices or libraries that might contain some of the information sources that we have discussed?

Reading Excerpts

Energy and Environment Information System (EEIS)

Based on an information sheet in the UNIDO press kit on the Industrial and Technological Information Bank.

The Situation of Developing Countries

A recent study commissioned by INTIB assessed the current supply of industrial information to developing countries, with particular emphasis on environmental information, especially for small and medium-scale enterprises (SME).

The study concluded that there are few systems that hold such information, that those that do, do not target SMEs in developing countries, and that other industrial information systems may reach end-users in developing countries, but not in the SME sector.

On the other hand, there are clear indications of growing demand for environment information in the SME sector in developing countries—there is therefore a gap between supply and demand.

Factors contributing to the 'data gap' between data producers and data users in developing countries are related to the location of many of these commercially oriented information systems in the North or in international agencies. The former frequently require full-cost recovery for their systems, thus excluding the SME sector in developing countries, and indeed any concentration on developing countries as such. The latter often have supply-led systems, set up on the basis of available information, rather than information needs, and consequently little thought is given to making this information relevant to end-users.

In particular, the following factors contribute to this information gap:

- Information provided concerns advanced Northern technologies rather than those appropriate to conditions and financial resources in the South;

- Even where information systems target users in developing countries, these are either large corporations, consultants or researchers at universities or research institutes which may have advanced communication capabilities. The use of advanced technologies and information systems for information transfer does not take into account the limited communication and data handling capabilities in the SME sector in developing countries, and therefore restricts their access;
- SMEs in developing countries rarely place monetary value on information, and are therefore unattractive targets for commercially run systems;
- The commercial hosts that carry the bulk of data bases in the North do not target developing countries. There is, therefore, a widespread lack of experience in small and medium enterprises in developing countries as to the existence of data bases, and methods of accessing them;
- While SMEs in developing countries are generally unaware of the available information resources, data base owners are unaware of the potential usefulness of the information they hold to SMEs in developing countries;
- SMEs recognize the need for environmental and energy information, but are rarely able to articulate this need. Any information system will therefore have an educational as well as an informative task. Few information system operators have attempted to undertake this task;
- Less-developed telecommunications in many developing countries and lower computer usage in SMEs act as physical and psychological barriers to effective information and technology transfer. Few information systems function by means of local contact points and have dissemination methods appropriate to local needs. Even fewer systems have recognized the educational role they must play in creating the market they intend to serve.

Considering the foregoing conclusions and capacity indicated above, UNIDO has a unique chance to contribute to bridging this gap. INTIB has broad experience of global industrial information to transfer to developing countries. The data bases that are currently being assembled and utilized within INTIB, and UNIDO's expertise in disseminating information to developing countries, are valuable foundations for a demand-led system that aims to facilitate information and technology transfer to end-users in developing countries, with a strong emphasis on SMEs. These capabilities can be employed to further not only North-South information transfer, but also South-South and South-North transfer.

Programme of Action

INTIB's environmental information strategy for the next few years will specifically address the needs of SMEs in developing countries, while continuing a broader programme of collection and dissemination.

The key issues that the strategy needs to tackle in order to achieve this objective are:

- Development or continuation of products that meet the real demand for such a service, in qualitative and quantitative terms;
- Use of highest-impact mechanisms for distribution, promotion and commercialization of the system;
- Identification of lowest-cost sources of information that yield maximum economies of scale.

The proposed strategy will be based on seven broad elements:

- Target group—identification of an SME clientele with a real need for an environment information service;
- Product—development of an information product range tailored to SME needs, with varying levels of content and formats;
- Sourcing—continued development of agreements with information sponsors to reduce data collection and preparation costs;
- Distribution—development and maintenance of a decentralized mechanism for information distribution;
- Dissemination mechanisms—application of the most cost-effective methods of information packaging, which will also be those appropriate to SMEs;
- Promotion—sensitization of information intermediaries and end-users, as well as regulatory authorities through a variety of fora and media;
- Pricing and cost recovery—development of a variety of price schemes for the different levels of information, keeping in mind the economic constraints many end-users are likely to encounter.

Project Status Report

The objective of the Energy and Environment Information System (EEIS) project is to test the establishment of sustainable, cost-effective mechanisms for management of industrial environment information targeted to SMIs within developing countries. The EEIS project follows a strategy that first identifies a key institution which has a proven capability in information management and an existing information programme with staff and budget as well as the ability to function as an information service to industry in the national context. Such a centre is the project's main liaison for the system in that country and is designated the Primary Contact Point (PCP).

It is one of the chief responsibilities of the Primary Contact Point to help build the EEIS network within the country by identifying and entering into working arrangements with from ten to fifteen other organizations which have direct association with SMIs. Such organizations could include trade associations, Chambers of Commerce, local administrative offices and environmental consulting companies. These Secondary Contact Points (SCPs) have access to the information products and services made available from UNIDO/INTIB through the PCP and have the responsibility to assist their member SMIs and entrepreneurs to make use of the information, as appropriate. Thus the network is built.

It is envisaged that existing and emerging national institutions which are responsible for the SMI sectors will, through this project, develop cost-effective mechanisms for the capacity-building support necessary to address the issues of information provision for environmental awareness and improved industrial response to pollution prevention. As each country's institutional structure varies, country studies are an essential first stage to pre-set terms of reference and contractual obligations, together with the application of a number of criteria for evaluation of the various components of the system. The Energy and Environment Information System project originally provided financial support for pilot surveys in four developing countries. The interest aroused during the project's initial study, however, indicated that a broader geographical coverage was needed in the pilot activities. Currently 20 additional institutions (7 in Latin America, 7 in Africa, 2 in Asia and 4 in Eastern Europe) have expressed interest in undertaking preparatory country surveys at their own cost.

The institutions that have been involved or expressed their interest in this first step of the strategy are from:

Africa
- Botswana
- Ethiopia
- Kenya
- Nigeria
- Sudan
- United Republic of Tanzania
- Zambia
- Zimbabwe

Asia & Pacific
- India
- Indonesia
- Thailand

Latin America & Caribbean
- Argentina
- Bolivia
- Brazil
- Cuba
- Ecuador
- Jamaica
- Peru
- Venezuela

Eastern Europe
- Czech Republic
- Hungary
- Poland
- Russian Federation
- Slovakia

Environmental Awareness Bulletin

No.43 December 1993

HIGHLIGHT: YAOUNDE PANEL

Participants and organizers voted the panel on **ecologically sustainable industrial development** held during the UNIDO General Conference in Yaoundé on 7 December a success. Participants from about 40 member countries and 6 international and non-governmental organizations attended the half-day session which was chaired by Mr. S. Singh, Secretary, Department of Industrial Development, India. There was an open exchange of views on issues presented by the UNIDO Secretariat in its background paper *Global Environmental Concerns* and its discussion paper *Ecologically Sustainable Industrial Development*. The tone for the discussion was set by the UNIDO documents which stressed the role that industry can play as the basic instrument with which countries can create the resources that are needed in order to reach the ecologically sustainable development goals formulated in Agenda 21, as adopted by the UNCED Conference in Rio de Janeiro in 1992.

Panel participants agreed that as a UN system-wide coordinating body in the field of industry, UNIDO should play a major role in the implementation of Agenda 21. They suggested that *UNIDO's policy making organs ensure that UN policy discussions on Agenda 21 take into account the role of industry and of UNIDO in the follow-up to UNCED*. The participants also suggested that the developing countries should *engage the broadest cross-section of agents, including ministries such as Industry, Environment, Health, Agriculture, Education, Science and Technology plus chambers of commerce and industry, industrial associations and the NGO community as counterparts for UNIDO programmes and projects in support of Agenda 21*. The participants in the Panel specifically discussed *the problems of small and medium scale industries (SMIs), the difficulties of financing pollution control measures for individual enterprises, and the difficulties in obtaining access to information on clean technologies that has been adjusted to the needs of SMIs in developing countries*. In response, the secretariat presented UNIDO's programmes for technology information and capacity-building for SMIs.

The findings of the Panel received full support in the Plenary Session and were reflected in draft resolution *GC.5/L.6 Item 8(e): Environment, energy and sustainable industrial development, including follow-up to the UN Conference on Environment and Development* in which the Director-General is requested to take into consideration in implementing the UNIDO environment programme the need *to enhance the transfer of cleaner production technologies and techniques to developing countries; to promote the capacity of developing countries to develop and produce such technologies and techniques; to promote technical cooperation among developing countries in environment-related matters; to further enhance in-house analytical capacity in the field of environment and energy; to disseminate information on environmental risks associated with industrial processes and technology, and measures for protection against such risks; and to take appropriate measures to comply with all relevant recommendations of Agenda 21 and seek a leading role for UNIDO in their implementation.*

Contact: A. Tcheknavorian-Asenbauer (ext. 3747)

UNIDO MISSION NEWS

African Ministerial Conference on the Environment (AMCEN): K. Ahmed and R. Touré participated in the Expert Group Meeting and Fifth Session of the African Ministerial Conference on the Environment. UNIDO's statement, delivered by Mr. Ahmed on behalf of the Director-General, as well as UNIDO interventions were well-received. Attended by 49 member states as well as organizations of the UN system, and regional and subregional IGOs in Africa, the Conference adopted a cross-sectoral orientation for environmental issues in Africa, providing political support and policy guidance for environmental programmes in Africa as well as coordination and harmonization of programmes at the subregional and national levels. Increased cooperation with UN agencies for the achievement of Agenda 21 objectives was welcomed. The new 1994/1995 work programme for the AMCEN Secretariat focusing on, among other topics, *capacity building at the national level; environmentally sound management of hazardous waste and all waste and toxic chemicals; environmentally sound management of marine and coastal areas, including island ecosystems; securing energy efficiency and sufficiency; and managing the environmental impact of climatic change and climatic variability* was adopted. (Addis Ababa, 20-27/11/93)

ESID Programme for Madagascar: R. Kumar participated in the mid-term review of the Environment Programme for Madagascar conducted by the Office Nationale de l'Environment (ONE). This programme is an outcome of the findings of the TSS-1 Study on the Requirements of an ESID Strategy (NC/MAG/92/012) and a subsequent preparatory assistance project (UC/MAG/92/179). After detailed consultations with ONE and the Ministry of Industry, two project documents covering implementation of various aspects of the proposed ESID programme to be financed by the African Development Bank and the World Bank respectively were finalized. The first project covers activities related to *survey and data collection on pollution emission levels; establishing a technological database as a complement to the Environment Information System currently being set up at ONE; and*

Prepared by IPCT/TDP/INF

For free distribution to UNIDO staff members. All comments welcome.

strengthening local capabilities for monitoring and controlling industrial pollution emissions. The second project covers activities relating to capacity building for *conducting and reviewing environmental impact assessments; elaborating industrial emission standards; implementing ESID policy measures; and promoting cleaner production methods through demonstration workshops for industry.* (Antananarivo, 29/11–5/12/93)

Industrial Pollution Prevention and Abatement Guidelines: R. Luken participated in the review of nine draft guidelines prepared by Dutch consultants for the World Bank/UNIDO/UNEP Pollution Prevention and Abatement guideline series. The Ministry of Environment of the Netherlands is financing the preparation of the nine guidelines through the World Bank: *waste water treatment plants; sewage disposal; glass manufacturing; electroplating; industrial estates; tourism development; meat processing and rendering; fruits and vegetables; and dairy products.* Mr. Luken also discussed the UNIDO National Cleaner Production Centre programme with staff of the Ministry of Environment. (The Hague, Utrecht 9–14/12/93)

IN PRINT/ELECTRONIC MEDIA

The draft version of UNIDO/UNEP **Technical Guide: Environmental Issues in the Electronics Industry** (December 1993) has been produced. The document contains a glossary of technical terms and chapters on various environmental aspects of *electronic component manufacturing:* environmental impacts, health impacts and environmental management; design; operational factors; waste minimization programmes; waste treatment; ozone depleting substances; and an integrated approach to environment policy and control.

Contact: C. Gürkök (ext. 5489/5177)

The World Bank and the Environment, Fiscal 1993 has been published by the World Bank as the fourth in its series of annual reports to document the progress of the World Bank towards incorporating environmental concerns into all aspects of its work. The report sets out the principal environmental activities of the Bank (IBRD and IDA) during fiscal 1993 (the period from July 1, 1992 to June 30, 1993) and its future initiatives.

Contact: R. Luken (ext. 3352)

The latest issue of the *FID News Bulletin* (vol. 43, issue 7/8 July/August) is devoted to environmental information. Titled **Environmental Information Update**, the issue contains articles discussing various sources including the ECLAS/AMBIONET Information System, CAB International, the UNEP/INFOTERRA programme (by Linda Spencer, UNEP), and UNIDO's Energy and Environment Information System (by P. Pembleton, UNIDO).

Contact: P. Pembleton (ext. 3705)

The third edition of the **UNESCO International Directory of New and Renewable Energy Information Sources and Research Centres** has been published by James & James Science Publishers, London, 1993 (price US$135 or £75). This is the printed version of their **Energy Database** which is available both on diskette (US$180 or £120) and on UNESCO's CD-ROM (available in the VIC Library). The Energy Database is a referral database of approximately 4000 records containing information on national governmental organizations, research centres, information centres, professional and trade associations, networks, training and education, databases and databanks, and journals and reference publications from about 170 countries, UN organizations and international non-UN organizations.

UNESCO has issued brochures describing two more new items:

- **Module on New and Renewable Energy** will be the latest module in the *Learning Package in Energy Engineering,* one of the UNESCO—ITU—Wiley Series of Learning Materials in Engineering Sciences. Designed for use by postgraduate students and engineers, the Module will be produced initially in conventional book format, but as the learning package evolves, it is foreseen that future material will be published in other media including audio-visual aids and computer software. Sections of the Module in preparation include *solar electricity; energy planning and policy; wind energy; energy conservation; ocean energy; energy from waste; biomass energy; geothermal energy; mini-hydropower; and magneto-hydrodynamic electrical power generation.* (No publication date given.)

- **Environmental Management** is the title of the three-volume series published by the Vrije Universiteit Brussels, Belgium. Volume 1, *The Compartmental Approach,* includes *water resources; air quality monitoring and management; noise; waste; and energy, economy and the CO₂ problems.* Volume 2, *The Ecosystems Approach,* includes *coastal, river and inland water, upland and mountain, urban, rural, and desert environments* plus environmental management for tourism, parklands, and reserves. Volume 3, *Instruments for Implementation,* includes *environmental impact assessment; life cycle assessment; disaster management; risk analysis; and environmental auditing.* Advertised as being intended for students, engineers, policy-makers, decision-makers and researchers and including a foreword by Gro Harlem Brundtland, each volume contains theoretical background information, discussions and analysis of recent developments, examples, and case studies. Price per volume is US$43.00 or US$112 for all three. (VUPRESS, Plainlaan 2, B-1050 Brussels, Belgium, April 1993).

Contact: P. Pembleton (3705/3706)

The Environmental Awareness Bulletin is an informal monthly newsletter alerting UNIDO staff to UNIDO's industry/environment activities and to related events and developments outside UNIDO. It is not an official document and does not express UNIDO policy or positions on any issue, explicitly or implicitly. Editorial responsibility rests with IPCT/TDP/INF.

Please call or write to: H. Gabbert D-1917 (5211/3706) P. Pembleton, D-1919 (3705/3706) or contact ENV (3778).

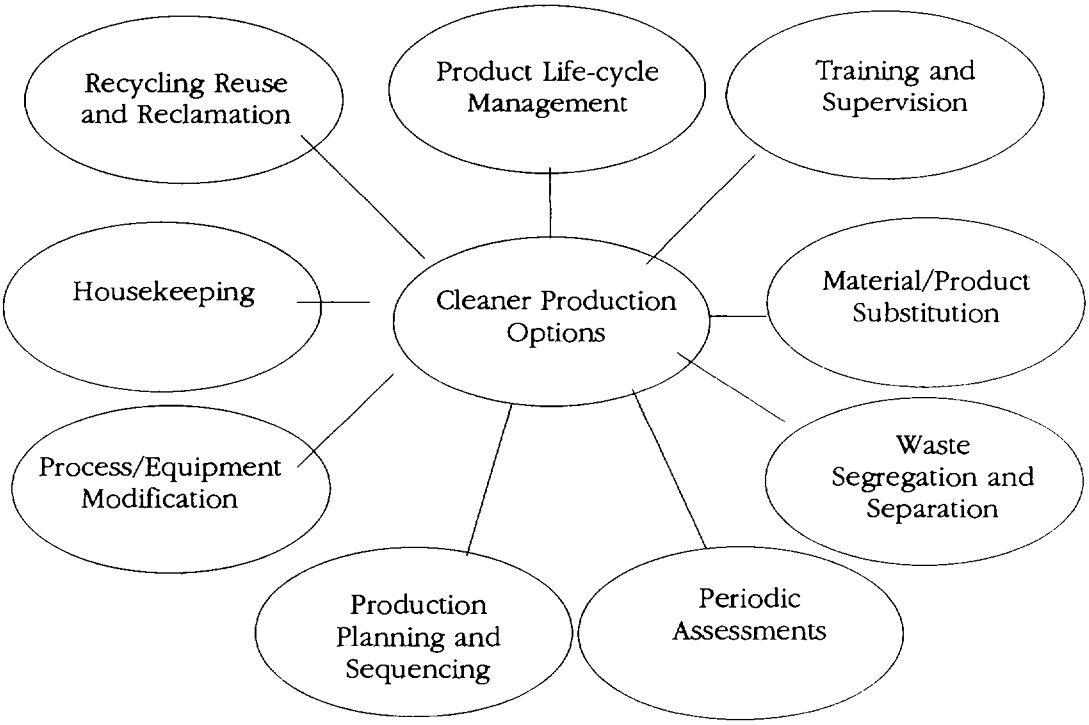
International Cleaner Production Informaiton Clearinghouse (ICPIC)

Excerpted, with permission, from the UNEP brochure *ICPIC: International Cleaner Production Information Clearinghouse.*

Cleaner Production

Reducing or eliminating discharges to the environment through source reduction, recycling, implementation of low and non-waste technologies, and product life-cycle management.

Cleaner Production saves money and reduces environmental impacts through a variety of options:



UNEP's Industry and Environment Office (IEO) was established in Paris in 1975 to bring industry, governments and non-governmental organizations together to work towards environmentally sound forms of industrial development. To this end, the IEO concentrates on formulating and promoting appropriate policies and strategies. More specifically, it seeks to:

- Define and encourage the incorporation of environmental criteria in industrial development;
- Formulate and facilitate the implementation of principles and procedures to protect the environment;
- Promote the use of safe, low and non-waste technologies; and
- Stimulate the exchange of information and experience on environmentally sound forms of industrial development throughout the world.

IEO's work programme is divided into four principal divisions: the publication of technical guides; technical cooperation; training; and information transfer. IEO has also developed a programme on Awareness and Preparedness for Emergencies at Local Level (APELL) to prevent and to respond to technological accidents.

Electronic Information Exchange

ICPIC Contains:

Message Centre

An on-line feature allows communication with other network members. You and others may leave information, system updates and questions and answers.

Bulletins

Latest news and announcements in the international clean technology community.

Calendar of Events

Listing of upcoming national and international conferences, training seminars and workshops.

Case Studies

A database of technical and programme case studies highlighting industry and waste involved, economic incentives and cost recovery time.

Programme Summaries

Descriptions of national and international programmes on Cleaner Production.

On-Line Bibliography

A bibliography of hundreds of clean technology documents, with information for ordering.

Directory of Contacts

An automated version of UNEP's Cleaner Production Directory.

Topical Conferences

ICPIC contains topical conferences on various issues of Cleaner Production. Operating just like the main computer system, each conference contains a message centre, bulletins, and data bases particular to the conference topic. Conferences currently available include:

PPIC/USA

Full access to features of the Pollution Prevention Information Clearinghouse (PPIC) run by the U.S. Environmental Protection Agency.

Industry Working Groups

Information on UNEP/IEO's working groups, including tanning, electroplating, textiles, halogenated solvents etc.

Government Policies Working Group

Descriptions of government policies and strategies to promote and transfer Cleaner Production processes and products.

Data Harmonization Working Group

Summaries of activities of UNEP/IEO's data harmonization working group intended to standardize clean technology data systems from member nations.

Cleaner Production Research

Search by topic area or organization to find the latest progress in programme and process research, including innovative technologies. Research topic include manufacturing options, product longevity, agricultural practices, transportation alternatives, and energy consumption.

Country-Specific Conferences

Clean technology activities of specific countries.

Accessing ICPIC

Anyone can access the ICPIC computer system using either an Apple or IBM (or compatible) personal computer, or a dumb terminal equipped with a modem (1200 or 2400 baud) and appropriate communications software.

To access the system directly, set your communications soft to 8 data bits, no parity, and 1 stop bit.

Using **CrossTalk**^{TM} or similar communications software, type in the bold characters at the "Command?" prompt:

- **NU**mber: 33-1-40-58-88-78*
- **DA**ta bits: 8
- **PA**rity: None
- **ST**op bits: 1

*Omit country code and city code if calling from Paris or France.

Once in ICPIC, all functions are easily performed using abbreviated commands. For example, type:

- B—to look at a Bulletin
- R—to Read a message
- E—to Enter a message
- J—to Join a topical conference

The ICPIC can be accessed by anyone using direct dial telephone lines for only the cost of a long distance telephone call. In many countries, ICPIC can be accessed through a local call to your country's packet switch network.

UNEP
IE/PAC

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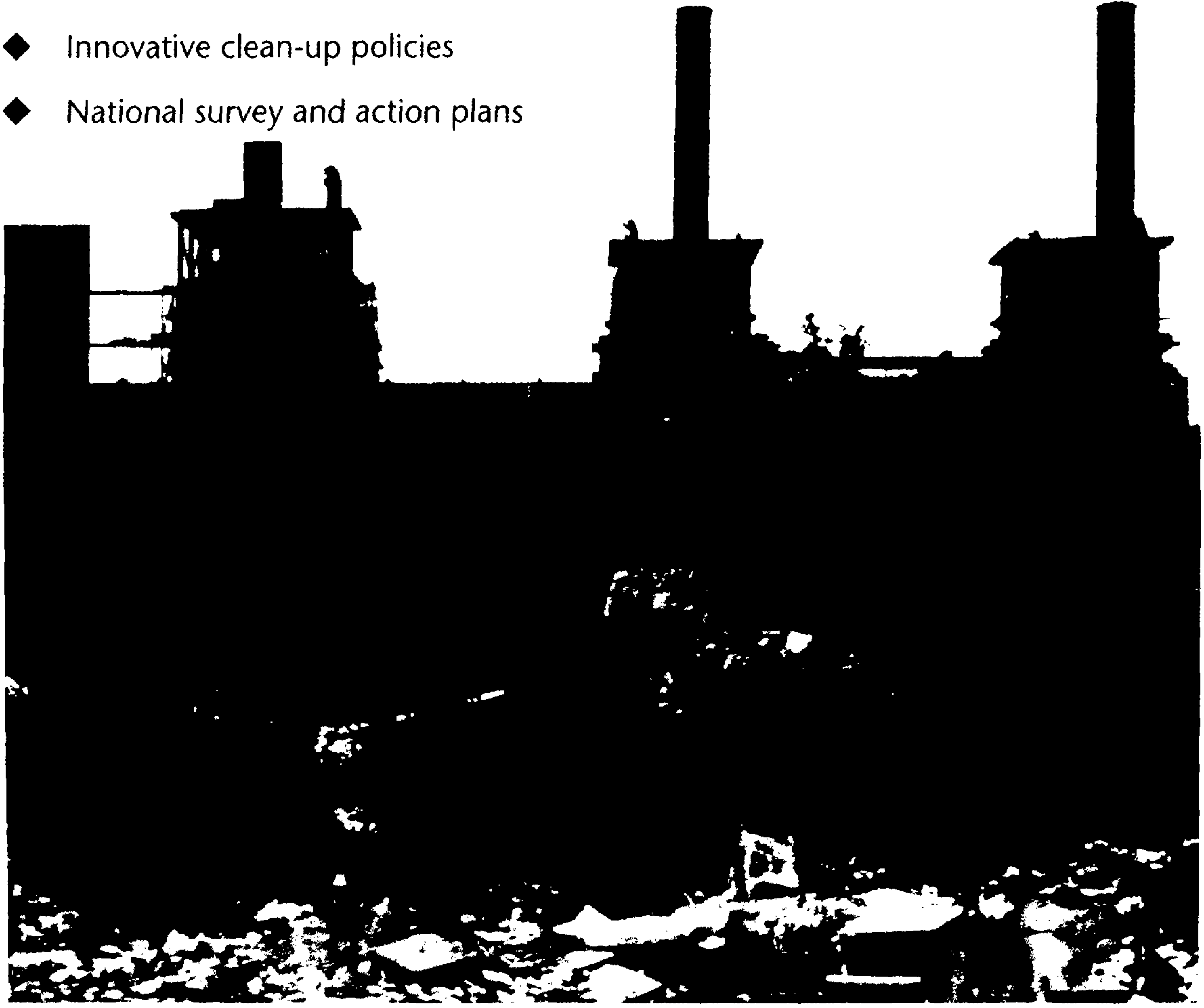
Une publication du Programme des Nations Unies pour l'Environnement
Centre d'Activité du Programme Industrie et Environnement - PNUE CAP/IE

Una publicación del Programa de las Naciones Unidas para el Medio Ambiente
Centro de Actividad del Programa Industria y Medio Ambiente - PNUMA CAP/IMA

Managing contaminated land

- Long-term chemical risks
- Remediation options for contaminated sites
- Soil contamination in the coal and wood preserving industries
- Innovative clean-up policies
- National survey and action plans



Cleaner Production

The Newsletter of the UNEP IE/PAC network dedicated to promoting cleaner production.
The preventive environmental strategy reconciling environmental protection and development.

No. 7
Fall
1993

Editorial: Cleaner Production Worldwide

I have had the honour to be involved with the UNEP Cleaner Production Programme ever since the days in 1989 when we tussled with the phrase "low-and non-waste technology" and ended up with the "**Cleaner Production**" theme.

The British Government hosted the launch of the Cleaner Production Programme at Canterbury in September 1990, and it was a pleasure to meet many people from all over the world at the two-yearly review meeting held in Paris in 1992. The follow-up meeting in 1994 should in my view be held in a developing country, and in a campus atmosphere more like Canterbury than Paris!! If readers overseas know of suitable settings where 200 to 400 people can live and work together for nearly a week then please let UNEP know: at least we should have a short-list and work on how to finance things after that.

As one of several British Government actions to follow up Rio the British Prime Minister John Major announced a Technology Partnership Initiative at Rio. A conference to launch this was held in Birmingham close to the birthplace of the Industrial Revolution (Ironbridge in Coalbrookedale) 23-25 March 1993. The Prime Minister himself came to launch the Initiative and it was a measure of the importance which UK attaches to the Cleaner Production Programme that the IE/PAC Director, Jacqueline Aloisi de Larderel was able to give a keynote address emphasizing the lessons learned from the Cleaner Production Programme.

It was also the occasion to launch a new publication – *Cleaner Production Worldwide* which will be described elsewhere in this issue. The examples given in the publication come from twelve different countries and I am sure that when you read them you will realize that similar, and perhaps even more appropriate examples can be found in every country of the world. Please let UNEP know the simple story about how a production process that *you* know created less pollution and as a result improved its profitability.

D. L. Pounder
Environmental Protection
Technology Advisor,
United Kingdom of the Environment, London

Inspecting the black liquor discharge from the Rakta pulp mill, Alexandria, Egypt.
John H. Skinner, UNEP and Mohamed A. Tohamy, Managing Director, Rakta

Technology Transfer: Demonstrating Cleaner Production in African Countries

A recent Mission to Egypt is in the process of identifying opportunities for cleaner production at the RAKTA pulp and paper mill, the largest facility in the world making paper out of rice straw. Senegal has issued a report describing the financial requirements for cleaner prodution at the SOCOCIM cement facility. Zimbabwe and and Ghana have identified pulp and paper and cement companies with an interest in cleaner production programs.

These projects were established at the October 1992 Ministerial Meeting on Cleaner Production hosted by UNEP IE/PAC. The purpose is to demonstrate the opportunities for and obstacles to cleaner production in developing countries. Pulp and paper production and cement production were selected because these industries are quite common in developing countries and development often requires expanded production in these sectors.

These demonstrations are intended to be catalytic in effect and bring together government and industry to deal with *the technical, social, financial and institutional* obstacles and opportunities for cleaner production. The projects are being carried out through a partnership involving representatives from the selected countries, the governments of the Netherlands and France, the Business Council for Sustainable Development, the International Chamber of Commerce and UNEP IE/PAC.

SEE PAGE 2

B. [illegible]
K. [illegible], J. [illegible], and
A. Aspengren

The editor welcomes all news on cleaner production from readers. Please send to UNEP IE/PAC

WICE

World Industry Council for the Environment

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75008 Paris, France
Tel: +33 (1) 49 53 28 91
Fax: +33 (1) 49 53 28 89

Volume 1, number 1

February 1994

NEWSLETTER

◆ A Promising Start

Welcome to the first issue of the WICE Newsletter! This quarterly publication will keep our members informed on WICE's policy work and activities. It will also contain interviews with member CEOs and, in future editions, a "Readers' Corner" dedicated to member company opinions. To ensure that the newsletter meets your expectations, please send us your comments and suggestions.

In its first year, WICE developed several partnerships with governments, international bodies and industry groups. The objective of these initiatives was to show that business is a credible partner for the environmental policy dialogue and that it can make a substantive contribution to the policy-making process.

Member companies are strongly involved in the Task Forces, which have formulated clear business positions and action programmes on the major challenges after the Rio "Earth Summit" in 1992.

Rather than dealing with too broad a spectrum of topics and risk neglecting what really matters to industry, WICE will focus on a few issues. Trade and Environment and Technology Partnerships are two issues which will lead the WICE list.

The "Rio process" focused the attention of business on the environmental policy debate. Attitudes are changing and industries are increasingly integrating environmental considerations into their global strategies.

These strategies will be successful if governments set the right framework. By promoting the views of business in the political arena, through increased government-industry partnership, WICE will contribute to make this framework cost-effective and "eco-efficient".

The success of our common mission relies on the close co-operation between the Secretariat and you, the member companies. If we work together towards a common objective, the commitment to environmental responsibility, we will be able to foster sensible environmental policy changes.

I look forward to this continued co-operation in 1994.

Jan-Olaf Willums
WICE Executive Director

■ What's Up?

In 1994, WICE's priorities will be: Policy and Technology Partnerships, Trade and Environment, and Environmental Management. The briefs, reports and guidelines will draw on case studies, illustrating not only success stories but also how and why certain initiatives failed.

Task Force 1, ***Post-UNCED Challenges***, has established two working groups. One is focusing on **Policy Partnerships**. The UN, OECD and many national governments have called for more co-operation between industry and governments in the process of formulating environmental policies. The WICE work will present proposals for these partnerships.
The other working group is looking at **Technology Partnerships** and is developing a new model of technology co-operation reflecting today's business realities. The working group is reviewing cases where technology transfer has been successful, where it has failed, and why.

Task Force 2, ***Trade, Environment and Global Business Challenges***, is working on how sustainable development considerations can be incorporated in the GATT multilateral trade system. This will become a key debate in the GATT discussions. WICE will look at the inter-relationship between the environment and international trade agreements. The Task Force will also evaluate the impact of environmental policy tools on international business.

Task Force 3, ***Environmental Management***, will address three issues. The working group on **Life Cycle Analysis (LCA)** and **Design for the Environment (DfE)** has collected cases and is now drafting specific policy recommendations. An Executive Brief and some practical guidelines will be the result.
The working group on **Environmental Reporting** is preparing a guide designed to accommodate a variety of industry sectors. This work will offer a broader-based approach to environmental reporting.
Promoting Energy Efficiency is another facet of this Task Force which will focus on technological opportunities (see STEEP project on page 2).

INEM

INEM

Wuppertal Institute

Volume 2 · Number 4

BULLETIN

Winter 1993/94

Contents

The Bulletin is a publication of INEM – the International Network for Environmental Management (Wedel, Holstein) – and the WUPPERTAL INSTITUTE for Climate, Environment and Energy. The Institute is a member of the North-Rhine-Westphalian Science Centre.

Key-note speaker, Prof. Jiro Kondo, President of the Science Council of Japan

Report on the International Conference on Eco-Management, Tokyo

Pages 2-8: Report on the International Conference on Eco-Management, organized by JELC, in cooperation with UNU and in collaboration with INEM

The Tokyo Appeal Page 8

Eco-Efficiency as a Principle

Guest Editorial

by Dr Ernst A. Brugger, President of PROPEL

The concept of eco-efficiency is receiving increasing attention from business. Why? What is meant by eco-efficiency? Eco-efficiency makes it possible to produce as much or more with less energy input and resource use. Economic growth and ecological degradation are to be decoupled. Environmentally benign production is in the self-interest of all economic actors, as through eco-efficient management of companies:

- productivity and innovation capacity are increased, this strengthening companies' competitiveness,
- risks and thereby incurred costs for accidents are reduced,
- the development of new products, materials and production processes is spurred, this opening up new markets, and
- the corporate image is improved, which widens a company's possible market activities.

These arguments are by now well-known in the industrialized world, but also in the newly developed countries a debate on eco-efficiency is emerging.

The Example of Latin America.

PROPEL stands for "Promoción de la Pequeña Empresa Eco-Eficiente en Latinoamérica" (Development of the Eco-Efficient Small and Medium-Sized Company in Latin America). This foundation was set up in Bogotá, Colombia, in 1991 by FUNDES-Switzerland and several Latin American private initiatives.

PROPEL wants to provide an effective contribution to sustainable development in Latin America and to generate interest among the Latin American business community for the eco-efficiency concept. Environmental risks are to be minimized and negative environmental impacts effectively and preventively reduced. PROPEL offers research, training and a systematic dialogue to reach this objective. Concrete projects, such as the leather-works project in Bogotá, Colombia, are to implement the eco-efficiency concept in practice. Entrepreneurs are, as is the consumer, best convinced by positive economic results.

More about Propel in the next issue

Dr Ernst A Brugger

1993 Reference Guide to Pollution Prevention Resources

Excerpted, with permission, from USEPA, *1993 Reference Guide to Pollution Prevention Resources*, EPA/742/B-93-001.

Introduction

> "There are significant opportunities for industry to reduce or prevent pollution at the source through cost-effective changes in production, operations, and raw materials use. Such changes offer industry substantial savings in reduced raw material, pollution control, and liability costs as well as help protect the environment and reduce risks to worker health and safety."
>
> —The Pollution Prevention Act of 1990

Purpose of This Document

This annual guide contains information about publicly sponsored pollution prevention resources and training opportunities available across the Nation. Drawing upon diverse sources, the document consolidates a wide range of information not easily accessible by the public. The goal of this publication is to provide persons interested in learning more about pollution prevention options with a single source of information on:

- Where to obtain pollution prevention training, or who might be able to share experiences about establishing a new training opportunity;
- What publications and videos are available that can help them learn more about pollution prevention;
- Whom to contact at the State and Federal levels for assistance;
- Which university centers are conducting pollution prevention research and training;
- Which Federal, State, and non-profit organizations can provide additional pollution prevention information and technical assistance;
- Where small businesses can obtain Technical Assistance.

Additional information on the topics covered in this manual and on related subjects can be obtained by accessing the Pollution Prevention Information Clearinghouse (PPIC), which offers a wide range of free information services (see section on Pollution Prevention Clearinghouses, Associations and Hotlines).

Updates to This Guide

Because of the high visibility and rapid growth of this field, many pollution prevention efforts are in a state of flux. We worked to ensure that the information in this guide was as current as possible when the document was sent to press. Given the dynamic character of the field, however, some information will have changed since it was collected. We plan to expand and update this publication annually to include additional information called to our attention in the future.

Please submit any updates or corrections concerning your training opportunities, programs, calendar events, or training materials to:

Pollution Prevention Information Clearinghouse
US Environmental Protection Agency, PM-211A
401 M. Street, SW, RM 2904
Washington, D.C. 20460
United States

Note: The appearance in this guide of training courses and materials other than those produced or sponsored by EPA does not constitute an endorsement of their quality by the Agency. Many of the organizations sponsoring such training opportunities have pollution prevention policies that differ significantly from those of the EPA and, thus, do not reflect the Agency's position.

Industry-Specific Guides and Fact Sheets

Industry-Specific Pollution Prevention Opportunity Assessment Materials and Fact Sheets

In addition to the generic pollution prevention instruction manuals noted in the previous section, numerous industry-specific assessment materials are now available that can be used for guidance in setting up a pollution prevention program tailored to a given industry or process.

The current PPIC holdings include assessment publications specific to the industries identified below. PPIC's document development, research, and information-gathering efforts produce a continual influx of material into the clearinghouse. For this reason, the list provided should be regarded as representative rather than exhaustive. Anyone is welcome to visit the U.S. EPA Headquarters library (401 M Street, Washington, D.C., Room M2904) to use this collection and other Library resources. Fact sheets and a number of EPA publications are available, free of charge, from the clearinghouse. For other material, interlibrary loan is available.

Industry/Process	SIC Code
Automotive Repair	7538
Automotive Paint	7535
Aviation Facility	4582
Boat Building and Maintenance	3732
Building and Construction	1500
Dairy Plant	2044, 2046
Dry Cleaning	7216
Electroplating	3471
Fiberglass	2221
Fur Dressing/Tanning	3111
General Medical and Surgical Hospitals	8062
Heavy Equipment Maintenance	7699
Manufacturing/Distribution Co.	3900
Metal Finishing	3471
Paint Manufacturing/Formulating	2851
Pesticide Formulating	2879
Pharmaceutical Preparations	2834
Photofinishing/Photoprocessing	7395
Poultry Processing	2016
Precious Metal Platers	3911, 3914
Printed Circuit Board Manufacturing	3672
Printing	2700
Pulp and Paper Products	2600
Research and Education Institutions	8732, 8733
Research Laboratories	7391
Seafood Processing	2091
Textile Manufacturing	2200
Vehicle Maintenance	7500
Vocational Shops	8249
Wood Treating/Preserving	2491

Industry-Specific Pollution Prevention Guidance Manuals

The Pollution Prevention Research Branch of EPA's Office of Research and Development, in Cincinnati, OH, is publishing a series of industry-specific pollution prevention guidance manuals. Sixteen manuals in the series have been published for the industrial categories designated in the titles provided below.

The manuals supplement the EPA's generic waste reduction manual entitled, *Facility Prevention Guide.* Both the general manual and the industry-specific guides are available free of charge from CERI: 513-569-7562 or Fax 513-569-7566.

Guidance Manuals Currently Available

Guides to Pollution Prevention:	Automotive Refinishing Industry	EPA/625/7-91/016
Guides to Pollution Prevention:	Auto Repair Industry	EPA/625/7-91/013
Guides to Pollution Prevention:	The Commercial Printing Industry	EPA/625/7-90/008
Guides to Pollution Prevention:	The Fabricated Metal Industry	EPA/625/7-90/006
Guides to Pollution Prevention:	Fiberglass Reinforced and Composite Plastics	EPA/625/7-91/014
Guides to Pollution Prevention:	Marine Maintenance and Repair	EPA/6
Guides to Pollution Prevention:	Mechanical Equipment Repair Industry	
	Metal Casting and Heat Treating Industry	

Note: Additional guidance manuals on Thermal Metal Working and Municipal Pretreatment Programs are scheduled for release in 1993.

The Following Volumes are Available

Source Reduction of Halogenated Solvents: **Summary Report**
Source Reduction of Halogenated Solvents: : **Lifecycle Inventory and Tradeoff Analysis**
Source Reduction of Halogenated Solvents: **Adhesives**
Source Reduction of Halogenated Solvents: **Aerosols**
Source Reduction of Halogenated Solvents: **Chemical Intermediates**
Source Reduction of Halogenated Solvents: **Dry Cleaning of Fabrics**
Source Reduction of Halogenated Solvents: **Electronic Products**
Source Reduction of Halogenated Solvents: **Flexible Foam**
Source Reduction of Halogenated Solvents: **Paint Stripping**
Source Reduction of Halogenated Solvents: **Parts Cleaning**
Source Reduction of Halogenated Solvents: **Pharmaceuticals**
Source Reduction of Halogenated Solvents: **Textiles**

The Source Reduction Research Partnership (SRRP) has published a report entitled *Potential for Source Reduction and Recycling of Halogenated Solvents*. This report is a result of a five-year collaborative effort between the Environmental Defense Fund (EDF) and the Metropolitan Water District of Southern California. The report consists of 12 separate volumes: a comprehensive summary volume, a separate lifecycle inventory and tradeoff analysis, and ten industry-specific technical support reports. The objectives of the SRRP study include a survey and evaluation of existing and potential techniques for reducing the generation of halogenated solvent wastes, and thus their potential release into the environment, across a wide range of the industrial users of these solvents.

Each of the industry-specific volumes begins with a description of the industry and processes where halogenated solvents are used. Sources and causes of releases are described and regulatory regimes discussed for waste streams of concern. Subsequent sections focus on source reduction opportunities through chemical substitution, process modification, product substitution and recovery/reuse.

Each volume is $10 and can be ordered from:

Environmental Defense FundTelephone: 510-658-8008
Rockridge Market HallFax: 510-658-0630
5655 College Avenue
Oakland, California 94618
United States

Fact Sheets

The fact sheets listed below contain overviews, tips, and/or guidelines for pollution prevention. Some provide only general information or advice on how to set up programs, while others identify pollution prevention opportunities for specific industries, processes, or materials. EPA, state agencies, and local governments produced these fact sheets. In many cases, multiple sources have published fact sheets on a particular topic. Fact sheets on the topic areas listed below are available from the Pollution Prevention Information Clearinghouse. *Orders are limited to 10 items per request.*

EPA Pollution Prevention Fact Sheets

ACE: Agriculture in Concert with the Environment
Design for the Environment: Chemical Design Project
Design for the Environment: Cleaner Technology for a Safer Future
Design for the Environment: Dry Cleaning Project
Design for the Environment: Printing Project
EPA's 33/50 Program
EPA's 33/50 Program: Forging an Alliance for Pollution Prevention
EPA's Pollution Prevention Enforcement Settlement Strategy
EPA's Pollution Prevention Incentives for States
EPA's Pollution Prevention Strategy
Guides to Pollution Prevention
Local Governments and Pollution Prevention
National Pollution Prevention Center for Higher Education
National Pollution Prevention Environmental Education Project
New Form R Reporting Requirements
Pollution Prevention Act of 1990
Pollution Prevention Grant Programs
Pollution Prevention Information Clearinghouse
Preventing Pollution Through Efficient Water Use
Pollution Prevention Training and Education
Recent Publications
Setting up a Pollution Prevention Program
Source Reduction Review Project
You Can Make a Difference

Fact Sheet Topic Areas

General Pollution Prevention Information
Aerospace
Automotive Repair, Maintenance, Salvage Yards, Painting, Radiators
Facility Audit Checklists
  Chemical Manufacturing
  Cleaning
  Coating/Painting
  Dry Cleaning
  Formulators
  Machining
  Metal Industry
  Operating Procedures
  Petroleum Industry
  Photoprocessing
  Printed Circuit Board Industry
  Radiator Repair
Chemicals
Circuit Boards
Coal Mining
Cooling Towers
Dry Cleaning
Electroplating
Local Government—policies of and guides for Lumber, Wood Products and Furniture
Paint
Paper
Pesticides
Petroleum Refining, Fossil Fuel for Electric Power Generation and Oil Cleanup
Plastics and Fiberglass
Primary Metal Industries—Metal Finishing, Manufacturing, Machine Toolers, Metal Recovery
Printing, Publishing, and Photoprocessing Recycling and Recycling Markets
Solvents
Steel and Foundry
Textiles - Mills, Manufacturing
Waste Water Treatment

Clearinghouses and Associations

Pollution Prevention Information Clearinghouse

The Pollution Prevention Information Clearinghouse (PPIC) is dedicated to reducing or eliminating industrial pollutants through technology transfer, education, and public awareness. It is a free, nonregulatory service of the U.S. EPA, and consists of: a repository, a telephone reference and referral service and a computerized information exchange system.

The repository of the PPIC is a hard copy reference library, housed at the U.S. EPA Headquarters Library, containing the most current pollution prevention information. The repository includes training materials, conference proceedings, journals, and Federal and State government publications. The repository can be visited at the Headquarters Library, Room M2904 (401 M. Street, SW, Washington, D.C.). For use outside the Washington, D.C. area, the Library maintains cooperative agreements with many academic, public, and special libraries to borrow or lend books, journals, and other research materials through interlibrary loan. Abstracts and titles of holdings can be viewed by accessing PPIC (see below).

The Clearinghouse distributes selected EPA documents and fact sheets on pollution prevention free of charge. For a current distribution list call, fax, or mail a request to the PPIC (see below).

Telephone service is available to answer or refer questions on pollution prevention or the PPIC and take orders for documents distributed by the PPIC.

Pollution PreventionPhone: 202-260-1023
Information ClearinghouseFax: 202-260-0178
Environmental Protection Agency, PM 211-A
401 M Street, SW
Washington, D.C. 20460
United States

Pollution Prevention Information Exchange System (PIES)

A 24-hour electronic network consisting of technical databases and mini-exchanges that focus on specific pollution prevention issues, a calendar of events, hundreds of case study abstracts on pollution prevention, and message centers for interaction and exchange with users. The International Cleaner Production Information Clearinghouse (ICPIC) and OzonAction are also available by accessing PIES.

Anyone can access PIES using either an IBM PC (or compatible), Apple, or a dumb terminal equipped with a modem (1200 or 2400 baud), and appropriate communications software. PIES is accessible through a regular telephone call, the SprintNet^{SM} network and the EPA x.25 wide area network (for EPA employees only).The following communications soft- ware settings are required if you are calling PIES on a regular telephone line:

Phone Number: 703-506-1025
Speed: 1200 or 2400
Data Bits: 8
Parity: None
Stop Bits: 1

Upon first calling PIES, you must answer some brief questions, and then select and enter a password (you must remember your password for subsequent calls to the system).

A short, 2 page, "PIES Quick Reference Guide" was written to help new users log-on to and use the system. This guide can be requested by calling the PIES technical support office. A PIES User Guide (version 2.1, Nov. 1992) is available and may be obtained free of charge by leaving a message on the system addressed to 'Sysop', or by writing or calling the Clearinghouse.

Phone: 703-821-4800
Fax: 703-821-4775

Contact the PIES Technical Support Office for information on how government employees can access PIES toll-free.

SprintNet^{SM}

SprintNet^{SM} is a data network subscription service that enables you to access PIES in most major metropolitan areas using a local telephone call. Users are billed for connect time through U.S. Sprint, thus saving long distance telephone charges. To access PIES through SprintNet^{SM} you must first obtain a SprintNet^{SM} account. If you already subscribe to this service, dial your local SprintNet^{SM} access number. At the @ prompt, type: c 202561311 (your SprintNet^{SM} account number) (your personal SprintNet^{SM} password to access the PIES). If you would like to receive information about how to subscribe to SprintNet^{SM}, contact the PIES Technical Support Office. (Note: SprintNet^{SM} is not affiliated with the U.S. EPA or the PPIC).

Center for Environmental Reserach Information (CERI)

CERI is the focal point for the exchange of scientific and technical environmental information produced by EPA. It supports the activities of the Office of Research and Development (ORD), its laboratories, and associated programs nationwide. CERI publishes brochures, capsule and summary reports, handbooks, newsletters, project reports, and manuals. Services are provided to EPA employees; federal, state and local agencies; businesses; and the public.

Dorothy WilliamsTelephone: (513) 569-7562
US Environmental Protection AgencyFax: (513) 569-7566
Center for Environmental Research
Information (CERI)
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
United States

United States
Environmental Protection
Agency

Office of Pollution
Prevention and Toxics
Washington, DC 20460

November-December 1993

EPA 742-N-93-004

EPA

Pollution Prevention News

POLLUTION PREVENTION

Inside:

President Announces Global Climate Change Action Plan to Reduce Greenhouse Emissions

The White House has announced a detailed strategy to combat global warming. President Clinton and Vice President Gore joined with industry and environmental leaders on October 19 to announce the Climate Change Action Plan, which will return greenhouse emissions to 1990 levels by the year 2000, and in the process, expand markets for U.S. technologies and services, create jobs and reduce the deficit.

This strategy is a critical step in addressing climate change, the highest risk environmental problem. The plan consists of 50 new or expanded programs to reduce all types of greenhouse gases. It establishes groundbreaking public-private partnerships with key industries across all sectors of the economy. The announcement fulfills the President's Earth Day promise to return U.S. greenhouse emissions to 1990 levels by 2000 through American ingenuity and creativity, not bureaucracy and regulation. The United States emits about 20 percent of the global total of greenhouse emissions, more than any other country.

The partnerships and programs resulting from the Climate Change Action Plan will stimulate more than $60 billion over the next six years in private investment in

(Continued on page 6)

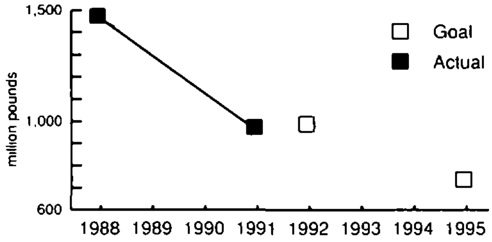
33/50 Program Exceeds Interim Goal

Data released by EPA show that the 33/50 Program met its 1992 reduction goal one year ahead of schedule. The 33/50 Program is a voluntary pollution prevention initiative which derives its name from its overall goals—a 33 percent reduction by 1992 and a 50 percent reduction by 1995 of emissions nationwide of 17 high-priority toxic chemicals. The latest Toxics Release Inventory (TRI) reveals that releases and transfers of the 33/50 Program chemicals declined by 34 percent since the program began, falling from 1.474 billion pounds in 1988 to 973 million pounds in 1991. This reduction exceeds the 1992 goal by 15 million pounds, one year ahead of schedule. EPA's analysis of the facilities' projections indicate that the 1995 goal of a 50 percent reduction is attainable.

As of August 1993, 1172 companies have chosen to participate in the program, promising to eliminate nearly 355 million pounds of pollution by 1995. EPA sends all participants a Certificate of Appreciation and recognizes the companies when they achieve their reduction goals. More than 200 companies have

(Continued on page 10)

TRI Emissions 1988-1995



Further information may be obtained from:

Environment and Energy Branch, UNIDO
Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49

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ID/395

Learning Unit 9

ENVIRONMENTAL CONSIDERATIONS IN PROJECT DESIGN

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

LU9

Additional Course Material

Video: *Paper Forest,* a film by UNEP

Introduction

Learning Unit 9 explains how to take environmental considerations into account when designing industrial development projects.

Objectives

The specific learning objectives of this unit are as follows:

- To recall priority environmental concerns that should influence the design of technical cooperation programmes and projects.
- To introduce publications that will help you assess the potential pollution problems created by industrial development.
- To describe UNIDO and UNDP guidelines that will assist you in introducing an environmental dimension systematically into technical cooperation projects.
- To practise incorporating environmental considerations into projects.

Key Learning Points

1 There should be an environmental dimension in most technical cooperation projects.

2 UNIDO programmes and projects should support the recommendations of the Conference on Ecologically Sustainable Industrial Development and Agenda 21 (UNCED) as well as the UNIDO environment programme.

3 UNIDO projects should address the following immediate environmental priorities:

- Minimizing the industrial discharge of conventional water pollutants, common air pollutants and toxic chemicals.
- Reducing the use of fossil fuels.
- Avoiding the inappropriate siting of industrial activities.

4 Most of the pollution problems from industrial activity are well known and can be assessed with existing guidelines. These rapid assessments can help set priorities, particularly if they are combined with estimates of potential exposure and adverse effects on human health and the ecosystem.

5 The publication *Guidelines for Environmental Appraisal* prepared by UNIDO, provides guidance on introducing environmental considerations into the design and development of UNIDO-implemented projects.

6 The publication *Handbook and Guidelines for Environmental Management and Sustainable Development*, prepared by UNDP, provides basic environmental information that a general development practitioner should have and a set of operational guidelines that should be taken into account in formulating UNDP-financed projects.

7 Long-term follow-up, monitoring and reporting are critical to ensure that projects adhere to environmental recommendations.

Suggested Study Procedure

1 Take the test in the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.

2 Work through the *Study Materials*, including the *Reading Excerpts* and the video. Prepare answers to the questions and check your answers against those suggested.

3 Read the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

4 Complete the exercises in the *Review*.

Study Materials

Throughout this training course you have been introduced to a wide range of environmental considerations that you can now bring to bear on your project design. Learning Unit 9 first reviews many of the important environmental considerations that you should keep in mind when designing industrial development projects. It then introduces you to UNIDO and UNDP guidelines for the environmental appraisal of projects and provides you with some exercises to test your understanding of these guidelines.

Project Design

Your project may be a free-standing environment project, i.e. one that is designed particularly to address an environmental problem, or it may be an industrial development project that needs an environmental dimension integrated into it.

In either case, begin by making sure that your project addresses an environmental problem of concern, particularly a problem that results from industrial activity. There is a considerable amount of information available on environmental conditions in developing countries, some of which has already been mentioned in this course. In addition, government agencies and NGOs, particularly those agencies and organizations that deal with the environment, public health and safety and natural resources, will have information on local environmental problems. Finally, environmental profiles of specific countries have been prepared. They can be obtained from representatives of the countries and organizations listed in table 1.

Review the proposed project elements to see how they fit into the following:

- The priorities of the UNIDO environment programme.

LU9

Table 1. Regional and National Environmental Assessment Studies(a)

Canada, Canadian International Development Agency. Environmental strategies: 10 countries.

Denmark, Department of International Development Cooperation. Environmental profiles: 5 countries.

Food and Agriculture Organization of the United Nations in cooperation with other United Nations agencies and institutions. Tropical forestry action plans: 75 countries.

Netherlands, Ministry of Foreign Affairs. Environmental profiles: 10 countries.

Permanent Interstate Committee for Drought Control in the Sahel. National plans to combat desertification: 6 countries.

United Kingdom. Environmental synopses: 12 countries.

United Nations Conference on Environment and Development. National reports: approximately 165 countries.

United Nations Environment Programme. Regional seas programme studies and reports: 45 countries.

United Nations Environment Programme and various national institutions. State of the environment reports: 42 countries.

United States Agency for International Development. Tropical forestry and biodiversity assessments: 35 countries.

United States Agency for International Development. Country environmental profiles: 62 countries.

United States Agency for International Development. Country disaster profiles: 49 countries.

World Bank. Environment action plans: 19 countries.

World Conservation Monitoring Centre. Biological diversity profiles: 48 countries.

World Conservation Union. National conservation strategies: 29 countries.

(a) A considerable amount of information is being compiled on the environment in developing countries, often with the support of bilateral and multilateral donors and NGOs. This list, arranged alphabetically by sponsoring country or organization, mentions some of these reports and is indicative of the number of countries covered.

Source: Excerpted from T. Mathews and Daniel B. Tunstall, *Moving Toward Eco-Development: Generating Environmental Information for Decision Makers*, (Washington, D.C., World Resources Institute, 1991) and contained in UNDP, *Handbook and Guidelines for Environmental Management and Sustainable Development* (1992).

- The priorities set at the Conference on Ecologically Sustainable Industrial Development.
- Agenda 21.
- International agreements.
- General environmental priorities.

The UNIDO environment programme seeks to ensure the ecological sustainability of industrial development and to maximize industry's beneficial impact by minimizing its adverse environmental effects. To achieve this goal the programme is divided into four subprogrammes.

- Subprogramme I aims to enhance, by means of training, the internal capacity of UNIDO in environmental matters. This involves not only the strengthening of in-house expertise but also the identification of regional and sectoral expertise on a given problem.
- Subprogramme II seeks to address the problem in developing countries of insufficient experience in addressing environmental degradation. The objectives are to raise awareness of environmental issues and to enhance the capacity of developing countries in industry-related environmental impact assessments, the prevention of accidents and the formulation of environmental policies, standards and legislation.
- Subprogramme III emphasizes the prevention of industrial pollution as distinct from the alleviation of its effects. Activities under this programme include preparation of guidelines and manuals, demonstration projects, training and the dissemination of information.
- Subprogramme IV offers technical advice for pollution abatement, which cannot be ignored even if pollution prevention has a higher priority. There is still much to be done to improve the maintenance and operation of existing industrial plants.

Some UNIDO actions that will contribute to ESID were discussed in Learning Unit 3. They include assisting developing countries with:

- Research, technical support and training to build technical and scientific capacity for pollution prevention and Cleaner Production processes.

- Technical and fund-raising support to implement international environmental agreements.

- Industrial guidelines and technical support for measuring environmental impacts and determining the soundness of industrial technologies.

- Technical support to identify priorities and rehabilitation techniques aimed at integrating environmental considerations into industrial strategies and policies.

Agenda 21 is also discussed in Learning Unit 3. It sets priorities for industrial activity, including

- Integrating environment and development in decision-making (chapter 8): government policies to promote more appropriate production and consumption patterns, establishment of environmental accounting systems, effective legal and regulatory frameworks, effective use of economic instruments and market incentives.

- Protection of the atmosphere (chapter 9): develop less polluting sources of energy; more efficient energy utilization in the transport and industrial sectors; prevention of stratospheric ozone depletion; and reduction in transboundary atmospheric pollution.

- Protection of water resources: the oceans (chapter 17) and fresh water resources (chapter 18): reduce marine pollution, 70 per cent of which comes from sources on land; sustainable use and conservation of marine living resources; integrated water resources development and management; and protection of water resources, water quality and aquatic ecosystems.

- Environmentally sound management of toxic chemicals, hazardous wastes and solid wastes (chapters 19, 20, 21): establishment of risk reduction programmes; prevention and minimization of hazardous waste; maximization of waste reuse and recycling; and promotion of waste disposal and treatment.

- Business and industry (chapter 30): promotion of Cleaner Production, elimination of the inefficient use of resources, promotion of responsible entrepreneurship.

- Technology transfer (chapter 34): cooperation between companies in developed and developing countries, joint ventures between suppliers and recipients of technology, licensing agreements.

Some major international agreements address the priorities of Cleaner Production:

- The Montreal Protocol sets limits for ozone-depleting substances.

- The Basel Convention aims to control the transboundary movement and disposal of hazardous wastes.

- The Framework Convention on climate Change aims to stabilize greenhouse gases.

General environmental priorities include reduction of the following:

- Discharges of conventional water pollutants (organic matter and solids) that threaten water supplies and productive resources.

- Discharges of common air pollutants, e.g. suspended particulate matter and SO_2 and NO_X, that cause acute and chronic health problems, particularly in urban areas.

- The use of fossil fuels, through energy conservation and the application of renewable energy sources.

- Discharges of toxic heavy metals, e.g. chromium, mercury and lead, and aromatic chlorinated compounds, e.g. PCBs and dioxins, and, in the long run, their elimination.

- Solid wastes and their disposal.

They also include the location of industrial facilities away from sensitive ecological areas or heavily populated areas.

If your project involves a specific industrial activity, you will need to assess its potential environmental problems. Learning Unit 5 discussed how to carry out a full environmental impact assessment; such assessments may be necessary, especially for large industrial projects. You can get a good preliminary idea of the potential problems from some of the following sources:

- The WHO publication *Rapid Assessment of Sources of Air, Water and Land Pollution* provides factors for estimating pollution from different industrial activities according to the level of output and the degree of pollution control in place. It describes how to apply these coefficients to estimate the magnitude of pollution that might be generated by a specific industrial activity.

- Two publications of the World Bank. The first, *Environmental Guidelines* (the year of publication was 1988, but the contents are based mainly on reports from the 1970s), describes industrial pollution problems for over 30 industries as well as several common air and water pollutants (see table 2). The second, *Occupational Health and Safety Guidelines* (also published in 1988, but based mainly on reports from the 1970s), covers health and safety issues for the same industries.

- The World Bank, UNIDO and UNEP are in the process of updating these guidelines to reflect the shift away from end-of-pipe treatment towards pollution prevention and waste minimization. A total of 85 guidelines are planned. As of November 1993, draft guidelines were ready for 20 sectors. Ten should be available for project staff by the end of 1993.

- The *Environmental Assessment Sourcebook* of the World Bank, in three volumes, covers a wide array of environmental topics; volume III describes the major environmental impacts of energy use in several industries (see table 3).

As always, you must ensure that your project conforms to the general guidelines for project design prescribed by UNDP in its *Programmes and Projects Manual* and by UNIDO in its *Guidelines for Project Design*. For large projects (normally over $1 million), the project design can be preceded by an objectives-oriented project planning workshop that aims to ensure that projects are client-oriented, catering to their specific needs.

It is very important, of course, that you identify the source of funding for your project. UNIDO relies on three main categories of funding: UNDP funds, special trust funds and UNIDO- administered funds. Special funds for environmental projects are also available from the Global Environment Facility of UNDP/UNEP/ World Bank, the Multilateral Fund of the Montreal Protocol and Capacity 21 (see *Reading Excerpts*). The project approval process, including the environmental review, varies with the type of funding, so it is a good idea to identify the probable source of funding as early as possible in the project design stage.

Table 2. Scope of Coverage of the World Bank's Environmental Guidelines, 1988

Aluminium
Cane sugar
Cement
Chlor-alkali
Dairy products
Dust emissions
Earthquake protection
Effluents: disposal of industrial wastes
Effluents: liquid, land disposal and treatment
Electrostatic precipitators (ESPs)
Ethanol production
Fertilizer manufacturing wastes
Fish and shellfish processing
Fruit and vegetable processing
Geothermal development
Glass manufacturing
Iron and steel: general considerations
Iron and steel: blast furnace
Iron and steel: by-product coke ovens
Iron and steel: ore preparation, sintering and pelletizing
Iron and steel: rolling and finishing operations
Iron and steel: steel-making process
Lead sampling and analyses
Leather tanning and finishing
Meat processing and rendering
Mining: strip surface mining operations (sediment and erosion control — land reclamation)
Mining: underground (coal)
Nitrogen oxide emissions
Nitrogen oxide sampling and analyses
Noise
Non-ferrous metals: aluminium
Non-ferrous metals: copper and nickel
Non-ferrous metals: lead and zinc
Non-ferrous metals: silver, tungsten, columbium and tantalum
Offshore hydrocarbon exploration and production projects
Oil pipelines
Palm oil
Pesticide manufacture: safety and ecology*
Pesticides: guidelines for use*
Petroleum refining
Plating and electroplating
Plywood manufacturing
Poultry processing
Pulp and paper
Rodenticides*
Rubber production (crumb)
Secondary environmental effects
Slaughterhouses: industrial waste disposal and design arrangement
Sulfur dioxide ambient levels
Sulfur dioxide emission standards
Sulfur dioxide sampling and analyses
Tea and coffee production
Textiles and synthetic fibres
Wood scouring

** an asterisk denotes environmental and occupational health and safety guidelines.*

Table 3. Scope of Coverage in the World Bank Publication: *Guidelines for Environmental Assessment of Energy and Industry Projects*(a)

Industrial hazard management

Hazardous materials management

Plant siting and industrial estate development

Electric power transmission systems

Oil and gas pipelines

Oil and gas development: offshore and onshore

Hydroelectric projects

Thermoelectric projects

Financing nuclear power:

Cement

Chemical and petrochemical

Fertilizer

Food processing

Small and medium-scale industries

Iron and steel manufacturing

Non-ferrous metals

Petroleum refining

Pulp, paper and timber processing

Mining and mineral processing

(a)*Environmental Assessment Sourcebook*, World Bank Technical Paper No.154, vol. III.

Next Steps

1. Read "Programme objectives: output and activities" and "Environment funding sources to be tapped by UNIDO", included in the *Reading Excerpts* at the end of this Learning Unit.

2. Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 Identify technical assistance activities that UNIDO could undertake under subprogrammes II, III or IV to assist developing countries meet the requirements of international environmental conventions and protocols.

2 Name some specific policy areas that UNIDO technical activities should address to promote ecologically sustainable industrial development.

3 Which UNIDO subprogramme encourages the preparation of guidelines?

4 What is the difference between subprogramme III and subprogramme IV?

Answers

1. *Under subprogramme II.5 (d), it could prepare guidelines related to compliance with international conventions and protocols; under subprogramme III.5 (e), it would disseminate information and under subprogramme IV.5 (c), it would identify and implement actions necessary to comply with the conventions and protocols.*
2. *Under subprogramme II.5 (e) (iii), ESID-related measures could be integrated into fiscal policies, financial and credit policies, regulatory policies, technology policies and spatial/location policies.*
3. *Under subprogramme I.4 (c), UNIDO could issues guidelines on pollution control, risk management, life-cycle analysis, environmental economics and environmental impact assessment.*
4. *Subprogramme III emphasizes the better use of human and natural resources as well as pollution prevention in preference to end-of-pipe solutions. Subprogramme IV recognizes that end-of-pipe technologies are often necessary to reduce pollutant discharges to a satisfactory level.*

Next Steps

1 Look over the questions below so that you have some idea of what you will want to learn from the video.

2 Watch the video *Paper Forest.*

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 List some product life-cycle considerations identified by the video.

2 What are the main pollutants associated with pulp and paper mills? What solution is proposed to minimize these problems?

3 Identify measures that the new mill can take to prevent pollution.

4 Why might you be sceptical that the new mill will manage its pollution problems? What innovative measure will the Government use to encourage pollution reduction?

5 Which negative effects have not been foreseen in the design of the mill?

Answers

1.Product life-cycle considerations raised by the video are the necessity for paper products, the impacts of raw material use (water and wood), recycling of waste paper and an alternative source (biogas) of fuel to conserve wood for paper use.

2. The main pollutants are dissolved organic matter and suspended solids. The proposed solution to these problems is to install primary and secondary waste-water treatment.

3. The new mill can reduce water use and use black liquor waste as a source of fuel.

4. You might be skeptical because most existing mills are causing water pollution problems and the Government appears to be powerless to address these problems. The Government did expect that the water cess (tax) would provide a new incentive to control pollution.

5. For its wood supplies, the new mill will rely on eucalyptus plantations which require large amounts of water. The eucalyptus monoculture will also impoverish the local ecosystem and reduce opportunities for hunting and gathering by villagers.

UNIDO Project Cycle Management: Environmental Considerations

Environmental issues must be considered in each of the six stages of the UNIDO project cycle: project identification, formulation/design, appraisal, approval/funding, implementation/monitoring and evaluation.

Guidance for environmental consideration in the UNIDO project cycle is provided by the UNIDO *Guidelines for Environmental Appraisal.* The *Guidelines* are most useful at the stage of project design.

The *Guidelines* provide for two classifications of UNIDO technical cooperation projects:

- Category A projects are those that do not involve capital investment, for example, human resource development or industrial management projects. Approximately 90 per cent of new UNIDO projects are category A projects.
- Category B projects are those that do involve capital investment, for example, plant expansions, process modifications or the introduction of waste management facilities including treatment plants, disposal sites and laboratories. Approximately 10 per cent of new UNIDO projects are category B projects.

Because category A and category B projects have different environmental implications, the *Guidelines* provide separate analysis procedures and check-lists for each. In addition, special check-lists are provided for four industries: tanneries and leather finishing, iron and steel manufacturing, fertilizer manufacturing and food and agro-industries.

For category A projects (no investment), the *Guidelines* take the user through several steps to ensure that environmental measures are integrated into the project. The procedure focuses on environmental awareness and the development of technical and institutional capability. UNIDO staff are expected to consider the following key questions:

- Does this project promote environmental awareness?

- Is training in environmental matters included?
- Is environmental information management included?
- Has institutional strengthening been considered?

For category B projects (investment), the *Guidelines* take the user from the sources of environmental impacts, to the receptors of impacts, to assessment of the significance of the impacts and, finally, to mitigation measures. The procedure examines various stages of the industrial process, highlighting

- Sources of pollutants.
- Points where environmental impacts are likely to occur (receptors).
- The actual environmental impacts (water, air, soil, land use) and their significance.
- Measures to mitigate environmental impacts.

Next Steps

1 Read the selection from *Guidelines for Environmental Appraisal*, included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 How would you define a category A project? List a few examples of such projects.

2 What type of environmental measures might you introduce into category A projects?

3 How would you define a category B project? List a few examples of such projects.

4 List some sectors where one would expect to find significant environmental impacts.

5 How would you define a significant environmental impact?

6 What would be your first priority in thinking about mitigation measures?

Answers

1. *Category A projects are technical assistance projects with no capital implications, i.e. no requirements for investments to build, expand or modify a plant. Examples of category A projects are human resources development, industrial management and industrial planning and strategies.*
2. *Potential measures are the promotion of environmental awareness by distributing environmental information and by instructing international experts to discuss environmental matters with the national counterparts; incorporation of environmental training as one activity in the project; and drawing on the INTIB database for environmental information about a specific topic.*
3. *Category B projects are technical assistance projects with potential primary or secondary environmental impacts. These are normally projects with capital implications, i.e. investment is required for construction or expansion of the industrial plant, process modification or introduction of waste management facilities. Examples of category B projects are energy feasibility studies, industrial rehabilitation and maintenance.*
4. *Some potential sectors are metal finishing, which discharges toxic metals; coal combustion, which discharges acidifying pollutants; pulp and paper manufacturing, which discharge large volumes of organic matter; and cement manufacturing, which discharges large volumes of particulate matter.*
5. *Criteria for a significant environmental impact include exposure of a large number of people, potential to adversely affect drinking water supplies or disrupt productive farming and fishing activities and location near sensitive ecological areas.*
6. *You would consider Cleaner Production options (different raw materials, reduce water use etc.) before waste treatment and disposal technologies.*

UNDP Programme/Project Management: Environmental Considerations

Guidance for environmental considerations in the UNDP project cycle is provided by the UNDP *Handbook and Guidelines for Environmental Management and Sustainable Development*, which is available at any UNDP offfice.

UNDP sees its approach as different from existing environmental guidelines because it focuses on the front end of development work, i.e. the planning and implementation of technical assistance and the pre-investment phase, rather than on problem identification and environmental assessment. Thus, its *Guidelines* do not follow the environmental impact assessment route. They endeavor, rather, to be proactive in orientation.

The UNDP *Guidelines* consist of three parts:

- General concepts of environmental management and sustainable development.
- Operational guidelines that assist in introducing an environmental dimension into all UNDP technical cooperation activities.
- Annotated bibliography of environmental impact assessment and environmental management guidelines.

The UNDP *Guidelines* identify environmental checkpoints, or key activities during which environmental management tools ought to be incorporated. These checkpoints include

- The programming of technical assistance, e.g. round table consultations.
- The country programme cycle: review of the existing country programme; advisory note; resource assessment; review by the Programme Appraisal Committee and the Action Committee; implementation; and monitoring and evaluation.
- Programmes and the project cycle: programme/project identification; project formulation; screening proposed projects, revision following project appraisal; project

approval; project implementation and project monitoring and evaluation.

UNDP prescribes four environmental management tools to be used at the various checkpoints:

- Tool 1, an environmental check-list, serves as a reminder of the key questions to be answered in assessing a programme or project.
- Tool 2, an environmental overview, is a short document providing basic environmental information and alternatives /modifications to increase the sustainability of a development alternative. Environmental overviews can be prepared for a country programme (EOC) or for a programme or project (EOP).
- Tool 3, an environmental screen, consists of criteria for screening the project from an environmental point of view.
- Tool 4, an environmental management strategy, is a detailed, action-oriented environmental plan prepared for a UNDP project. Whereas environmental overviews simply examine what might happen to the environment with a proposed UNDP project, an environmental management strategy identifies what must be done to mitigate the environmental disturbance, designates who must do it and when, and describes what resources will be required. An environmental management strategy is an ongoing effort demanding close UNDP monitoring throughout the project life cycle.

Next Steps

1 Read "Operational guidelines", included in the *Reading Excerpts* at the end of this Learning Unit.

2 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

1 What is the difference between an environmental overview of a project and an environmental management strategy?

2 At what stage in the project cycle is one required to prepare an environmental overview of a country programme? At what stage in the project cycle is one required to prepare an environmental overview/management strategy?

LU9

3 What types of programmes/projects should be subject to further environmental consideration?

4 The UNDP *Guidelines* recommend that infrastructure and industrial strengthening projects be subject to further environmental considerations, including those with risks of accidents. In what sector is there the greatest potential for accidents?

5 What type of questions should be addressed in an environmental management strategy (EMS or EOP/MS)?

Answers

1. *An environmental overview of a project describes what is happening or might happen to the environment with a proposed action. An environmental management strategy identifies specific mitigation measures, when they will be carried out, who will undertake them, when will they be implemented and what resources are needed to implement them.*
2. *An environmental overview of a country programme should be prepared at the advisory note formulation stage and, where necessary, an environmental overview/management strategy should be prepared at the project formulation stage.*
3. *The five types are environmentally sensitive areas or activities; livestock, farming and fishing practices; activities dealing with water resources; infrastructure and industrial strengthening; and urbanization, land development and waste management.*
4. *The chemical sector.*
5. *Questions include how to mitigate disturbance, when will mitigation activity take place, who is responsible for implementing action, how long it will take to implement action and what is required to carry out action.*

Additional Suggested Readings

This concludes the study section of Learning Unit 9. For additional information on environmental considerations in project design, you may refer to the following sources.

Economopoulos, A.E. *Assessment of Sources of Air, Water and Land Pollution*, Environmental Technology Series (Geneva, WHO, 1993), *Part One: Rapid Inventory Techniques in Environmental Pollution* and *Part Two: Approaches for Consideration in Formulating Environmental Control Strategies.*

Environmental Resources Limited, "Environmental assessment procedures in the UN system", Report prepared for UNEP, 1990.

Finland, Department of International Development Cooperation, *Guidelines for Environmental Impact Assessment* (Finnish International Development Agency, 1989).

UNIDO, "First guide for UNIDO officers in evaluating the environmental impact of industrial projects", (PPD.76 (SPEC.)).

World Bank, Environment Department, *Environmental Assessment Sourcebook*, Volume I: Policies, Procedures, and Cross-Sectoral Issues, Technical paper No. 139, Volume II, Sectoral Guidelines, Technical paper No. 140; Volume III, Guidelines for Environmental Assessment of Energy and Industry Projects, Technical paper No. 154 (Washington, D.C., 1991).

World Bank, *Environmental Guidelines* (Washington, D.C., 1988).

World Bank, *Occupational Health and Safety Guidelines* (Washington, D.C., 1988).

Case Studies

Next Steps

1 Familiarize yourself with the draft pollution prevention and abatement guidelines for cane sugar processing and refining in the *Reading Excerpts*. Then read the short hypothetical case below and answer the questions that follow, if possible working in a small group.

2 Compare your answers with those suggested.

Case Study 1: Industrial Rehabilitation of Sugar Processing Plants

As a result of a UNIDO preparatory mission, you have received a project document calling for a complete diagnosis of the cane sugar industry in a developing country. The project will address the overall efficiency and profitability of the 20 mills that are currently operating below capacity and at a financial loss.

LU9

After reviewing the project document, you decide, based on the UNIDO *Guidelines for Environmental Appraisal*, that it has capital implications (category B) and that it must be expanded to address environmental and energy issues. Consult the excerpt on cane sugar processing and refining and, if available in your office, Section III-D, "Food-agro industries", of the UNIDO *Guidelines for Environmental Appraisal* to answer the following questions that must be addressed in the background section in the project document and to prepare terms of reference for an environmental expert.

Questions

1 What environmental problems need to be addressed?

2 What pollution prevention measures would you recommend that the environmental expert should consider?

3 What by-products would you suggest that the expert should consider for recovery?

4 What air pollution prevention measures should the expert consider?

LU9

Answers

1. *The primary environmental problem is waste water that is produced throughout the production process. For mechanically harvested cane, water demand during the initial cleaning is particularly high. Other environmental problems are suspended particulates from the combustion of bagasse, fuel oil or coal; solid waste produced during the initial mechanical operation; and fugitive dust from granulation operations.*
2. *Water conservation through recycling and reuse should be the major area to examine. The sulphitation clarification process, which processes a high pollution load, can be replaced by the Talo-floc process, or by the use of bentonite, double centrifugation or affination. The fermentation of sugarcane juices can be averted by appropriate straining, by the systematic application of disinfectants or biocides in mill juices and by systematic cleaning when the milling has stopped.*
3. *The expert should consider boiler and fly ash; bagasse; filter mud; molasses and residual waters for irrigation.*
4. *Flue gas emissions can be reduced by controlling combustion, air pressure and the rate of excess air.*

Case Study 2: Coastal Area Development

Next Steps

1 Read "Environmental overview of project and management strategy for a sample UNDP project" in the *Reading Excerpts*.

2 Answer the questions below, if possible working in a small group.

3 Compare your answers with those suggested.

Questions

1 What major environmental impacts are associated with the implementation of the project?

2 What potentially significant environmental impact was not mentioned?

3 What additional environmental policy would help to mitigate the excessive use of pesticides?

4 As a proponent of industrial development, what would you like to see included in this project?

5 If the project were to include a feasibility study for processing cocoa, what potential environmental impacts should be addressed in the environmental management strategy? (Hint: Many agro-industries have similar environmental problems; refer to the guidelines for cane sugar).

Answers

1. *Major environmental impacts might include the following:*
   Disruption of the nutrient level in the ecosystem due to the shift to monoculture.
   Population migration that would degrade the existing resource base.
   Adverse health effects.
2. *There is no mention of the effect in the aquatic ecosystem of increased pesticide use for estate cocoa and coffee. In other estate crop areas of Indonesia, the aquatic ecosystem has been disrupted by the intense use of pesticides.*
3. *The Government could stop subsidizing pesticide use. If the price of pesticides were higher, farmers would be restrained in their use of pesticides.*
4. *The project did not support the processing of the coffee and cocoa beans. This processing would generate additional wealth and employment for the people. Additional processing might also be possible for the fishery industry.*
5. *The potential environmental impacts of cocoa processing include the following:*
   Waste water is generated in the washing operations and in roasting plants that employ wet-stack scrubbers.
   Solid waste is produced during crushing and grinding.
   Roasting operations release SO_2 and particulates into the atmosphere.

Review

Test ✓

The following test will help you review the material in this Learning Unit.

1 The four subprogrammes of the UNIDO environment programme cover all of the following except

a. Prevention of industrial pollution
b. Small and medium-size enterprises
c. Policy level advice
d. Technical assistance for pollution abatement

2 Which subprogramme of the UNIDO environment programme calls for information dissemination?

a. Subprogramme II, policy advice
b. Subprogramme III, pollution prevention
c. Subprogramme IV, pollution control
d. All of the above

3 All of the following are ESID recommendations except

a. Implementing environmental protocols
b. Demonstration projects
c. Ambient environmental monitoring
d. Training

4 Which chapter of Agenda 21 addresses Cleaner Production?

a. Chapter 34, "Technology transfer"
b. Chapter 30, "Business and industry"
c. Chapter 9, "Protection of the atmosphere"
d. Chapter 8, "Integrating environment and development in decision-making"

5 Which United Nations organization has prepared guidelines for the rapid assessment of sources of air, water and land pollution?

a. WHO
b. UNIDO
c. UNEP
d. UNDP

6 Which of the following is not a special source of funds for environmental projects?

a. Global Environment Facility
b. Basel Convention
c. Capacity 21
d. Multilateral Fund of the Montreal Protocol

7 The UNIDO guidelines are most useful at which stage of the project cycle?

a. Design
b. Identification
c. Approval
d. Evaluation

8 All of the following might be appropriate environmental measures for projects *without* capital implications except

a. Environmental awareness
b. Technology change
c. Training
d. Information mangement

9 UNIDO projects that require no capital investment (category A) constitute approximately what per cent of UNIDO tachnical assistance?

a. 90 per cent
b. 70 per cent
c. 50 per cent
d. 30 per cent

10 All of the following measures might be appropriate environmental measures for projects with capital implication except

a. Information management
b. Good housekeeping
c. Process changes
d. Treatment snd disposal of wastes

11 The UNDP *Handbook and Guidelines for Environmental Management and Sustainable Development* focuses on

a. Identifying environmental problems
b. Assessing environmental impacts
c. Designing environmental management agencies
d. Planning technical assistance

12 The environmental overview required by the UNDP *Guidelines* can be prepared for

a. A country
b. A project
c. A programme
d. All of the above

Answers
1-5 *b d c b a*
6-10 *b a b a a*
11-12 *d d*

Some Ideas to Think About

Use a recently completed category A (no capital investment) project that you know well to think about the following questions. Take some time to think about them. If possible, work in a small group and try to achieve consensus.

1 What were the potential environmental impacts?

2 How could the *Guidelines for Environmental Appraisal* have helped to identify adverse environmental impacts?

3 What appropriate mitigating measures did you suggest in terms of awareness, training, institution building or environmental management information systems?

4 To what extent were the measures cost-efficient and to what extent were they effective?

LU9

5 What were the barriers and difficulties for addressing environmental concerns in that particular project? How could they be approached in the future?

Reading Excerpts

Programme Objectives: Output and Activities

Excerpted from "UNIDO environment programme", (IDB. 10/17), chap. IV.

The proposed programme comprises four subprogrammes which together address the priorities outlined.

Subprogramme I	Enhancing the organization's capacities in rendering ESID-related assistance
Subprogramme II	Integrating environmental considerations in developing countries' industrial development strategies and policies
Subprogramme III	Promotion of Cleaner Production
Subprogramme IV	Technical cooperation in pollution abatement

Subprogramme 1: Enhancing the Organization's Capacities in Rendering ESID-Related Assistance

Problem to Be Addressed

There is a growing need for UNIDO to deliver increasingly diversified ESID-related assistance to developing countries. It is therefore essential that staff knowledge be continuously upgraded in such areas as environmental and energy policy, technology, information and funding sources and that that information be incorporated in the development, appraisal, implementation and evaluation of all UNIDO programmes and activities.

Objective

To continue to enhance, through training and recruitment, UNIDO's capacity to provide effective ESID-related assistance, applying the latest solutions based on the recommendations of the ESID Conference.

Subprogramme Focus

UNIDO Secretariat and field staff, United Nations and other international organizations and development agencies, counterpart staff in developing and other countries.

Outputs

- Effective ESID-related assistance provided by trained UNIDO staff to developing countries, particularly in the areas of Cleaner Production, environmental and energy policy, information and funding sources, and capability of designing, appraising, implementing and evaluating technical cooperation and investment promotion based on the same principles;
- Enhanced capacity to prepare technical cooperation, investment and other projects supported by national authorities for submission to international funding authorities including, *inter alia*, those set up to help implement international environmental conventions and protocols;
- Manuals, handbooks, guidelines and other documented material on pollution control, risk management, life-cycle analysis, environmental economics, environmental impact assessment and other fundamental issues pertaining to sustainable industrial development for use by UNIDO and national counterpart staff;
- Promotional material prepared on a regular basis which presents the work of UNIDO in support of ESID in developing countries;
- Environmental issues fully integrated into all activities which address major themes of the UNIDO medium-term plan.

Activities

- Continuation of seminars and training courses for headquarters and field staff on, *inter alia*, Cleaner Production, energy efficiency and conservation, ESID policy and strategy formulation, environmental economics, and pollution monitoring and control;
- Integration of environmental management guidelines into all stages of the UNIDO project cycle; incorporation of methodologies for environmental impact assessment into feasibility and pre-investment studies; promotion of tools demonstrating economic and financial advantages of environmental protection and rehabilitation; continuous updating, further development and

dissemination of the UNIDO Industrial and Technological Information Bank information networks and databases;

- Collection and dissemination to UNIDO staff and national counterparts of information on priorities of and access to funding sources for ESID;
- Preparation of written materials on fundamental issues pertaining to ESID for use by UNIDO and counterpart staff in designing and implementing technical assistance, investment promotion and other UNIDO projects;
- Preparation of bulletins, reports, speeches, lectures, press statements, letters, books, prefaces and other public statements and presentation material for use in promoting the work of UNIDO in support of ESID;
- Incorporation of energy, gender, economic and technical cooperation among developing countries (ECDC/TCDC) technology and other areas emphasized in the UNIDO medium-term plan, including the promotion of regional and subregional cooperation, into all ESID programmes and projects.

Subprogramme II: Integrating Environmental Considerations in Developing Countries' Industrial Development Strategies and Policies

Problem to Be Addressed

Developing countries could make a decisive contribution to preventing and controlling industrial pollution within their own borders and at the global level. Yet, many developing countries lack sufficient experience to deal with environmental problems, as well as the necessary institutional infrastructure to appraise the environmental impact of industry and develop policies, norms, standards, regulations, legislation and market-based measures that would contribute to sustainable industrial development.

Objective

To enhance capacities of developing countries in the formulation of policies and strategies, in particular with regard to industry-related environmental standards and regulations combined with appropriate market-based measures, and in conduct of industry-related environmental impact assessments and accident prevention. The successful achievement of this objective would necessitate close collaboration with other multilateral, bilateral and regional organizations active in the field.

Subprogramme Focus

- Industrial subsectors: metallurgical and metal-finishing industries, pulp and paper, cement, textiles and tanneries, food-processing and chemical process industries, with due priority given, as stated in General Conference resolution GC.4/Res. 18, to the five subsectors that were highlighted at ESID, with particular attention throughout to energy sources and use.
- Environmental issues that transcend geographical and subsectoral boundaries such as industrial restructuring (scale, siting, mix of production), technological options, internalization of the cost of environmental protection in price calculations, industrial emissions, primarily from energy generation (NO_x, SO_2 and SO_2), ozone-depleting substances and hazardous waste.

Outputs

- Guidelines, methods and manuals produced and advisory projects implemented on environmental impact assessment, accident prevention techniques and management, environmental risk management and hazardous waste management; for plants and/or subsectors at the national, subregional, regional and international levels;
- Guidelines on ESID-based legislation, standards, regulation, monitoring, and development and application of market-based measures, including contingency plans for the industrial subsectors listed above;
- Advisory projects implemented to provide options to Governments in formulating sectoral policies, using an appropriate mix of regulatory and market-based measures, to promote industries that contribute to ESID using clean and low-waste technologies;
- Training programmes implemented to train developing country cadres in environmental planning for industry (in particular, environmental impact assessment and monitoring) and in formulation of industry-related environmental norms, standards, regulations, legislation and market-based measures.

Activities

- Conducting of studies on environmental impact, alternative technologies available to alleviate that impact, in addition to the environmental protection norms and standards employed in industry in various parts of the world;
- Preparation of environmental protection guidelines and occupational health and safety regulations related to industry, in cooperation with other United Nations organizations and agencies;

- Continuous updating of the UNIDO system of databases, preparation and dissemination of guidelines, manuals and methods for introducing accident-prevention techniques and methodologies in industrial enterprises, and for safe disposal of hazardous waste, in cooperation with other United Nations agencies;
- Preparation of guidelines related to compliance with international environmental conventions and protocols, environmental standards, regulations and monitoring for the priority subsectors, in cooperation with other United Nations organizations;
- Implementation of ESID-based technical advisory projects which include the following:
  - Review of current and planned sectoral policies, policy instruments, strategies and institutional infrastructure;
  - Proposal of measures for integrating ESID into regional industrial policies, in accordance with national priorities and with due consideration for the incidence of those policies (national and regional);
  - Integration of ESID into specific areas such as fiscal policies, financial and credit policies, regulatory policies, technology policies, spatial/location policies, transboundary regulations and policies, and environmental auditing;
  - Encouragement of ESID through research and development, acquisition and transfer of technologies;
  - Promotion of education, public awareness, and information exchange on ESID policies, strategies and guidelines;
  - Establishment and/or strengthening of environmental impact assessment mechanisms to achieve qualitative and quantitative assessment of environmental impact of industrial activity;
  - Construction of information management systems for acquisition and organization of data on sources and effects of industrial pollution;
  - Assessment and protection of the impact of alternate ESID strategies on such socio-economic indices as population growth, income disparities, spatial variations in development and resource demands;
  - Strengthening of institutional capabilities to achieve ESID through expert advice and on-site training with special emphasis on the promotion and involvement of local organizations;
- Formulation and implementation of training programmes for developing country cadres in environmental planning, monitoring, modelling, auditing and impact assessment and in formulation of industry-related environmental norms, standards, regulations and legislation.

Subprogramme III: Promotion of Cleaner Production

Problem to Be Addressed

In the long run, as the UNCED and ESID conferences made clear, Cleaner Production, which emphasizes better use of human and natural resources and pollution prevention rather than end-of-pipe solutions, is more economical and conducive to sustainable development. Furthermore, in some instances, the use of cleaner technologies may actually prove more profitable to the firm. In the case of energy, greater benefit is derived from improvements in energy efficiency than from investments in pollution control. Furthermore, improved energy efficiency offers potential for reducing the emission of a broad range of pollutants. The critical gap in that respect, however, is the lack of information on technological options or the methods available to transfer them to enterprises in and Governments of developing countries.

Objective

To support the adoption of Cleaner Production, based on ESID, in the industrialization of developing countries.

Subprogramme Focus

Industrial subsectors: metallurgical and metal-finishing industries, pulp and paper, cement, textiles and tanneries, food-processing and chemical process industries, with due priority given, in accordance with resolution GC.4/Res.18, to the five subsectors covered by the ESID Conference, with particular attention throughout to energy sources and use.

Outputs

- Advisory projects implemented providing technological information to Governments and/or entrepreneurs on the identification, assessment, acquisition and transfer of appropriate Cleaner Production technologies, including potential for ECDC/TCDC, conducted within the industrial structure and environment of the requesting developing countries;
- Pre-investment and feasibility studies undertaken to assess the economic viability and potential macroeconomic and micro-economic savings of Cleaner Production technologies over traditional solutions;
- Technical cooperation projects implemented that employ Cleaner Production technologies;
- Expanded information systems within UNIDO and in appropriate developing country institutions on Cleaner Production technologies based on ESID, including those required for com-

pliance with international environmental conventions and protocols (for example, non-CFC technologies);

- Information on appropriate, including new, financial resources, where possible on concessional terms, that would enable developing countries to have improved access to Cleaner Production technologies;
- Expanded roster of experts and database on institutional facilities providing training in the environmental upgrading of existing industries;
- Improved demonstration and training centres at new or existing industrial facilities and at centres of excellence where research and development suited to local industrial needs and capabilities will be strengthened;
- Cadres of developing country counterparts, trained to evaluate options and incorporate Cleaner Production technologies as appropriate in their industrialization processes.

Activities

- Assistance to developing countries in the identification, assessment, acquisition and transfer of pollution prevention techniques and Cleaner Production processes essential to making the transition to ESID, including potential for ECDC/TCDC;
- Demonstration of the financial and economic advantages and environmental benefits of ESID by undertaking pre-investment and feasibility studies;
- Provision of technical support for the design, establishment, operation, evaluation and monitoring of pollution prevention technologies and Cleaner Production processes and technologies;
- Assistance to developing countries in contract negotiation and transfer of environmentally sound technology;
- Strengthening existing UNIDO databases and the Organization's capacity to coordinate the dissemination of technical and policy information on ESID, including relevant information on international environmental conventions and protocols;
- Assisting developing countries in identifying appropriate, including new, financial resources, where possible on concessional terms, that would enable them to take necessary steps to achieve ESID;
- Identifying experts, institutes and training facilities and promoting their inclusion in existing UNIDO industrial information systems and in appropriate institutions in developing countries;

- Establishment of demonstration and training centres at newer existing industrial facilitates, and providing support to centres of excellence;
- Training of developing country counterparts to enable them to evaluate options and incorporate Cleaner Production technologies into their industrialization processes.

Subprogramme IV: Technical Cooperation in Pollution Abatement

Problem to Be Addressed

Owing to social and economic circumstances, it is often not possible to implement Cleaner Production all at once by adopting sweeping ESID strategies and technologies in the manner outlined in subprogrammes II and III above. Instead, in particular where heavily polluting, often outdated, industrial facilities already exist, it can be more economical to curb pollution rather than investing heavily to eliminate it altogether. Industrial upgrading and industrial rehabilitation selectively employ ESID technologies to contribute to pollution abatement, saving scarce resources by increasing efficient resource utilization, in particular energy, and reducing environmental degradation, especially that caused by hazardous waste.

Objective

Building on extensive UNIDO experience in industrial rehabilitation, to control and mitigate the adverse impact of industrial pollution in developing countries.

Subprogramme Focus

- Industrial subsectors: metallurgical and metal-finishing industries, pulp and paper, cement, textiles and tanneries, food-processing and chemical process industries, with due priority given, in accordance with resolution GC.4/Res.18, to the five subsectors covered by the ESID conference, with particular attention throughout to energy sources and use;
- Pollution abatement technologies and methods relevant to more than one industrial subsector.

Outputs

- Improved maintenance, operation and upgrading of existing industrial plants, selectively employing the principles of ESID based on results of environment, energy and waste audits;

- Technical cooperation projects, including pilot or demonstration projects, implanted to assist Governments and enterprises to adopt/adapt selected ESID programmes for pollution control, energy saving and industrial waste recycling, including as part of efforts to assist them in complying with international environmental conventions and protocols;
- Upgraded databases and technical manuals on generic treatment, reuse, recycling and management operations for wastes, in particular hazardous wastes;
- Information on appropriate, including new, financial resources, where possible on concessional terms, that would enable developing countries to employ selected ESID principles in their pollution abatement efforts;
- Upgraded databases and guidelines for measures and methods of preventing industrial accidents and extending operational life of plant and machinery (non-destructive testing, monitoring of condition and remote sensing), as well as guidelines for dynamic plant management;
- Expanded roster of experts in industrial pollution control;
- Training projects implemented on the handling, treatment and disposal of industrial wastes, including the selection of repository sites and related monitoring systems.

Activities

- Development and implementation of technical cooperation projects related to the maintenance, operation, upgrading and rehabilitation of industrial plants in order to reduce their environmental impact and energy consumption per unit of output;
- Development and implementation of technical cooperation projects, including pilot and demonstration projects, showing the efficacy of employing selected ESID pollution control, energy saving and industrial waste recycling programmes;
- Assistance in the implementation of international environmental conventions and protocols, by providing technical cooperation to help countries identify and implement the actions needed, as well as helping them to locate expertise and funding;
- Development of technical manuals and databases that address issues related to the design, function and efficiency of treatment operations for industrial wastes, as well as guidelines and methodologies for accident prevention techniques;
- Development of standards and guidelines for the safe disposal of industrial, including toxic and hazardous, wastes in cooperation

with other governmental and non-governmental organizations, Governments and industry;

- Assistance to developing countries in identifying appropriate, including new, financial resources, where possible on concessional terms, that would enable them to take necessary steps to undertake pollution abatement measures based on ESID principles;
- Further development of information systems for the exchange of technological information, research and development and experience in managing industrial wastes.
- Identification of experts for the expanded roster;
- Development and implementation of training projects on the handling, treatment and disposal of industrial wastes, including the selection of repository sites and related monitoring systems.

Environment Funding Sources to be Tapped by UNIDO

This text was prepared by the Environment Coordination Unit of UNIDO.

Global Environment Facility

Overview

The Global Environment Facility (GEF) is a pilot programme for helping developing countries to contribute towards solving problems in pre-specified areas of global concern. Initially funded for three years, (mid-1991 to mid-1994), the Facility provides the incremental capital costs associated with environmental protection, technical assistance, and to a lesser extent, research aimed at protecting the global environment and transferring environmentally benign technologies. The Facility's work falls into four main areas: prevention of global warming, protection of international waters, protection of biological diversity, and prevention of further depletion of the stratospheric ozone layer.

The aim of the GEF is to select projects (country and multicountry) which benefit the global environment, as distinct from the local environment. In addition, projects financed by the GEF must be innovative and demonstrate the effectiveness of a particular technology or approach to environmental protection. Given its pilot nature, other criteria include the contribution a project makes to human development and the extent to which project results can be definitively evaluated and disseminated.

All IPF receiving countries with a per capita income of US$ 4,000 or less are eligible for GEF funds. Governments in developing countries are the primary agents in identifying and selecting projects, but they may seek assistance in project identification from the GEF's implementing agencies. All projects require government endorsement. GEF technical assistance projects are limited to US$ 10 million; GEF components of investment projects cannot be higher than US$ 30 million.

Responsibility for managing the programming of the GEF is shared by UNDP, UNEP and the World Bank. UNDP is responsible for technical projects and the World Bank for investment projects. The GEF is an administrative umbrella. The 'core fund' is approximately US$ 775 million. As of end of 1992, US$ 700 million of the 'core fund' will have been programmed. This means that the balance for 1993 is minimal unless the GEF is replenished, which is likely.

Of the US$ 700 million, approximately 32% went for technical assistance/capacity building and 68% went for investment projects. The specialized agencies are involved in implementation of approximately US$ 65 million or one third of the technical assistance/capacity building activities. The one UNIDO project is "Water Pollution Control and Biodiversity Conservation in the Gulf of Guinea Large Marine Ecosystem (LME)", totalling US$ 5.2 million.

For additional information, you might wish to contact:

GEF Technical Advisory Division — Telephone: (212) 906 5044
United Nations Development Programme — Fax: (212) 906 5365
One United Nations Plaza
New York, New York 10017
United States

Basel Convention

Overview

The Basel Convention on the Control of the Transboundary Movement of Hazardous Wastes and their Disposal came into force on 5 May 1992 after the requisite 20 countries (out of 104 signatories) had ratified it. However, aside from France and the Nordics, major industrial countries such as Japan, Germany and the USA have not ratified to date.

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There is no fund set up as yet for implementing the provisions of the Basel Convention nor is there likely to be a fund for the provision of technical assistance, such as exists for the Montreal Protocol. There is discussion of a fund that would compensate developing country victims for damages from illegally dumped wastes from industrialized countries. The compensation fund is unlikely to provide funds for remediation of contaminated sites.

So far UNIDO's participation in the Basel Convention at the working level has been limited to cooperation with UNEP in the preparation of technical guidelines for the preparation of the First Meeting of the Contracting Parties to the Basel Convention, Uruguay, 30 November - 4 December 1992.

For additional information, please contact:

UNEP Secretariat of the — Telephone: (41 22) 979 9111
Basel Convention — Fax: (41 22) 797 3454
Geneva Executive Centre
15 chemin des Anémones (Building D)
Case Postale 356
1219 Châtelaine, Geneva

Capacity 21

Overview

In order to fulfill the special mandates given by UNCED, in 1992, UNDP launched Capacity 21, a fund in support of Agenda 21. Capacity 21 is designed to assist countries in the formulation and implementation of sustainable development strategies and of required national capacity building programmes.

The stated objectives of Capacity 21 are as follows:

- Formulate, on the basis of existing plans, sustainable development strategies for the achievement and implementation of development goals.
- Identify priority areas of UNCED's Agenda 21 and formulate a national Agenda 21 in support of sustainable development goals.
- Identify major capacity building requirements for effective implementation of the national Agenda 21 and sustainable development plans.
- Formulate programmes and projects to meet the capacity building requirements, to strengthen national or, where appropriate, regional scientific and technological research and development institutions, enhance knowledge, information and data bases and increase the participation of all stake-holders in the decision-making processes.

Essentially, Capacity 21 consists of two parts. One part would be refinement of sustainable development strategies for developing countries; the second or operational part would be activities in:

- Institution building for environmental regulations and standard setting,
- Technology transfer,
- Human resource development, and
- Support for public participation.

As at the end of 1992, US$ 15 million had been received as follows: UNDP - $6 million, Germany - $6 million, Canada - $2 million, Austria - $1 million. It is expected that by the end of the UNDP Governing Council in February 1993, the total will be $28 million (included are USA, Japan, Canada CIDA, US EPA, possibly the Nordic countries and France).

For additional information, contact:

Capacity 21 Unit Telephone: (212) 906 5001
Environment and Natural Resources Group Fax: (212) 906 6947
United Nations Development Programme
One United Nations Plaza
New York, New York 10017, USA

Montreal Protocol

Overview

In September 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in Montreal, Canada. The parties adopted some adjustments to tighten the schedule for phasing out the ozone-depleting substances at their 2nd Meeting in London in 1990. The amendment established a Multilateral Fund to provide resources to assist developing countries to phase out the ozone depleting substances. The Fund operated from 1 January 1991 as an Interim Multilateral Fund. The 4th Meeting of the Parties, in November 1991, decided to transform the Interim Multilateral Fund to the Multilateral Fund to be effective as of 1 January 1993.

The Fund is managed by the 14-member Executive Committee established by the Parties. The Committee has a balanced representation of Parties from industrialized countries and developing countries that can receive assistance from the Fund as specified in Article 5 of the Protocol. The Committee is assisted by the Fund Secretariat based in Montreal, Canada. Projects and activities are undertaken mainly through implementing agencies, which are the World Bank, UNDP, UNEP and UNIDO.

As at end October 1992, a total of US$ 93 million had been contributed to the Fund. Out of this amount US$ 64 million have been disbursed. A developing country eligible for assistance is defined by paragraph 1 of Article 5 as a developing country whose annual calculated level of consumption of the controlled substances does not exceed 0.3 kg per capita.

LU9 UNIDO became an implementing agency in October 1992. A detailed work programme for 1993 was approved at the Ninth Meeting of the Executive Committee in March 1993 in Montreal. The focus of UNIDO activities will be at plant level investments to reduce the use of CFCs.

For additional information, you might wish to contact:

United Nations Multilateral Fund for the implementation of the Montreal Protocol
Telephone: (514) 282 1122
Fax (514) 282 0068
1800 McGill College Avenue
Montreal Trust Building
Montreal
Quebec H3A3JC
Canada

or

United Nations Industrial Development Organization
P.O. Box 300
A-1400 Vienna, Austria
Telephone: 21131-0
Fax: 232156

Operational Guidelines

Excerpted, with permission, from UNDP, *Handbook and Guidelines for Environmental Management and Sustainable Development* (New York, 1992), part II, pages 30-39.

Environmental Management Tools

Four management tools to be used at each step of UNDP operations are discussed in this section.

In addition, environmental documents and related reference materials are now being produced in copious amounts. As many of these materials could be used to prepare Environmental Overviews and Management Strategies, a library-style reference system on the environ- ment could be set up in each field office. That is, environmental infor- mation arriving at UNDP field offices could be categorized and collected in one place for staff members to be able to consult and retrieve. Field offices that already have libraries could set up sections on the environment and encourage Programme Officers to forward all appropriate documents to this facility.

Field office environmental focal points may also assist offices in assuring that environmental management processes are completed as outlined here and that environmental information flowing into the office is disseminated to the appropriate staff members, government counterparts and NGOs. Activities of the Sustainable Development Network and the Global Environment Facility should also be linked to the guidelines.

Tool 1: Environmental Checklist for UNDP Technical Cooperation

To ensure that proper consideration has been given to the environment, a checklist serves as a reminder to those participating in activity implementation. (See Box 1.) These specific questions should be answered to facilitate the process of assessing whether the environmental dimension has been included.

Tool 2: Environmental Overviews

An Environmental Overview (EO) is an assessment tool that forms the basis for an Environmental Management Strategy. The aim of this short document is to provide basic information on the present environmental situation of a country or project. It will also include an assessment of how the environment might be altered if the programme or project is implemented. This tool is the simplest instrument, which can be used to determine whether a proposed activity is being designed and implemented within an environmentally sound and sustainable approach. The EOs will be used in designing all UNDP activities.

All Environmental Overviews should:

- identify the main environmental opportunities and constraints that the implementation of the programme or project could bring about;
- suggest alternatives to the programme/project design that would take better advantage of potential environmental opportunities and/or mitigate likely environmental disturbances associated with the programme/project; and
- identify areas of uncertainty regarding modifications to the environment, as well as those potential social and economic conflicts that might arise if environmental changes are introduced in the programme/project area.

Whether the overview is prepared for a Country Programme or for specific projects and programmes, it should not be longer than seven pages. Box 2 (Preparation of Environment Overviews for UNDP Country Programmes [EOCs]) and Box 3 (Preparation of Environmental Overviews for UNDP-sponsored Projects and Programmes [EOPs]) contain annotated outlines of what to include in each type of overview. Only Box 3 is included in this reading excerpt.

The responsibility of preparing EOs belongs to those who are proposing a programme or project and, when appropriate, should be included in the terms of reference. This would include UNDP staff, other UN agency professionals, government or NGO counterparts and outside experts.

For the Country Programme, the EOC should be prepared at the same time the Advisory Note is being drafted. For a project or programme document, the EOP should be done before or while the Project Formulation Framework (PFF) is being drafted but not finalized. This leaves ample time to make revisions if necessary and to incorporate mitigation measures and other environmental considerations throughout the Note or PFF. Once the EO is prepared, some of the information it contains should be incorporated into appropriate sections of the Advisory Note (eventually the Country Programme) or the actual PFF (for example, justification, objectives and so forth). The EO should also be attached as an annex to the programme/project document so that it can be reviewed by the Project/Programme Activity committee (PAC) and the Action Committee (AC).

Generally speaking, EOs are not based on original research, although occasionally independent research might be necessary. EOs should be developed mainly from existing information contained in country environmental profiles such as those prepared by other international organizations, academic institutions, bilateral donors and NGOs (for example, those of the World Bank and Interregional Development Banks, or the national reports prepared for the U.N. Conference on Environment and Development). New information should be generated only if no other details about the characteristics/functions of the local environment are available. Participatory development techniques that take advantage of grass-roots knowledge will help improve the accuracy of EOs.

An EOP should in principle be prepared for all projects from forestry to education to management training. For projects that lack any environmental factors or potential environmental components, the EOP will be limited to one page of outline subheadings with an explanation in each case as to why it is not applicable. For projects that do not have detailed EOPs, the project document chapter on 'Special Considerations' will explain in brief that no EO was created because of the non-applicability of the topic. Very few projects will fall under this category, however.

UNDP staff should use the information contained in the document as an important input to the evaluation of the proposed programmes and projects. The EOC can influence, for example, the drafting of many sections of the Country Programme.

Box 1. Environmental Checklist for UNDP Cooperation

- Has an EOC/EOP been prepared for the programme/project?
- Does the programme/project document include explicit actions to prevent and conserve the environment?
- Have the sources of environmental impact (positive and negative) been properly identified in the programme/ project document?
- Does the programme/project document include environmental mitigation measures?
- Have the potential conflicts of interest been properly addressed in document?

Tool 3: Environmental Screening of UNDP Activities Using EOPs

EOPs contain the necessary basic information to allow those who are designing or responsible for the proposed programme/activity to decide whether the activity deserves further environmental consideration. To facilitate this, box 4 provides five main reference points to screen UNDP proposed activities. These criteria are not comprehensive, but mainly serve as a reminder for the environmental reviewer. EOCs will also be annexed to the Country Programme, and this will provide the basis for assessing the environmental performance of the programme or project over time.

After UNDP screens the EOPs, the following choices of actions exist:

- Given potential environmental opportunities and/or the absence of negative environmental impacts, write the final document (incorporating the EOP) and submit it to the PAC and, if necessary, the Action Committee.
- Do not pursue the proposal further due to its potential negative impact on the environment.
- Request additional information/clarification regarding the environmental characteristics of the area where the proposed activity is expected to take place; demand elaboration of some aspects of the EOP or expansion of information regarding potential environmental impacts prior to drafting the final document.
- Introduce changes to the design presented in the PFF to eliminate or mitigate potential negative environmental impacts, or to make better use of opportunities.
- Recommend preparing an in-depth Environmental Management Strategy for the project document that would be referred to throughout the implementation of the activity.

If the screening process leads to a choice to provide UNDP support for the programme/project under consideration, the EOP should be annexed to the project document.

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Tool 4: Environmental Management Strategies

An Environmental Management Strategy (EMS) is a detailed action oriented plan prepared for UNDP projects. Environmental Overviews answer the question 'what' is happening or might happen to the environment with a proposed action. Environmental Management Strategies answer the questions:

- 'how' (to improve the environment or mitigate its disturbance),
- 'when' (at what time, through the life of a project, this will be done),
- 'who' (will be accountable for implementing and monitoring environmental activities),
- 'how long' (before the results will be seen), and
- 'what is required' (in terms of experts, information, institutional and financial support) for integrating environmentally sound and sustainable development principles within a proposed development activity.

Box 3 Preparation of Environmental Overview of Programme (Project) and Management Strategy (EOP/MS) Annotated Outline for Tool 2 and Tool 4

Although the text of this EOP/MS refers to projects, it can also be used for programmes. This outline contains a 'menu' of possible topics that might assist staff members to develop EOPs. Thus the sections included here should be completed only when applicable (see also Annex III for a sample EOP and MS). Information can be presented sectorally rather than geographically if necessary. Linkages between sections should be identified.

1 Brief Description of the EOP/MS Environment of the Area of the Project (1 page maximum)

In general, this section is intended to provide all those who are participating in the development of a UNDP Project with basic general information on the physical characteristics of the environment in the area. The idea is to highlight any important aspect of the natural environment that might be a ***determinant*** in the design, appraisal, extension, approval and assessment of a proposed UNDP regional, national or local project.

Land and water ecosystems	Describes those types of land and water ecosystems that characterize the project area (such as plains, valleys, mountain ecosystems, rivers, lakes) and whether any of these are known to represent untapped environmental opportunities or areas of particular environmental concern. Includes information on climate if appropriate, such as when the project relates to specific types of agricultural production. In urban areas, describes briefly the relevant geographical features.
Living resources	Describes (1) the biological species (fauna and flora) in the project area that represent particular concerns and/or opportunities for the environment (for example, the unexploited potential of certain resources such as medicines that could be obtained from tropical forest species), (2) the socio-cultural context in the project area (population size, ethnicity, poverty and gender indicators, etc.).

2 Main Environmental Issues in the Project Area (1 page maximum)

This section covers the three environmental issues that are most important in the area where the project will be implemented—whether, for example, the area is prone to flooding, there is an ongoing process of desertification, or the sustainable fish catch potential is smaller than present exploitation. Topics to consider might include quality of life of the local population, natural hazards, fragile ecosystems, role of children and women and over-crowding. Consultations with local population groups will improve the accuracy of this section.

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3 Economics and the Environment in the Project Area (1 page maximum)

This section generally discusses whether the prevailing economic situation in the project area will effect the environment. Lists any prevailing national or local economic policies and regulations in the project area that affect the quality of the environment. Any enforcement mechanisms that prevail in the project area to protect the local environment should also be included. General statements about the population's socio-economic situation may be added if not listed under 1 above.

4 Environmental Management in the Project Area (1 page maximum)

This section should describe the capacity of the people and institutions working in the project area to cope with their environmental problems, achieve appropriate environmental management and promote sustainable development.

Legal and regualtory	Describes whether there are explicit environmental policies and regulations in the project area and, if so, whether they have the enforcement mechanisms and appropriate technical and financial support to be effective.
Major environmental actors	Includes a brief description of the main environmental actors in the project area (government authorities, international organizations, private sector, NGOs, in- dividuals) and their objectives and strategies. Identifies possible conflicts among the actors if the proposed project is implemented. Consider whether women play an active role in all these groups and are able to make the necessary contributions, explain their role.
Technical and managerial capacity to deal with environmental issues	Describes generally the existing educational, technical and managerial capacity in the project area (within the public, private, NGO and academic sectors) to deal with the environmental issues relevant to the project. Special emphasis should be given to the presence and activities of grass-roots organizations working on environmental protection. The strength and resources of environmental institutions in the project area should be briefly assessed.

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5 Major Natural and Socio-Economic Impacts and Opportunitites Associated with the Project Implementation (1 page maximum)

Both these sections should incorporate the views of the affected population groups; participatory development techniques should therefore be used whenever possible.

Potential impacts on the natural environment	Identifies the potential impacts, both positive and negative, that the implementation of the project may have upon the natural environment. Identifies the three most important environmental impacts that the implementation of the project might bring about, and describes how the project *will address them.* If the project is on agroforestry, for example, indicates whether soil conservation, watershed management and appropriate selection of pesticides and fertilizers have been envisaged.
Potential socio-economic impacts	Lists the three most important potential benefits and costs to the socio-economic impacts environment that may result from the implementation of the project.

6 Alternatives for Project Design (1/2 page maximum)

This section will discuss the possibility of altering the project design (technology, project objectives and methodology of implementation) to take better advantage of the opportunities offered by the environment in the project area, and to mitigate and eliminate the environmental disadvantages that the project might create.

7 Identification of Environmental Objectives of the Proposed Activity (1/2 page)

The EOP/MS should state clearly and succinctly the environmental objectives of the alternative. These must conform with the broader development objectives of the country and therefore might go beyond the particular activity's goals. If a proposed activity does not explicitly indicate any environmental objectives, UNDP staff should request that such objectives be identified.

For example, a project on animal husbandry might identify production targets but not explicitly include environmental objectives. If the proposed activity will introduce new technologies or exotic animal and plant varieties, relocate people or introduce new chemical products, the local environment will be affected. The strategy, in this case, will help identify and clearly design the *environmental objectives* of such an animal-husbandry project. Environmental objectives could include soil protection, plant conservation and integrated agricultural development.

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8 Identification of Conflicts of Interest

Some of the objectives pursued by different environmental actors might conflict. For example, the interests of companies that commercialize chemical fertilizers will conflict with activities aiming to promote organic fertilization. The EOP/MS must identify such conflicts of interest and devise possible alternatives to avoid them. In the previous example, an incentive might be proposed for the commercial chemical enterprise to sell other fertilizers (including organic) that will promote soil fertility without damaging the environment.

9 Formulation of an Operational Strategy

The most important action-oriented part of the EOP/MS is the formulation of an operational strategy that will allow the achievement of the environmental objectives and goals proposed by the EOP/MS. The strategy must be formulated by the staff proposing, designing or evaluating the activity in consultation with project participants.

Specific environmental targets to be achieved	Identifies specific environmental targets in addition to the main environmental policy objectives identified in Section 2. If the proposed activity entails manufacturing processes (such as tanneries or food processing) which generate waste, for example, specific environmental targets would be set such as reducing all waste emissions by 15% over a period of three years and installing interim measures.
Participants in environmental management	Identifies the objectives and strategies of the major actors related to the environment in the area where the proposed activity will take place.
Plan of activities and timetable	Identifies a number of activities that will lead to the implementation of the strategy. A timetable must also be formulated indicating when such activities are expected to occur, and who will be responsible for them. As the EOP/MS will eventually become part of either the programme or project document, the proposed environmental activities and timetable should be compatible with the overall activities and timetable of the Programme or Project. Relevant national and local activities and timetables should also be considered.

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Environmental information	Provides reliable and accurate environmental information as the basis for sustainable decision making, while acknowledging that accurate environmental information is difficult to obtain, especially in developing countries. The EOP/MS might include efforts to obtain the most accurate environmental information relevant to the proposed activity or to initiate work that will generate the necessary information over an identified period.
Supporting needs:	Identifies the specific needs required for the successful implementation of the strategy. The needs to be identified include: • Education and training • Technical and managerial skills • Access to environmental data banks • Institutional support • Financial aspect The development and implementation of the EOP/MS requires technical and financial resources. Technical assistance might be needed from UNDP in order to develop the strategy and identify the resources required to carry it out.
Assigning implementation responsibilities	States clearly who will be accountable for implementing each one of the activities proposed within the strategy.
Decision making	Analyzes the environmental chain of command and responsibilities in the area where an activity is being considered. This analysis should not be restricted to the chain of command in the environmental field (ministry of the environment, forestry sector) but should include the other sectors of the economy that are intimately related to the environment such as industry, trade, health, and so on. The objective is to identify to whom suggestions and recommendations—indeed, the entire EOP/MS—would be addressed. It should also include what would be the most efficient way to influence the decision-making process to protect and enhance the environment.

10 Monitoring the EOP/MS

Every UNDP-sponsored activity is monitored regularly to ensure that its stated objectives are being achieved in the time framework envisaged. As the EOP/MS will probably be incorporated into the programme or project document that describes the proposed activity, it should be monitored according to the procedures presented. Constant, cautious monitoring on a as frequent a basis as possible, using specific success indicators for the points raised in the strategy will help guarantee that the objectives ar achieved.

The main difference between an EO and an EMS is that the latter is an ongoing effort demanding close UNDP monitoring throughout the activity while the former is a more static undertaking completed during project formulation.

The EMS should be prepared by those proposing the implementation of a project: mainly government officials, NGOs, academic institutions and UN agencies responsible for implementation. Terms of reference will need to refer to the EMS preparation.

The EMS, as part of the EOPMS, steps 7 to 10, will be prepared according to the specifications provided in box 3, using participatory development techniques to the greatest extent possible. The length of an EMS can vary greatly, so guidelines on the length of each section are not included. UNDP staff are responsible for ensuring that the EMS is prepared according to these guidelines. It is recommended that the proposed project executer undertake the technical coordinating responsi- bilities, using, as necessary, appropriate UN agencies and/or other affiliated agencies or NGOs.

The ideas expressed in the EMS eventually need to be incorporated into the objectives, activities, inputs, work plan and so on of the project or programme document. Special references should also be made to the EMS and, if necessary, a specific section summarizing the EMS should be added. The EMS should also be attached as an annex to these documents to assist in monitoring the activities over time.

BOX 4 Criteria for Screening UNDP EOCs and EOPs
Tool 3

It is recommended that the programmes/projects that fall within any of the following categories be subject to further environmental consideration:

Environmentally Sensitive Areas or Activities

Activities leading to encroachments on tropical rain forests, wetlands, mangrove forests, coral reefs, coastal zones or other vulnerable areas

Activities changing natural vegetation and/or the habitats of wildlife species, or in areas inhabited by endangered species

Activities in legally declared protected areas

Ecologically fragile areas (including those identified as such by NGOs)

Areas subject to desertification, arid and semi-arid zones, drylands

Ecotourism activities

Areas of unique conservation, historical, cultural, archaeological or aesthetic interest

Areas of particular social significance (habitats for nomadic people or indigenous populations)

Areas where pre-established pollution limits have been exceeded or where activities would lead to air, water, soil, radioactive or noise pollution

Livestock, Farming and Fishing Practices

Sustainable agriculture

Activities leading to soil erosion or in soil-conservation areas

Integrated pest control or pesticide use/management

Agroforestry

Afforestation

Activities leading to increased grazing

Introduction or modifications of new crops or livestock

Introduction of new species where there is limited knowledge of the ecological functions of the local ecosystem

Biotechnology

Activities with the possibility of exceeding carrying capacity (e.g., catching larger quantities of fish than can be replaced by natural rate of growth)

Controlled breeding and exploitation of fish or shellfish carried out in marine or inland waters or in artificial ponds

(Continued on next page)

(Continued from previous page)

Activities Dealing with Water Resources

Water management
Irrigation and flood control
Hydroelectric
Ground water
Management of inland wetland ecosystems
Health and sanitation

Infrastructure and Industrial Strengthening

Large infrastructure and urbanization activities (e.g. port development, airports and railway systems)
Energy generation
Mining (land and water)
Activities leading to conflicts over use of resources (e.g. port development and tourism)
All industrial development
Activities causing emissions to soil, water and air and/or that may endanger the environment
Activities demanding considerable increases in consumption of raw materials (water, land, fossil fuels)
Activities creating major changes in landscape
Activities creating risks of accidents that could have serious consequences for local people or the natural environment
Occupational safety and training
Activities that introduce immigrant labour and change local social fabric

Urbanization, Land Development and Waste Management

Human settlements (housing, office, commercial buildings)
Land-use planning or road building
Activities leading to accumulation of waste and creation of unwanted disposal sites
Production, transport or storage of hazardous wastes

Guidelines for Environmental Appraisal

Excerpted from UNIDO, *Project Design Reference File Volume II: Guidelines for Environmental Appraisal,* 1990.

Introduction

The environmental appraisal guidelines presented in this series have been prepared for the Project Appraisal Section of UNIDO. They are technical guidelines covering different industrial sectors, and they have the following objectives:

- To provide guidance to project planners in the introduction of environmental considerations in the design and development of projects under the auspices of UNIDO.
- To help the appraisal staff judge whether appropriate environmental measures have been included in the project in order to recommend, on environmental grounds, whether or not the project should proceed as designed.

The guidelines are for use within an environmental appraisal (EA) procedure. In a typical EA procedure, environmental appraisal comes after the screening of projects during project identification.

The screening process categorises projects according to the likely significance of their environmental impacts in order to determine the type of environmental appraisal required. Projects and programmes are screened into the following categories:

- Technical assistance projects with no capital implications. The environmental appraisal of this type of project will concentrate on environmental awareness, training and information management and on the development of technical and institutional capabilities.
- Technical assistance projects with capital implications. The environmental appraisal of this type of project will conentrate on measures for environmental management and pollution control.

Box 1 shows the list of industrial areas and their corresponding screening categories. The categorisation is indicative; the assessor will decide, according to the objectives and expected outputs, which is the appropriate category for each project.

When required by local legislation, Type B projects will be subject to an Environmental Impact Assessment (EIA). Large Type B projects sited in particularly sensitive areas will also be subject to a full EIA.

Box 1. Categorisation of UNIDO Programmes and Projects

	Industrial Areas	**Screening Categories**
HRD	Human Resource Development	A
WOM	Integration of Women in Industry	A
SEC	Sector and Sub-sector Development Planning	A
ECDC	Economic Cooperation between Developing Countries	A
STRAT	Global Industrial Strategies and Policies	A
INFR	Institutional Infrastructure	A
MGMT	Industrial Management	A
PLAN	Industrial Planning and Strategies	A
FIN	Mobilisation of Financial Resources	A or B
DTT	Development and Transfer of Technologies	A or B
QC	Quality Control	A or B
ENT	Enterprise to Enterprise	A or B
PRIV	Private Sector	A or B
RUR	Rural Area/Rural Development	A or B
TCDC	Technical Cooperation between Developing Countries	A or B
ENER	Energy	B
ENV	Environmental Protection and Pollution Control	B
FEAS	Pre-feasibility and Feasibility Studies	B
REH	Industrial Rehabilitation	B

Following screening, environmental appraisal is the mechanism by which UNIDO officers judge whether environmental considerations have been duly introduced into a given programme or project, and determine which additional environmental actions should be considered.

Although Category A projects, without capital implications, do not produce direct environmental impacts, it is important to ensure that opportunities for introducing environmental concepts and skills are duly considered. Figure 1 presents a flowchart for the Guidelines for Environmental Appraisal for Category A projects.

For Category B projects, the guidelines take the reader through the industrial process, highlighting the points where environmental impacts are likely to occur, the receptors that may be affected and the measures to minimise the impact at each stage. The guidelines were designed in order to allow UNIDO officers to verify, at a glance, whether or not a project is environmentally sound and what can be done to improve it. Figure 2 presents a flowchart for the Guidelines for Environmental Appraisal for Category B projects.

Since environmental impacts of most industrial sectors are readily identifiable and there is sufficient information available regarding clean practices and waste treatment and disposal, we expect that most projects will be dealt with at the project formulation stage, and only exceptionally will a full EIA be required.

Figure 1. Environmental Appraisal Category A Projects

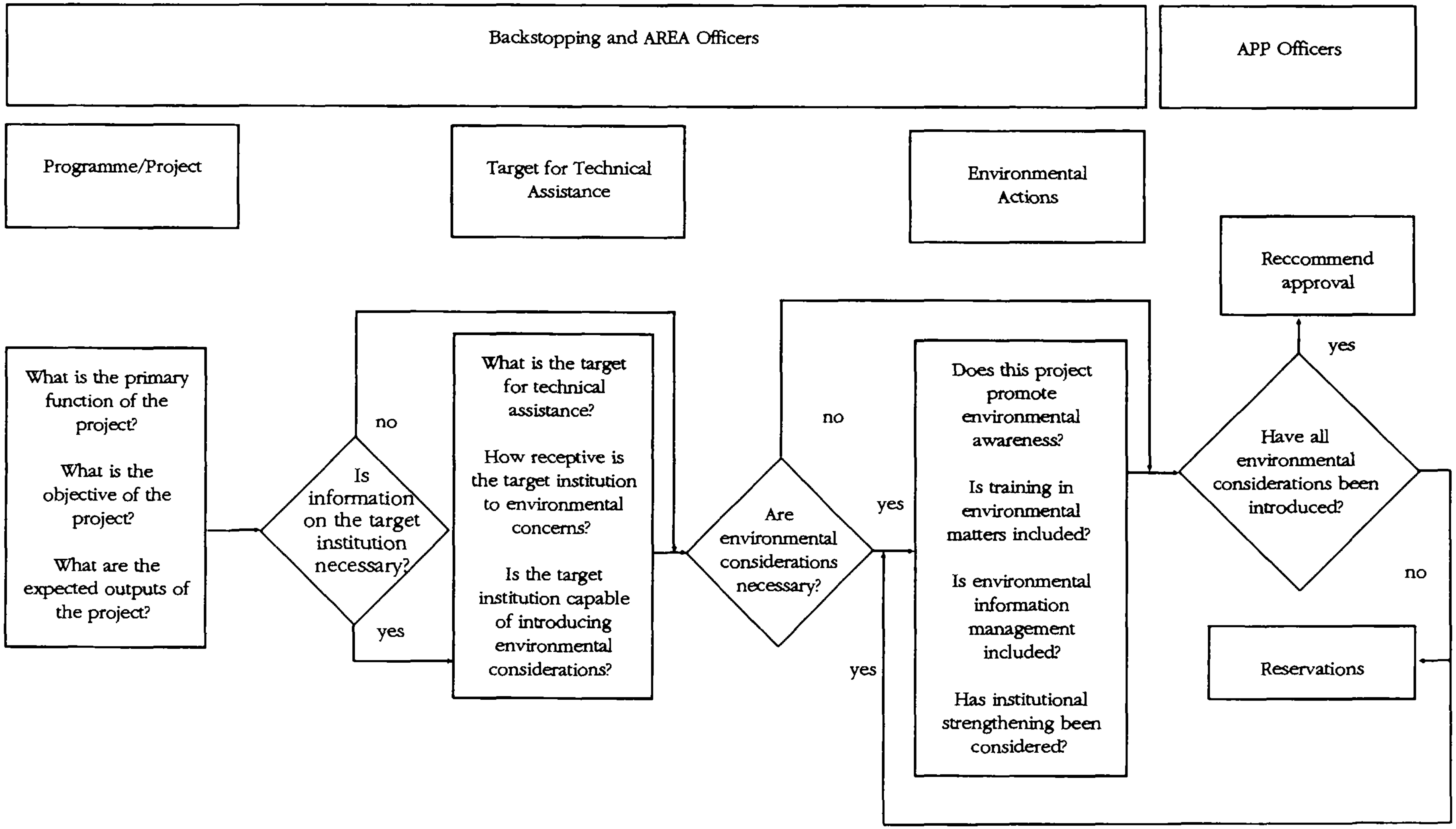
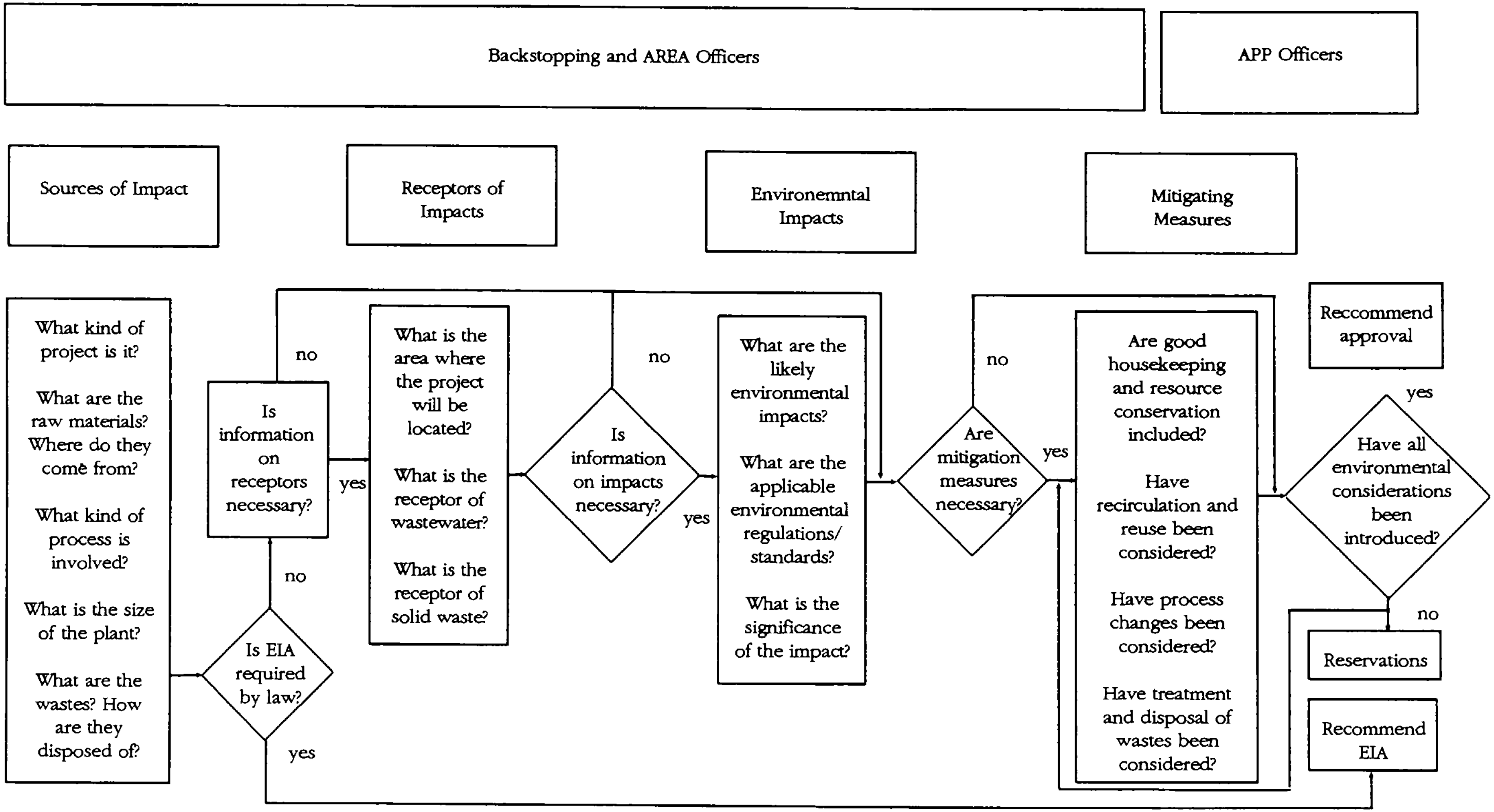


Figure 2. Environmental Appraisal of Category B Projects



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Pollution Prevention and Abatement Guidelines for Cane Sugar Processing and Refining

Excerpted from a draft document on pollution prevention and abatement guidelines for cane sugar processing and refining, prepared by UNIDO. It will become one of a series of industrial pollution prevention and abatement guidelines being issued jointly by the World Bank, UNIDO and UNEP IE/PAC.

Executive Summary

In 1991 the world sugar production amounted to approximately 114 million tons, of which 64% came from sugarcane and 36% from sugarbeet. There are more than 2200 sugar processing plants in 111 countries.

The report describes raw cane sugar processing and cane sugar refining and their respective impact on the environment. Generally, it is the effluent from the processing which is of major concern, although discharges to air, water and land occur in both operations. The residuals are generally putrescible organic materials.

Little more than 10% of the sugarcane can be processed into commercial sugar. Furthermore, for every ton of cane processed about twenty tons of water are needed. Thus, recycling and reuse of process water and residuals are very important both for the protection of the environment and for the overall profitability of operations. A well controlled and balanced production process with good sanitation which fully utilizes the possibilities for reusing residuals in the process or as by-products should be the starting point for environmental protection. In addition, treatment of water and air discharges is often necessary.

The United States New Source Performance Standards can serve as guidelines on achievable discharge limitations in the absence of national regulations. It is however important to consider factors such as: scale, age and location of plant; the assimilative capacity of the recipient medium during the crop season; and the time needed for plant upgrading (as preventive measures for pollution control are preferred it has to be recognized that these, in general, take more time to implement than end-of-pipe measures).

A considerable development of sucrochemistry and ethanol applications is expected in the near future. This development is expected to bring forth problems of pollution by aggressive molasses and vinasses on a much wider scale than previously associated with the sugar industry.

Waste Characterization and Impacts

The wastes associated with cane sugar processing and refining include water and air pollution and the disposal of solid wastes. The huge amount of biodegradable organic wastes from the processing is a major concern. The pollution load is therefore generally expressed in terms of biochemical oxygen demand (BOD5) or chemical oxygen demand (COD) and suspended solids. The hydrogen ion concentration (pH) and the temperature are also important parameters in determining the polluting effects of wastes in sugar factories and refineries.

Waste Quantities and Qualities

Atmospheric Emissions

The atmospheric pollution in the sugar processing and refining industry results mainly from the combustion of bagasse, fuel oil or coal. Examples of other processes giving small air emissions are: gases from juice fermentation; uncondensable gases from the evaporation stage; and sulphurous vapours released from the sulphitation process.

Bagasse combustion results in emissions of flue gas and fly ash. The composition of the flue gas depends on the composition of bagasse, its moisture and on the quantity of air used in combustion. A typical flue gas composition resulting from burning of bagasse is shown in table 1.

Assuming an average steam consumption of 550 kg/tonnes of cane (tc) and 1 kg bagasse producing 2.25 kg of steam, the production of CO_2 would be 218 kg/tc.

Table 1. Bagasse Combustion Composition of Flue Gas

Gas	Weight	Percent (%)
N_2	3.455	63.1
O_2	0.346	6.3
H_2O	0.784	14.3
CO_2	0.894	16.3
Total	5.479	100

Source: Hugot, *La Sucrerie de Cannes*, 3rd Ed.
Tech. & Doc. Paris (1987)

Table 2. Effluent Characteristics of Various Cane Sugar Processing and Refining Waste Streams in Different Countries

Parameter	Puerto Rico	Hawaii	Philippines	Louisiana	India
pH	5.3-8.8	—	5.3-7.9	—	6.8-8.4
BOD5 (mg/1)	112-225	115-699	130-1220	81-562	667-1660
COD (mg/l)	385-978	942-2340	50-1880	720-1430	890-2236
SS (mg/l)	100-700	915-3590	240-5440	150-8120	504-936
TSS (mg/l)	500-1400	3040-4500	—	409	792-2043
Temperature (C°)	31-49	—	34-48	—	—

Source: UNEP, *Environmental Aspects of the Sugar Industry—An Overview*, Paris (1982).

The forced draught in modern boilers implies a large proportion of fly ash in the smoke. Boiler manufacturers estimate amounts to 5.5 kg of fly ash/tc or 4.5 g/m^3 of fly ash in the smoke during bagasse combustion.

Refineries as well as some sugar processing plants (where the bagasse is used for other purposes) burn fuel oil or coal. This results in sulphur dioxide emissions (besides fly ash emissions) which can be high when using low-grade coal or oil with high sulphur content.

Waste Waters

The sugar industry is generally considered a large water consumer and polluter. However, the situation varies from country to country and inside countries as shown in table 2.

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Table 3. Example of Sugar Processing Plant Waste Waters Using Approximately 1.3 m^3 Water/tc

Source	BOD$_5$ (mg/l)	COD (mg/l)
Cane washing	300-1500	450-8000
Condensate water	35-45	80-150
Barometric condensers	50-200	100-400
Filter mud slurry	2900-10000	6000-20000
Cleaning factory etc.	3000-5000	6000-10000

Source: Meade and Chen, Cane Sugar Handbook, 10th Ed.,
John Wiley & sons, New York (1977).

Raw cane sugar processing

Water is essential in sugar processing, not only as a sugar solvent but also for many other uses in the process. It is used, for example, in: cane washing; extraction; liming; filter washing; crystallization; barometric condensers; cooling of engines and processing equipment; and for general purposes.

In modern sugar factories, water from vacuum condensers is recycled and a large part of condensed water from heat exchangers is recuperated for boiler feeding and other process uses. Older factories do not recycle the vacuum condenser waters and this creates a very large water through put.

If Q is the quantity of cane processed, then the immediate need of water in a sugar processing plant would be approximately 20Q. This could be reduced to 0.9Q if all possibilities for recycling are employed, and to 1.3Q with partial recycling. Table 3 illustrates BOD_5 and COD values of the main waste water sources in a sugar factory, using partial recycling of process water.

Cane washing

In some cane-growing regions the cane, though still cut by hand, is loaded mechanically for transportation to the sugar factory. In this case field mud, trash and sometimes stones are brought along with the cane to the factory. All of this creates problems in milling, clarification, juice filtration and bagasse combustion. To resolve these difficulties, washing of the cane has been introduced in some countries. There are many variations and some installations are quite elaborate. Water coming from condensers is generally used for this purpose. The amount of mud removed by cane washing varies between 5 kg to 15 kg/tc. A disadvantage of cane washing is additional loss of sugar. When washed, the amount of sugar loss can reach 0.16% of the total weight of the sugar cane.

Water from barometric condensers

The vapours from the final evaporation stage and vacuum pans are condensed in barometric condensers. This condensation requires large amounts of water (18 tons of water/tc, with central barometric station), which gets mildly polluted, see table 2. This waste water is characterized by high temperature (45□C), low oxygen content and the presence of sugar and gases (CO_2, NH_3) in solution. In the past, the waste water from the condensers was normally directly discharged. Today it is generally re- cycled to the condensers after passing through an atmospheric cooler.

The water from barometric condensers of vacuum mud filters has a considerable sugar content, but, as it cannot be recycled, must be discharged.

Condensate water

The first stages of evaporation also generate condensate water. Some of this (all from the first and some from the second effect) is used as feeding water for the boilers. Condensate from heaters cannot be used for this purpose because it may contain juice in case of a tube failure in the heater.

The remainder of the condensates has various uses in the process (milling, liming, cake filter washing, crystallization, melting, clearing, vacuum pan washing, heating of the massecuite etc.). The excess is generally discharged. It is characterized by high temperature (80°C), low oxygen content and the presence of sugar and gases (CO_2, NH_3) in solution.

Cooling water for engines

Cooling of turbo-machines requires very clean and demineralized water which can also be used for cooling pumps, compressors and crystallizers. The cooling water for the mill roller bearings becomes charged with oil and is generally discharged.

Water for general purposes

The water used for cleaning of the factory becomes highly polluted. There are three main sources of contamination:

- Fermentation of juice: this occurs mainly in the preparation, extraction and clarification stages of the process.
- Mechanical sugar losses: overflows, leaking pumps etc.
- Cleaning of calorific exchangers: chemical cleaning with corrosive products such as sulphuric acid and soda implies a discharge of polluted and corrosive water after washing.

Cane sugar refining

Waste water discharges may originate from condensers, filter backwash, truck and equipment washing, floor drains, boiler feed blowdown,

Table 4. Example of Refinery Waste Waters

Source	BOD_5 (mg O_2/l)	COD (mg O_2/l)
Condenser waters	4-21	6-42
Filter mud slurry	730	1200-1400
Charcoal waste	750-1200	1200-2400
Truck wash water	15000-18000	22000-36000

Source: Meade and Chen, Cane Sugar Handbook, 10th Ed., John Wiley & sons, New York (1977).

engine cooling, floor washing and other miscellaneous processes. The pollutants are primarily:

- Insoluble suspended solids: mostly water slurries of calcium carbonate or phosphate salts, diatomaceous earth, spent charcoal etc.
- Dissolved waste consisting primarily of biodegradable carbohydrates.

The average BOD_5 content in refinery waste water is about 1000 to 2000 mg/liter. Volumes of effluent range typically between 18 to 25 m^3 water per ton of sugar.

Fugitive Emissions

Small, fugitive emissions result from juice fermentation; uncondensable gases from the evaporation stage; and sulphurous vapours released from the sulphitation process.

Upset and Emergency Conditions

The storage of raw bagasse is a problem due to the large volumes involved and its low time of preservation. A considerable storage area is required and the rapid degradation causes a risk for internal combustion after a few months of storage only.

Impact on Receptors

Most waste waters from sugar processing and refining are not toxic yet harmful to the environment at higher levels of biological oxygen demand. This is due to the carbohydrate content and the products of their degradation. Organic substances discharged into water (rivers, lakes) are decomposed by microorganisms which use large quantities of oxygen. The resulting lack of dissolved oxygen affects the breeding of fish and the ecological equilibrium of the receiving medium. Waste water from sugar processing also contain oil, solids, caustic and acid. All of these products cause severe non-biological contamination of receiving waters.

On land, the use of residual water or by-products for irrigation must be strictly controlled and used according to the requirements of the crop and the soil, and not as a means of waste disposal. The high Chemical Oxygen Demand/Nitrogen content (COD/N) ratio does not allow an intensive application during the first stages of cane development.

Pollution Prevention and Control

Management Implications

A considerable development of sucrochemistry and ethanol applications is expected in the near future. This development will bring forth problems on a scale, especially associated with pollution by aggressive molasses and vinasses, that make current problems appear insignificant. To counteract, suitable national strategies for environmental protection in the sugar sector must be developed.

Such strategies must consider the current situation of the sugar sector, its achievements and difficulties and its future development. If a national Master Plan for the restructuring, strengthening and development of the sugar sector exists, it is a good base on which to formulate a comprehensive environmental protection strategy. Issues to consider include:

- How to establish a step-wise approach that is suitable for the current situation as well as future developments. Environmental protection is as much a problem of attitudes as of investment capital. Acquisition of knowledge and training takes time. It took developed countries more than 20 years to modify attitudes concerning pollution problems so as to obtain a wide consensus that action was needed.
- What legal dispositions and control means must be set up? What encouraging measures and aids are needed? What penalties should be imposed in case of regulations being violated?
- How to ensure full and close cooperation between government authorities, sugar institutions and sugar producers, and how to provide them with adequate training and necessary laboratory equipment and facilities.

Immediate improvements of the environmental performance are possible at the plant level. Sugar producers must be made aware that a well-controlled and balanced factory with good sanitation is the most effective way to prevent pollution. Furthermore, the possibilities for reusing wastes in the process or as by-products are rarely fully exploited. Once this awareness is established two actions which assist them in achieving a higher level of environmental performance are:

- a corporate environmental policy that gives clear goals, responsibilities, actions and targets
- establishment of a proper environmental management structure to ensure implementation of the policy, to allocate resources, and to monitor (and report) the results.

Source Reduction

Cane sugar processing and refining offer many waste minimization opportunities through reduction of wastes at the source, or, reuse in the process or as by-products.

Atmospheric emissions due to uncondensable gases can be decreased by using good sanitation and careful control of the whole operation. Flue gas emissions can be reduced by controlling combustion, air pressure and the rate of excess air.

The sulphitation clarification process is used in many sugar factories for the production of 'white plantation sugar'. This process, associated with a high pollution load, has been replaced increasingly by other methods, such as: Talo-floc process; uses of bentonite; double centrifugation; affination etc.

It is important that the cane is processed as soon it arrives at the plant to avoid deterioration with resulting sugar losses and odour problems. Immediate processing will also reduce the storage area needed. Dry cleaning systems which reduce or replace cane washing will result in reduced amounts of sludge.

If the production of slurries is unavoidable, in several cases contamination can be greatly reduced by means of such precautions as:

- Elimination of refuse, pieces of cane stalk and suspended dirt from the used wash water by screening before lagooning. This precaution allows decreasing the BOD load.
- Maintaining absolute cleanliness at all stations.
- Avoiding fermentation of sugar-cane juices by: appropriate straining; proper sanitation of the mills; controlled application of disinfectants or biocides in mill juices; and systematic cleaning when the milling has stopped.
- Investigation of abnormal sugar losses in order to find and rectify the cause.
- Calculation of the general water balance of the factory for each crop.
- Maintaining a systematic control not only of boiler feeding water but also of the waste water.
- Periodic inspection and BOD control of lagoons.

A significant source of waste water loading is due to poor housekeeping practices, involving spills of sugar and molasses, and poor maintenance of machinery and equipment, which also contribute to oil and grease contamination of effluent. The cost of effective in-plant control is negligible when compared to the costs of effluent treatment and production losses.

Recycling and/or By-Product Recovery

Little more than 10% of the sugarcane can be processed into commercial sugar. Furthermore, for every ton of cane processed about twenty tons of water is needed. Thus, recycling and reuse of process water and residuals are very important both for the protection of the environment and for the overall profitability of operations.

Waste Segregation

Establishing good water management with as much recycling of process water as possible is essential. The segregation of waste streams with a low BOD load from streams with a high BOD load is vital in this context. Few sugar factories and refineries segregate waste streams in a systematic way. Examples of the potential of this approach are:

- Excess condensate water does not need any treatment because of its low pollution load and can be separated from other streams, see tables 2 and 3.
- In sugar factories where cane washing is practiced, the spent water is generally treated by impounding and recycled to the initial wash. This circuit has to be separated from other treatment circuits because the retention time is different. Fresh water is only used for the final wash.
- Cooling water for mill bearings contains mineral oils and should not be mixed with other waste streams destined for biological treatment without a previous passage through an oil separator (which is a very simple factory-made device). With an efficient oil separation, this water can be recycled.
- In both sugar factories and refineries, acid and caustic waste arise from the cleaning of heat exchangers, evaporators, pans and other equipment. These wastes must be kept separated from other wastes, stored and released gradually into furrows, and blended with general effluent.
- In refineries, the main water pollution load comes from washing trucks and floors. Two waste water circuits are sufficient, one for excess condensate water which needs no treatment and another for treating the wash water.
- Vacuum condenser streams are too large for economical treatment. Entrainment channels should be installed to prevent any contamination of this waste stream.
- Concentrated low volume streams can be biologically treated in lagoons or aerobically in an activated sludge plant.

By-Products

In almost all sugar factories and refineries, by-products are recovered for industrial use, for animal feeding and for fertilizing.

Boiler ash and fly ash

Boiler ash and fly ash can be used in glass manufacturing, as a basic fertilizer in agriculture and incorporated in slag cement and road bases. The average quantity produced is about 0.3% of the weight of cane.

Another possibility is to use recovered fly ash in place of bagacillo in vacuum filters. The density and composition of fly ash and the dimension of particles would produce an excellent filter cake. The need of bagacillo for filters is about 6 kg/tc at 49% moisture, equivalent to 4 kg/tc of fly ash which is more dry. Available quantities of fly ash (5.1 kg/tc) adequately fulfill these requirements. The arrangement is very simple and inexpensive and consists of a mixing tanker and a slush pump. This is particularly interesting for those cane sugar plants which are short of bagacillo.

Bagasse

1000 kg of cane produces some 250/300 kg of bagasse, consisting on average of 49% water, 48.5% fiber and 2.5% of dry matters (sucrose and non-sucrose). Most of it is used to generate the steam and energy required by the factory. Surplus bagasse, due to its low density (160 kg/m^3) and relative inflammability, is a cumbersome material to handle and transport. It is generally used to produce paper, board and electricity.

Filter mud

About 30-35 kg of filter mud are produced per ton of cane. Filter mud consists of 80% water and 0.9 to 1.5% sugar. It can be spread directly on agricultural fields or stored in an intermediary silo for later use as a soil conditioner. When used for this purpose care must be taken to avoid runoff to watercourses; filter mud has a large BOD load.

Molasses

Between 27 kg to 40 kg (average 30 kg) of molasses are produced per ton of cane. Its average composition is 20% water, 35% sucrose, 20% reducing sugar, 15% sulphated ash and 10% others. Molasses is mainly used as animal feed or transformed into rum, alcohol or ethanol by fermentation and distillation.

In the distillery, 1000 kg of molasses give 400 l of pure alcohol (240 kg) and 380 l of stillage (also called slop or vinasses). Direct distillation of 1000 kg of cane juice yields approximately 70 l of pure alcohol and 910 l of vinasses. Vinasses are often sent to the cane field as fertilizer, either pumped to neighbouring fields or carried to more remote fields in motor tankers. This practice constitutes a major risk for the environment and especially contamination of ground waters if not adequately controlled by agronomists.

The use of diluted molasses and vinasses as fertilizers is much more complicated than, for example, the use of ashes and filter mud for such purposes. Successful fertilization with molasses and vinasses must consider the demand of the cane plant which differs with variety, age, soil, climatic condition and season. Furthermore, the retention time needed for the release of the fertilizing elements from the by-product has to be considered in relation to the permeability of the soil.

Irrigation with residuals

The residual water from cane sugar operations has a high content of organic matter and nutrients and is thus considered a valuable biofertilizer. In countries where water is scarce cane sugar effluent can be used for irrigation. With strict control and norms of application it can be considered the most practicable technology. In Cuba, irrigation with residual water has been systematically used with the following modes of application (See ICIDCA/GEPLACEA/UNEP, *Handbook of Sugar Cane Derivatives*, UNEP, Mexico):

- Outflows with high dissolved salt content, particularly sodium, and acidic effluent must be separated from the water used for irrigation. Examples of such effluents are exhausted soda, overflow from the coolers when soda has been used to raise the pH and acidic cleaning water.
- After preliminary treatment to remove oil and suspended matters and correction of pH, the residues are cooled and homogenized before being applied to the soil. A storage system with two reservoirs designed for the total volume of residual water from the sugar factory is used. In the first reservoir the water remains for one or two days, giving time for homogenization and cooling but without allowing degradation of the organic matter. The second reservoir is only for preventing the water from spilling into a watercourse, when steady irrigation is not possible.

Table 5. Cost and Benefits of an Effluent Irrigation System of a 6,800 tc/day Sugar Factory in Cuba

Technology	**Investment (1991 US$)**	**Maintenance and operating cost (US$/1000m3 effluent)**	**Savings (US$/1000m3 effluent)**
Irrigation system	297,000	59.24	40.76

The plant in question produces about 0.55 m^3 effluent for every ton of milled cane or 560,000 m^3 per crop season. The pay-back period for the investment is thus approximately 13 crop seasons. 188 hectares are irrigated.

Source: ICIDCA/GEPLACEA/UNEP, *Handbook of Sugar Cane Derivatives*, UNEP, Mexico.

- One year of effluent irrigation must be followed by one year of normal irrigation for light soils (two year periods for heavy soils), and in both cases using standards that do not exceed 300 to 400 m^3/hectare at intervals of 10 to 15 days.
- The salt level in the soil subject to irrigation with cane sugar effluent must be checked periodically.
- Where necessary grease and oil traps are installed and cleaned periodically.
- Due to the high carbon/nitrogen (C/N) ratio in this type of water, irrigation must not be applied intensively during the first stages of crop development, when plants require more nitrogen. It might be necessary to add a nitrogen fertilizer.

Actual investment, operating and maintenance costs, and savings for a cane sugar effluent irrigation system, compiled in table 5, are based upon experiences from Cuba.

Environmental Overview of Project Management Strategy for a Sample UNDP Project

Excerpted and modified, with permission, from UNDP, *Handbook and Guidelines for Environmental Management and Sustainable Development*
(New York, 1992), annex III and annex IV.

Cenderawasih Bay Coastal Area Development (INS/88/011/D/01/12)

The three main objectives of this project are to establish a cost-effective system of local transportation and communication to improve the collection and marketability of produce from the area; to introduce new methods and techniques to increase the use of fisheries and estate crop resources, ensuring the increased participation of women, and to strengthen the institutional capacity of the national, provincial and local planning bodies and various line agencies.

1. Brief Description of the Natural Environment of the Area of the Project

The land area of Irian Jaya province, including the fringe islands, is 416,000 square kilometres. In general the climate can be divided into two seasons: a dry one December to April, and a wet season from May through November. However, the dry season is relatively wet, with as much as 7,500 millimetres of rain a year. In the coastal towns the mean temperature is 26 degrees Celsius, with a minimum of about 20 degrees Celsius. In the mid-mountain valleys, the temperature ranges from about 11 to 27 degrees Celsius.

Irian Jaya has a population of 1.5 million inhabitants, more than half of them in the lowland (coastal) areas and on off-shore islands. These people have had varying degrees of contact with modern civilization. The nine principal towns are Jayapura, Biak, Sorong, Manokwari, Fakfak, Nabire, Wamena, Merauke and Serui.

Jayapura, located on Jos Sudarso (Humbolt) Bay had a population of some 111,030 in 1987; it is the administrative centre of the province as well as the principal port. Biak is an island north of Cenderawasih Bay with an estimated population of 41,850.

This is a decentralized area development project that integrates development assistance initiatives for the Biak, Yapen and Waropen areas. The population affected as recorded in the 1985 census was 139,900, approximately 10% of the population of Irian Jaya.

The marine resources of the area are substantial, but at present they are used to supply only the small markets. Of predominant importance are the pelagic fish, the main species being skipjack, tuna and mackerel. Prawns of high quality exist in some coastal areas.

2. Main Environmental Issues in the Project Area

The residents of the project area are almost entirely indigenous Irianese of several distinct ethnic groups whose livelihood is based on hunting and gathering, shifting cultivation and to a limited extent coastal fishing.

Most of the people in the Cenderawasih area rely to some extent on sea fisheries and/or some smallholdings of perennial tree crops. Small-scale fisheries and estate crops can be used as a source of food, employment and non-oil export earnings. These small operations have the advantages of being labour-intensive, having a high return on the capital invested and being central to the operation of the project.

The fish species in the Cenderawasih Bay are migratory and use the Bay for a temporary feeding ground before continuing on to other areas. This nutrient-rich feeding ground is a fragile ecosystem created by a unique island and underwater geological formation and its resulting influence on ocean currents of the region. The intensive exploitation of this ecosystem and its resources must be carried out only after a thorough examination is made of the total ecological dynamics of the bay ecosystem and its resources.

One of the objectives of the project is to introduce new methods, techniques and technologies to increase the use of the fisheries and estate crop resources. Accomplishing this goal can bring significant benefits to the local population (mainly new jobs and additional income). Fish and prawns can be caught by local fishers and can be iced (or frozen) immediately to be sold in local markets or to a multinational company based in Biak, which has agreed to purchase the project's catch. It is of paramount importance to take into consideration that intensive fish exploitation might easily have an adverse effect (especially on the tuna fish) if the carrying capacity of the pelagic migratory species is not assessed and fully respected.

The project document addresses the need to further incorporate women in commercial activities such as marketing fish and estate crops. However, women in the project area show a much higher mortality rate than men. Thus in order for them to benefit from the economic undertakings envisaged by this project, any activity that requires additional work for women must be carried out only after taking into consideration their health situation and the quality of the working environment for women.

Another objective of the project is to introduce a coastal transportation system to export estate crops. Again, by linking the project area to the external economy it is expected that the exploitation of cocoa will increase considerably. The sustainable exploitation of this and other local crop produce must be determined to maximize profits and avoid the degradation of local land ecosystems.

3. Economics and the Environment in the Project Area

Approximately 55% of Indonesia's labour force works in agriculture, forestry, hunting and fishing. The incidence of poverty (44.6%) and underemployment is twice as high in rural areas, where 80% of Indonesians live, as in the cities.

Indonesia's production of fish, both for domestic consumption and for export, accounts for approximately 6.8% of real GDP. In recent years fish products, particularly shrimp, have become increasingly important exports. Indonesia has great potential in further developing tuna fish production.

All the fish production in the Cenderawasih Bay comes from very small-scale marine capture. Some 77% of the registered fishers in Irian Jaya work in the Cenderawasih Bay. With the exception of one large joint venture holding, all estate crops production comes from smallholder operations, based on the family unit.

A multinational fishing company, P.T. Multi Transpeche Indonesia, operates a number of tuna fishing boats. Although not permitted to fish in the Cenderawasih Bay area, the company has expressed its desire and provided both verbal and written assurances to purchase all tuna species caught by those in the project. Prices would be agreed on prior to sale and could be revised to reflect the changing nature of the international market. The economic benefits that the multinational company would bring to the project area will be optimal only if the demand for tuna fish does not exceed the carrying capacity of this migratory species. The project should discuss how the carrying capacity would be determined and respected.

The development of estate crops in the area is directed to only cocoa and coffee. Cocoa is by far the most important. The Estate Crop Department would undertake the activities as outlined in the project document. The Irian Jaya Joint Development Foundation has a series of marketing outlets in the area and has disbursed credit to many local estate crop farmers.

Indonesia has a long tradition of significantly subsidizing the use of chemical pesticides. The project should discuss how the promotion of estate crops will be carried out while protecting the environment.

Women in the traditional Irianese fishing country are involved in the marketing of the catch. In the case of estate crops, women play a much broader role, being responsible for harvesting as well as processing and marketing the produce. The development and extension of post-harvest technology and activities will be aimed particularly at women and women's groups to provide the basis for additional income-generating activities. The benefits of these activities, however, will only be realized if the working conditions of women are appropriate from an environmental viewpoint. The project does not discuss this.

4. Environmental Management in the Project Area

The main environmental actors in the project area include: the fishers (smallholders and co-operatives); the central government; various government departments (Ministry of Environment and Population, the Assistant to the Minister/Chairman BAPENNAS for Women's Affairs, Directorate General of States, Directorate General of Fisheries, Directorate General of Co-operative Development and Department of Finance); local government, and outside governments (the Government of the Netherlands).

Within the private sector, the main actors are a multinational fishing company (P.T. Multi Transpeche Indonesia), local industries and agricultural co-operatives. The various non-governmental organizations involved include Irian Jaya Joint Development Foundation, Yayasan Pendidikan dan Pengembangan Masyarakat di Irian Jaya-Foundation for Education and Community Development in Irian Jaya (YPPM), the World Wide Fund for Nature and church groups. International organizations such as UNDP, UNFPA, UNESCO, FAO, the Asian Development Bank and World Vision International are also involved.

The introduction of new technologies to exploit marine resources will intensify their exploitation. This might result in depletion of pelagic species unless an appropriate environmental management scheme is adopted.

Some of the objectives of the actors conflict with each other. For example, smallholder fishers prefer to work individually rather than in co-operatives. By the same token, the interests of the multinational fishing company conflict with the objectives of resource protection as expressed by the World Wide Fund for Nature. The project must envisage ways to avoid or at least lessen these conflicts.

The main institution responsible for the environment in Indonesia is the Ministry of Environment and Population (KLH). This ministry is represented locally by the BKLH, including in the project area.

The Ministry of Agriculture has two divisions that are relevant to the work of the project area the fishery division and the Agency for Agricultural Research and Development (ARD). The Vice-Governor's Office has a division specifically assigned to review women's issues.

There is a local Environmental Studies Centre in Biak as well as a Population Studies Centre. Both institutions carry out relevant environmental research in the project area.

Most of these institutions located and/or operating in the project area need to strengthen their technical and managerial capabilities in order to develop policies and practical actions to protect and enhance the local environment.

5. Major Environmental Impacts Associated with the Implementation of the Project

The project promotes the development of a monoculture economy. This might impose serious limitations in the ability of land ecosystems to retain nutrients. The diversification of agricultural produce should be considered.

The promotion of labour-intensive activities in low-populated areas such as Biak will promote migration. More people living in poor environments usually results in environmental degradation. The additional population would have to be furnished with appropriate living conditions in order to avoid further degradation of existing resources.

The project envisages training for some local fisheries and the promotion of co-operative schemes. While both objectives are expected to improve the economic situation of some sectors of the local population, those who will not benefit from the project (other fishers and women) might be displaced from local markets.

6. Alternatives to Proposed Project Design

The project of the Cenderawasih Bay Coastal Area Development could be improved, from an environmental point of view, by carrying out the following actions:

- Define with more precision the link between fishery and agriculture activities.
- Examine underlying government policies that might affect the management of resources in the project area.
- Integrate the local government administration (particularly the BKLH) in project implementation.
- Identify more precisely the potential environmental benefits that could be derived from implementing the project.

7. Identification of Environmental Objectives of the Proposed Activity

The marine resources of the area are substantial, but at present they are used to supply only the small markets. Of predominant importance are the pelagic fish, the main species being skipjack, tuna and mackerel. Prawns of high quality exist in some coastal areas.

The main environmental objectives of the Cenderawasih Bay Coastal project include:

- Promoting a sustainable exploitation of marine resources in the Cenderawasih Bay Coastal area,
- Promoting a proper demographic distribution of the population who will be attracted by the implementation of the project,
- Developing agricultural production schemes for cocoa and coffee using techniques compatible with the functioning of the local environment,
- Improving the environmental working conditions of women participating in the project,
- Strengthening local institutions responsible for the use of natural resources in the project area, and
- Redesigning the local policies relevant to the exploitation of natural resources in the project area.

8. Identification of Possible Conflicts of Interest

The Cenderawasih project must identify in advance all possible conflicts of interest that might occur if the project is implemented and provide a forum and organize relevant negotiation activities for these groups in order to mitigate or resolve such conflicts.

Several actors have objectives and strategies that might conflict with each other. For example, the interests and strategy of Transpeche, the multinational fishing company in the area, will conflict with smallholder fishers and with some environment non-governmental organizations (NGOs).

Similarly, the local Ministry of Environment and Population (BKLH) might conflict with the cocoa and coffee cooperatives if the latter use chemical fertilizers and pesticides to increase the productivity of agriculture.

Additional possible bottlenecks include:

- Resistance of government officials and UNDP staff to development and implementation of the EMS,
- Lack of economic resources for implementation,
- Potential resistance of the executing agency to adoption and implementation,
- Refusal of government authorities to use some of the funds assigned to this project for the implementation,

- Lack of support of UNDP HQ staff for implementation and lack of cooperation of one or more of the participants in environmental management for the project area.

One possible way to overcome the last bottleneck would be through environmental negotiation with neutral mediators who would assist conflicting interests and parties to work together to form alternatives that might incorporate the interest of all parties concerned.

9. Formulation of an Operational Strategy

The operational strategy of the project consists of identification of specific environmental targets to be achieved for the protection of the marine environment and the agricultural sector and for institutional development. The strategy also suggests ways to manage the potential conflicts between those involved in environmental management in the project area. Finally, this strategy includes a plan of activities and timetable, and the identification of information and other supporting needs necessary to implement the strategy.

Specific Environmental Targets

For the marine environment

- Determine the size and ecological dynamics of commercial pelagic species such as tuna fish and mackerel and of shrimp.
- Determine a maximum ceiling for the catch of tuna fish and shrimp during the dry season and develop appropriate mechanisms to establish a ban on fishing in breeding areas.
- Review and integrate the present laws, policies and programmes of the fishery sector with a view to promoting higher fish productivity while protecting and enhancing the marine environment.
- Analyze the potential environmental impacts of proposed new fishing technologies and select only those compatible with the environment.

For the agricultural sector

- Make an inventory of the chemical fertilizers and pesticides used in the country and authorize only those products that have not been banned or severely restricted in Indonesia and/or by other countries according to the United Nations List of Toxic Chemicals and Harmful Substances.
- Examine the possibility of promoting the development of agricultural produce other than cocoa and coffee.
- Analyze the potential environmental impact of proposed new agricultural technologies and select only those compatible with the environment.

For institutional development

- Train local personnel (at the Centre for Population Studies and Centre for the Environment) in techniques to assess the carrying capacity of marine ecosystems; develop managerial schemes to monitor the exploitation of tuna fish and shrimp.
- Train local planners at the BKLH to integrate marine and coastal development activities in order to protect the local environment and obtain the maximum benefits of long-term sustainable exploitation of resources.
- Support the activities of the Department of Women's Affairs in the Office of the Vice-Minister of Indonesia in order to strengthen their participation in local projects such as the Cenderawasih Bay Coastal Area.

Participants in Environmental Management

The main participants in environmental management in the project area have different objectives and strategies.

Actor 1: government sector

The main government actors at the national level include the Assistant to Minister/Chairman BAPENNAS for Women's Affairs, Directorate General of States, Directorate General of Fisheries, Directorate General of Cooperative Development, Department of Finance, Directorate General of Agriculture, and Ministry of Environment and Population (KLH). The strategy of these actors is to regulate the activities of other social actors and to coordinate the economic development programmes and activities of Indonesia, keeping in mind the priorities established in the 5th National Development Plan (REPELITA V).

The main government actors at the local level include BKLH (from the Ministry of Environment and Population), BAPENNAS (from the Ministry of Planning), and Ministry of Agriculture. The strategy of these actors is the same as the national government but this time the scope of application is local.

Actor 2: private sector

The main actors within the private sector include Multi Transpeche Indonesia, fishers and agricultural cooperatives, smallholder fishers and the local sea transport company that will benefit from the project and increase the movement of agricultural produce from Biak to other villages in the project area.

Transpeche's main objective is to maximize the exploitation of tuna fish. Their strategy is to establish joint ventures with the local cooperatives of fishers especially in view of the fact that Transpeche is banned from fishing in Cenderawasih Bay. The local cooperatives want to work with Transpeche and oppose individual fishing schemes. In turn, smallholder fishers see themselves as independent entrepreneurs. Their strategy is to promote artisinal fishing and avoid organized schemes. They oppose the participation of Transpeche in the commercial life of the project area. Women who participate in the commercialization of fruits and other agricultural products would probably like to work with the local sea transport company in order to have a greater input into local commercial markets where cocoa and coffee are sold. Their strategy also includes supporting local agricultural cooperatives. By the same token, the agricultural cooperatives strategy is to promote organized work for the exploitation of agricultural produce.

Actor 3: non-governmental organizations

The main NGOs present in the project area include Irian Jaya Joint Development Foundation, Irian Jaya Joint Development Foundation, Yayasan Pendidikan dan Pengembangan Masyarakat di Irian Jaya-Foundation for Education and Community Development in Irian Jaya, World Wide Fund for Nature and church groups. These NGOs are mainly development and environment-oriented. Their general aim is to work at the community level and assist people in satisfying their basic needs (health, food and shelter) and attaining a higher standard of living.

The international organizations in the project area include United Nations Organizations (UNDP, UNFPA, UNESCO, FAO), the Asian Development Bank (ADB) and World Vision International. Their strategy is to support the activities and development initiatives established by the Indonesian government.

Plan of Activities and Timetable

A list of activities and a timetable necessary to explicitly include the environmental dimension in the project should be included in the EOP/MS.

Environmental Information

The following environmental information must be sought to implement the EMS properly (this is not a comprehensive list but examples of the type of information needed for implementation):

- Inventory of environmental studies related to the project area and its resources.
- Dynamics of local marine ecosystems.
- Size and dynamics of tuna fish population.
- Patterns of human migration associated to the implementation of the project.

- Inventory of chemical fertilizers and pesticides used in the project area.
- Environmental factors that influence the present higher mortality rate in women living in the project area.

Supporting Needs

The EMS will require five main types of support in order to be implemented: education and training, technical and managerial skills, access to data banks, institutional support and financial aspects. The following are the specific supporting needs required to implement the Cenderawasih project:

Education and training

- Training course for local government authorities on environmental planning and environmental monitoring.
- Course on environmental protection of marine resources.

Technical and managerial skills

- Training UNDP local staff and BKLH on methodologies for conducting environmental audits.
- Training members of cooperatives on environmentally sound practices for fishing and for coffee and cocoa production.

Access to environmental data banks

- Identify environmental data banks relevant to the project area, such as the United Nations List of Banned and Severely Restricted Chemicals.

Institutional support

- Identify the technical needs of the Centre for Population
- Studies and the Centre for Environmental Studies of Irian Jaya.
- Strengthen the environmental auditing and environmental monitoring capacity of the BKLH.

Supporting needs

The original project proposal may need to be modified in order to incorporate the activities outlined in the EMS. While it is beyond the scope of this example to create an entire new budget, this section should contain all of the budget changes each activity should be itemized, and potential short and long-term savings and costs should be noted.

Implementation Responsibilities

In order to list who is responsible for implementing each of the activities listed in the EMS, each of the potential players will have to be consulted and give their consent. After this is done, a list should be drawn up identifying each individual by name and the task for which he/she has responsibility and the time in which it will be completed. In order to not specify Indonesian citizens in the example, this section has not been completed.

Decision Making

The regulatory decision making in Indonesia lies with the central government. Local government institutions are rather weak and lack autonomous power. BAPPENAS is the government ministry with highest political authority in the country. The Ministry of Finance allocates economic resources for an activity within the framework of the REPELITA V.

10. Monitoring the EMS

The responsibility for monitoring the implementation of the EMS belongs to UNDP, the executing agency and the government counter-part responsible for implementing this project. Page 43 and Table 1 of the Environmental Management Guidelines can be used for suggestions regarding specific checkpoints during the life of a project when the EMS can be monitored for environmental impact.

Further information may be obtained from:

Environment and Energy Branch, UNIDO
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Learning Unit 10

REVIEW, WITH A COURSE APPRAISAL

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

Additional Course Materials

Reading:	Transforming Technology, a booklet written for the World Resources Institute by G. Heaton, R. Repetto and R. Sobin
Audio tape:	Learning recall tape
Floppy disc:	Sample project document "Pollution prevention at the (name) industrial facility"

Introduction

Learning Unit 10 is designed to help you review the information that has been covered in this training course and to stimulate your thinking about how you can apply that information to both your professional and your personal life.

Objectives

The specific objectives of this unit are as follows:

- To understand the relationships among the many ideas presented in the preceding Learning Units of the training course.
- To reflect on how the information and ideas presented in this course are relevant to the promotion of ESID.
- To stimulate your thinking about how you can begin to promote ESID and Cleaner Production in your country.
- To point out how the lessons you have learned can affect both your professional and your personal life.

Key Learning Points

1 The information and ideas presented in this training course offer an integrated approach to the challenge of developing industry and, at the same time, protecting the environment.

2 The ESID approach to industrial development through Cleaner Production ensures that industrial development is compatible with environmental protection. The approach draws on a wide range of concepts and techniques that must be adjusted to each country's level of economic and institutional development.

3 Some ESID-related programmes and projects are relevant in all countries; others must be designed to respond to specific needs.

4 To become an effective spokesperson for ESID and Cleaner Production in your country, it is essential that you take actions in your personal life and your work to ensure better resource utilization and environmental protection.

Suggested Study Procedure

1 Work through the *Study Materials*. Prepare answers to the questions and check your answers against those suggested.

2 Read the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

3 Complete the exercises in the *Review*.

LU10

Study Materials

This training course has introduced you to a wide range of concepts and issues concerning the relationship between industrial development and the environment. The problems and the issues are the same worldwide, and the need to achieve ecologically sustainable industrial development is urgent in every part of the world. This Learning Unit first asks you to reflect on what you have learned from the preceding Learning Units. It then asks you how the concepts and techniques are relevant to the situation in your country and suggests some actions that you might take to begin promoting ESID and Cleaner Production.

How ESID Training is Relevant to Your Work

Next Steps

1 **Read through the course outline that follows.**

2 **Think about how the concepts and techniques are relevant to your situation by answering the questions.**

LU1	*Introduction* provides a general overview of the course content and its objectives. It includes an introductory test to assess existing knowledge about the subject matter.
LU2	*The Need for Ecologically Sustainable Industrial Development* explains the significance of trends in industrial development and the environment.
LU3	*Defining Ecologically Sustainable Industrial Development* presents the concept of ESID and the three criteria (eco-capacity, efficiency and equity) for measuring progress in achieving it. It also sets out the actions that industry can take to meet the criteria.

LU4 *Cleaner Production* explains the concept of Cleaner Production, describes many specific activities that constitute such production and outlines the advantages of and barriers to implementing Cleaner Production programmes in developing countries.

LU5 *Analytical Tools for Identifying Cleaner Production Opportunities* introduces techniques for identifying Cleaner Production opportunities that may be profitable for enterprises and beneficial to the environment: waste reduction audits, environmental compliance audits, product life-cycle analyses and environmental impact assessments.

LU6 *Economic Techniques for Assessing Cleaner Production Options* introduces economic analysis techniques that can be used to justify investments in Cleaner Production: financial analysis, micro-economic impact analysis, benefit-cost analysis and macro-economic impact analysis.

LU7 *The Role of Government in Industrial Environmental Management* describes the range of government activities that are used to manage the environment and discusses which of these are most effective for promoting Cleaner Production. It covers the basics of an environmental regulatory programme as well as innovative approaches such as economic incentives, multimedia permits, national sustainable development strategies and international agreements.

LU8 *Sources of Information on Cleaner Production* explains how to obtain information about Cleaner Production from UNIDO, UNEP and many other sources.

LU9 *Environmental Considerations in Project Design* describes how UNIDO staff can incorporate environmental considerations into project designs consistent with the goals of the UNIDO environment programme, with the recommendations of the Conference on Ecologically Sustainable Industrial Development and with Agenda 21 of United Nations Conference on Environment and Development.

LU10 *Review, with a Course Appraisal,* provides a few exercises to help students recall the main points of the training course.

Questions

1 What have been the trends in industrial development and environmental degradation in your country over the past 10 years? Can you see any direct cause-and-effect relationship?

2 What actions should be taken in your country to meet the three ESID criteria: eco-capacity, efficiency and equity?

3 What actions in Agenda 21 are most relevant for your country?

4 Do you know of any Cleaner Production/waste minimization programmes under way in your country?

5 What three industrial branches in your country most need to implement Cleaner Production techniques and technologies?

6 Which technique for identifying Cleaner Production opportunities is most relevant for your country? Why?

7 Which technique for identifying Cleaner Production opportunities is least relevant for your country? Why?

8 Why is it useful to prepare an economic impact analysis of environmental regulations?

9 What types of environmental benefits do you think would be most persuasive in justifying environmental regulations in your country?

10 How effective are the four components of an environmental regulatory programme in your country?

11 Can you identify some government policies in your country that discourage Cleaner Production? What would be required to change these policies?

12 Where is the INTIB focal point located in your country? Does it have any information on the EEIS information progamme?

13 Does your office receive the UNIDO *Environmental Awareness Bulletin* or the UNEP periodicals *Industry and Environment* and *Cleaner Production*? If it does, do you read these publications on a regular basis? If it does not, do you know how to obtain copies?

14 Where in your office is a copy of the UNIDO publication *Guidelines for Environmental Appraisal* kept? Have you found it useful in assessing the environmental impacts of a project?

15 Where in your office is a copy of the UNDP *Handbook and Guidelines for Environmental Management and Sustainable Development*? Have you used it to prepare an environmental overview of a project?

16 Where in your office is a copy of your country's national report submitted to UNCED? Have you read the sections that describe industrial activities?

Next Steps

1 Read through the six actions you might initiate in your country to promote ESID.

2 Look at the UNEP/UNIDO publication *Audit and Reduction Manual for Industrial Emissions and Wastes*.

3 Think about how you might initiate such a project in your country. Answer the questions that follow Action 7 to stimulate your thinking.

Actions to Promote ESID

Action 1:

Participate in the preparation of a sustainable development strategy

This is not a project but rather an activity that UNIDO should be involved in to ensure that industrial activities are addressed when a country's sustainable development strategy is prepared. As a result of UNCED, every country is preparing a sustainable development strategy with assistance from the United Nations and bilateral donors.

To get started, find the country focal point for the effort and ask how the strategy will address industrial issues. Offer to participate in the effort. No funding is needed for this activity.

For additional information, see the World Bank publication *Environmental Assessment Sourcebook* (suggested as additional reading for Learning Unit 9).

Action 2:

Conduct an ESID industrial policy review

You could initiate a study in your country to identify the positive and negative effects of government policies and institutions on the shift of industry to proactive, eco-efficient production. The study would make recommendations on how to eliminate negative effects (usually a difficult task) and on how to create or enhance positive effects.

Such a study would start with a review of government policies and institutions based on published and unpublished information on government policies and institutions as well as on interviews with government officials, industry associations and chambers of commerce, donor groups and environmental NGOs. It would then examine the categories of government actions that are most relevant: those explicitly encouraging eco-efficiency through pollution prevention and those indirectly encouraging eco-efficiency through national environmental regulatory programmes.

This project could be funded under Technical Support Services (TSS-1) from UNDP or Indicative Planning Figure (IPF).

For additional information, write to the Environment Co-ordination Unit of UNIDO to obtain the TSS-1 proposal "Government of (name of country) policy options and institutions to promote industrial 'eco-efficiency' and competitiveness" and the UNIDO publication *Ecologically Sustainable Industrial Development Strategies: A Methodological Framework.*

Action 3:

Conduct a conversion feasibility study for a plant using CFCs

Existing plants in developing countries that use CFCs will have to carry out a conversion programme. This can range from rearranging the production process to accommodate an alternative process of washing and drying chips, changing the length or diameter of the tubing used in refrigeration equipment, to totally replacing all existing capital equipment if a completely new production technology is to be introduced, e g. food preservation via irradiation. The conversion feasibility study would examine the available options for a conversion, select the best option and estimate the incremental costs.

Funding for this project might be available through the Multilateral Fund of the Montreal Protocol.

For additional information, see your country's focal point for the Multilateral Fund and write to UNIDO, Industrial Operations Technology Division.

Action 4:

Persuade your country's environmental management agency to establish a Cleaner Production unit

Most environmental management agencies have only a traditional environmental regulatory programme that concentrates on achieving discharge standards with end-of-pipe technology. These programmes are not always effective because they require too large a capital investment by industry.

The objective of this project would be to develop a core group within the environmental management agency to promote Cleaner Production. The core group would need a chief technical advisor, external training, international consultants and a revolving loan fund. Funding for this project might be available through IPF.

You might build this type of project into the UNDP Country Programme, as was done in Sri Lanka.

For additional information, write to the Environment Coordination Unit of UNIDO to obtain the project document "Industrial pollution reduction programme in Sri Lanka" (DSRL/91/019).

Action 5:

Conduct a survey of the environment industry

The environment industry will grow significantly in this decade in response to new environmental requirements. It consists of two sectors, one for the manufacture of equipment and other for the provision of services. The latter will experience the most rapid growth, because the fuller incorporation of clean technologies into industrial processes requires enhanced engineering and analytical services.

You might conduct a survey that would estimate the demand for and the supply of both environmental equipment and environmental services in your country. The focus would be on the potential of domestic firms to meet the growing demand and the steps needed to increase their capacity.

Funding for this project might be available through the UNIDO Industrial Development Fund and Trust Funds.

For additional information, request from UNIDO, OECD, USEPA and bilateral organizations their studies on this topic.

Action 6:

Encourage a non-governmental organization, such as a trade association or an industry confederation, to apply to be a national Cleaner Production centre

UNIDO, in cooperation with IE/PAC, will support national cleaner production centres (NCPCs) in approximately 20 countries. The NCPCs will play a coordinating and catalytic role in Cleaner Production by providing technical information and advice, by stimulating demonstrations of Cleaner Production techniques and technologies and by training employees of industry and Government in this new area of industrial environmental management.

UNIDO, in cooperation with UNEP, launched phase I of this programme in October 1992. Funding for the programme is coming to UNIDO from the Industrial Development Fund.

For additional information, write to the Environment Coordination Unit of UNIDO for background information on NCPCs.

Action 7:

Undertake a demonstration waste reduction audit for an industrial facility

Most developing countries are failing to achieve significant reductions in industrial pollution by requiring conventional end-of-pipe solutions. Industry claims that it is too costly to install the equipment; moreover, when it is installed, it often fails to operate properly. Accordingly, much more emphasis has to be placed on achieving pollution reductions through modifications of the production process, because these modifications tend to be more cost-effective and sustainable.

You could suggest conducting a waste reduction audit at one facility in your country to demonstrate the waste being generated by current production processes and the opportunities for reducing it. The results of the demonstration would be shared with similar facilities in other parts of the country.

You might focus on the five manufacturing sub-sectors known to be the most energy- and materials-intensive as well as the most pollution-intensive: iron and steel; non-ferrous metals; non-metallic minerals; chemicals; and pulp and paper.

Funding for this project might be available from Special Industrial Services and Industrial Development Funds.

Next Steps

For additional information, see the UNEP/UNIDO publication *Audit and Waste Reduction Manual for Industrial Emissions and Wastes*. After having looked at the manual, answer the following questions.

Questions

1 Do you know of any waste reduction audits that have been performed in your country? Have they been successful?

2 Can you think of any companies that might benefit from a waste reduction audit and that would welcome such an opportunity?

3 Who could you approach for help in initiating the project?

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4 What would you think are reasonable funding and resource requirements for such a project? (Hint: A generic project document for a waste reduction audit is on one of the two floppy discs included in this training kit).

5 How would you set about organizing the project? Do you have enough time and financial resources to manage the project?

Optional Suggested Reading

This concludes the study section of Learning Unit 10. For an overview of the material covered in the course, you may wish to read *Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century*, included in the training kit. It will help you look again at the imperative to meet ESID objectives.

Questions

1 What have been the effects on the environment of technologies developed since the Second World War?

2 Why should we be concerned about these effects?

3 Is a lack of Cleaner Production techniques and technologies the limiting factor in transforming industrial production?

4 What are some of the main impediments in transforming technology?

5 Why do environmental regulatory programmes often discourage technological transformation?

6 What are some measures that can be used to change management attitudes towards technological transformation?

Answers

1. *The technologies developed since the Second World War have resulted in significant increases in the amount of pollutants generated, new types of toxic pollutants, the spread of environmental degradation to developing countries and the emergence of global pollution problems.*
2. *These effects are unsustainable, i.e. they exceed the eco-capacity (assimilative capacity) of the earth. The emerging global problems are now large enough to alter the fundamental natural processes that support life.*
3. *No. Technical solutions are available right now that could make dramatic environmental improvements at small costs or even at a saving. They are not adopted primarily because of corporate leaders' attitudes, organizational structure and competing priorities.*
4. *The most fundamental impediment is that the use of environmental resources (air, water etc.) is not fully priced. Thus, there is no incentive to conserve these resources. Another main impediment is that Governments create perverse incentives, such as regulatory policies, taxes and subsidies, that encourage excessive resource use.*
5. *Environmental regulations generally promote the use of existing technologies rather than the adoption of Cleaner Production technologies.*
6. *The most important step is to draw management's focus away from end-of-pipe pollution control towards pollution prevention through Cleaner Production. Another important step would be to ensure that corporate accounting systems charge the full costs of waste generation to the responsible processes and plants.*

Case Studies

Because all of our activities affect the environment, the concepts that have been introduced in the industrial context can also be applied to our daily lives. The following *Case Studies* are designed to help you think about your own relationship with the environment. Think about the issues raised, preferably discussing them in a small group.

Case Study 1: Waste Reduction Audit

The techniques used in waste reduction audits can be applied to all of our activities. Prepare an informal waste reduction audit of your own kitchen. Use the example of cooking a simple dinner, say chicken and rice. Identify the inputs and the outputs and circulate the material balance. Remember, the sum of the inputs must equal the sum of the outputs. Can you identify any waste reduction options. Which options would be most effective. What steps would you have to take to implement them?

Household Kitchen Waste Reduction Audit

Inputs	Outputs
Total inputs:	Total outputs:

LU10

Waste reduction options

Ranking of three best options

Case Study 2: Environmental Compliance Audit

Environmental standards and policies apply even to you and your own household. Again using the preparation of a chicken dinner as an example, prepare an informal environmental compliance audit of your own kitchen. What wastes do you generate? What environmental regulations and policies apply to the disposal of these wastes? Do you conform to those regulations and policies? Given the environmental trends in your community, do you think these regulations and policies might change? How? What might you want to do now to prepare for these changes?

LU10

Household Kitchen Environmental Compliance Audit

Wastes	Environmental requirement	Compliance status	Potential changes

Case Study 3: Product Life-Cycle Analysis

Claims that products are environmentally friendly, or green, are becoming important marketing tools for many companies. What products are really environmentally friendly? The techniques used in product life-cycle analysis can help us answer those questions.

1 A recent political platform called for the use of non-polluting electric vehicles. Are electric cars really non-polluting? Compare the environmental impacts of an electric car with those of a gasoline-powered car. First look at the differences in production, particularly the materials used in the engines and energy systems. Then look at the energy-related emissions resulting from operation of the cars. Finally, look at the disposal problems that the two different cars might create. Which cars do you think are less polluting? (Hint: for additional information, see UNEP *Industry and Environment*, vol. 16, No. 1-2 (January-June 1993), pp. 3-66.

Product Life-Cycle Comparison: Electric Cars vs. Gasoline Cars

Environmental impact	Electric cars	Gasoline cars
Manufacture		
Energy used in operation		
Disposal		

2 Prepare a list of some products that are truly non-polluting.

3 Some people argue that truly dedicated environmentalists should pursue a lifestyle that does not in any way pollute the environment. Describe such a lifestyle. Would it be possible? Is it desirable? Is it necessary?

Review

Final Review Test

✓

LU2 The Need for Ecologically Sustainable Industrial Development

1 The developing countries' share of industrial output in 1990 was approximately

a. 10 per cent
b. 15 per cent
c. 20 per cent
d. 25 per cent

2 The region with the highest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia/South-East Asia
c. Latin America
d. Africa

3 The region with the lowest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia/South-East Asia
c. Latin America
d. Africa

4 Industry uses approximately

a. One fifth of the world's energy
b. One quarter of the world's energy
c. One third of the world's energy
d. One half of the world's energy

5 Emissions of CO_2 from fossil fuel burning are a major cause of

a. Greenhouse effect
b. Aquatic system damage
c. Ozone depletion
d. All of the above

6 Emissions of CFCs come from

a. Refrigerators
b. Solvents
c. Foams
d. All of the above

7 Acid rain results primarily from emissions of

a. Sulfur dioxide
b. Nitrogen oxides
c. Hydrocarbons
d. Particulate matter

8 All of the following are toxic heavy metals except

a. Mercury
b. Lead
c. Cadmium
d. Dioxin

LU10

9 The most polluting fuel per unit of energy is

a. Oil
b. Coal
c. Nuclear
d. Natural gas

10 The World Commission on Environment and Development called for

a. Zero economic growth
b. Economic growth that is equitable and compatible with the environment
c. Large-scale financial transfers to developing countries
d. Preservation of the world's resources

LU3 Defining Ecologically Sustainable Industrial Development

11 Sustainable development means meeting the needs of the present without

a. Compromising the needs of the future
b. Creating pollution problems for those over 60 years of age
c. Increasing population
d. Creating greenhouse effects

12 To achieve ESID, we need all of the following except

a. Eco-capacity
b. High GNP per capita
c. Efficiency
d. Equity

13 The critical load of industrial pollutants beyond which the quality of life and the proper management of natural assets are affected is called

a. Clean production limit
b. Effluent standard
c. Eco-capacity
d. Ambient environmental standard

14 Waste minimization is an objective of environmental

a. Eco-capacity
b. Equity
c. Economic analysis
d. Efficiency

15 The concept of a fair opportunity to share in the benefits of industrialization refers to

a. Efficiency
b. Eco-capacity
c. Dreams
d. Equity

16 The key to achieving ESID is

a. Transfer of clean technology
b. Government financial subsidies
c. Reduction of pollution intensity
d. Commitment to the Business Charter of the International Chamber of Commerce (ICC)

17 ESID is justified mainly by

a. Limited capacity for absorbing wastes from humanactivities
b. Shortage of natural resources
c. The need for new business ethics
d. UNCED

18 Agenda 21, chapter 30, "Strengthening the role of business and industry", calls for

a. Support of the Valdez Principles
b. Shipment of hazardous wastes to developing countries
c. Annual environmental reporting
d. Preparation of emergency response plans

19 The Rio Declaration is

a. A call for reform of the United Nations system
b. A statement of principles of sustainable development
c. A commitment to address climate change issues
d. Industry's response to sustainable development issues

20 Agenda 21 is

a. A global action plan to implement the Rio Declaration
b. A call for a new international order
c. A tropical forest action plan
d. A UNDP initiative for capacity building

LU4 Cleaner Production

21 The first step in improving Cleaner Production in industry is a change in

a. Technology
b. Customer preference systems
c. Attitudes
d. Legislation on recycling

22 Industrial environmental management has evolved through

a. Abatement to prevention to dilution
b. Prevention to dilution to abatement
c. Dilution to prevention to abatement
d. Dilution to abatement to prevention

23 The most cost-effective management choice for combating industrial pollution is

a. Prevention
b. Dilution
c. Abatement
d. Control

24 Cleaner Production eliminates waste

a. During production
b. At every stage of the life cycle of a product
c. By disposing of wastes safely in approved facilities
d. By recycling processing residues

25 Cleaner Production does not include

a. Better housekeeping
b. Ecologically benign products
c. Recycling of wastes by outside contractors
d. Low- and non-waste technology

26 From the practical business point of view, pollution prevention

a. Often pays
b. Does not pay
c. Has a long payback period
d. Is not possible

27 The implementation of Cleaner Production actions does not need

a. Training
b. Cooperation between government and industry
c. Change in management attitudes
d. Advanced technology

28 "Cleaner Production is just not realistic in developing countries where per capita GNP is below $1,000". This statement is

a. False
b. Correct
c. True
d. Helpful

29 The 10 steps for introducing Cleaner Production in an enterprise include all of the following except

a. Involvement of senior employees
b. Seeking government subsidies
c. Monitoring and evaluation
d. Disseminating information to employees

30 All of the following are barriers to Cleaner Production except

a. Lack of financial resources, awareness, training, expertise and know-how and access to existing knowledge
b. Uncertainty about the right information, technology and regulations
c. Attitudes of employees who feel threatened by change
d. Demonstration projects

LU5 Analytical Tools for Identifying Cleaner Production Opportunities

31 Pollution prevention opportunities may best be identified through

a. Environmental impact assessment
b. Waste reduction audit
c. Environmental compliance audit
d. Product life-cycle analysis

32 A waste reduction audit makes a detailed analysis of plant processes and wastes with the purpose of

a. Producing wastes
b. Completely eliminating wastes
c. Identifying wastes
d. Hiding wastes

33 A waste reduction audit is best described as

a. An input characterization
b. A material balance
c. A balanced financial statement
d. A least-cost production programme

34 The main purpose of an environmental compliance audit is to

a. Ensure that a firm is complying with environmental norms
b. Provide information to environmental management agencies
c. Meet the requirements of the Business Charter of ICC
d. Protect environmental quality

35 Conducting a waste reduction audit requires a commitment of

a. Top management
b. Supervisors
c. Workers
d. All of the above

36 A product life-cycle analysis considers

a. Only the design of a product
b. The potential for product recycling
c. All stages of production and consumption
d. The production process

37 The most controversial step in a product life-cycle analysis is

a. Cost analysis
b. Inventory analysis
c. Impact analysis
d. Improvement analysis

38 An environmental impact assessment predicts

a. Effects on the environment
b. Effects on production cost
c. Effects on management
d. Effects on pollutant discharge

39 Scoping for an environmental impact assessment means

a. Finding the best environmental location for a project
b. Identifying the major environmental impacts
c. Choosing the least-cost mitigation strategy
d. Finding the most qualified team of experts

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40 All of the following are important principles in managing an environmental impact assessment except

a. Balancing the benefits and costs of mitigation measures
b. Involving the appropriate persons and groups
c. Linking information to decisions about the project
d. Presenting clear options for the mitigation of impacts

LU6 Economic Techniques for Assessing Cleaner Production Options

41 To justify a Cleaner Production investment, the economic technique that measures cash flows and profitability over a future period at the plant level is

a. Financial analysis
b. Micro-economic analysis
c. Macroeconomic analysis
d. Environmental impact assessment

42 A payback period of one year is equivalent to a

a. 25 per cent return on capital
b. 50 per cent return on capital
c. 100 per cent return on capital
d. 200 per cent return on capital

43 Payback analysis is a limited measure of investment because it fails to account for

a. Economic life of the investment
b. Income tax
c. Present value of cash flows
d. All of the above

44 The technique that estimates the economic impact of Cleaner Production investment at an industry level is

a. Environmental impact assessment
b. Micro-economic analysis
c. Macroeconomic analysis
d. Financial analysis

45 Micro-economic impact analysis examines all of the following except

a. Plant closure
b. Product price increases
c. Capacity expansion
d. Balance of payments

46 The economic technique that measures the cost of a Cleaner Production activity against possible benefits is

a. Marginal cost analysis
b. Financial analysis
c. Macroeconomic analysis
d. Benefit-cost analysis

47 The main difficulty with benefit-cost analysis is usually

a. Quantifying health effects
b. Estimating the costs
c. Valuing the benefits
d. Arithmetical

48 In environmental benefit-cost analysis, values can be

a. Market values based on prices and cost savings
b. Surrogate values based on land values, wage premiums, travel costs etc.
c. Survey values
d. All of the above

49 To justify a Cleaner Production investment, the economic tool that measures the effect of environmental expenditures on GDP, consumer prices and unemployment is

a. Environmental impact assessment
b. Micro-economic analysis
c. Macroeconomic analysis
d. Financial analysis

50 Expenditure on pollution prevention and control in most developed countries accounts for

a. 2 per cent of GDP
b. 5 per cent of GDP
c. 8 per cent of GDP
d. 10 per cent of GDP

LU7 The Role of Government in Industrial Environmental Management

51 The concept of market failures in environmental management refers to

a. State ownership of enterprises
b. Subsidies for energy use
c. Accelerated depreciation for pollution control equipment
d. Treating environmental resources as free goods

52 An example of policy failure in environmental management is

a. Absence of environmental laws
b. Subsidies for water use
c. Absence of a national environmental action plan
d. Subsidies for building municipal waste-water treatment plants

53 One essential environmental management activity that needs to be undertaken by Governments is

a. Support for environmental non-governmental organizations (NGOs)
b. Tax credits to industry for installing pollution control equipment
c. Collection and dissemination of environmental data
d. A ministerial appointment for the head of the environmental management agency

54 An effective command-and-control regulatory programme requires

a. Issuing discharge permits
b. Monitoring compliance
c. Enforcing permit conditions
d. All of the above

55 A multimedia approach to environmental management means

a. Using both command and control regulations and economic incentives
b. Documenting pollution problems with a video film
c. Using both self-monitoring and independent inspections to ensure compliance
d. Simultaneously regulating pollutant discharges to air, water and soil

56 Economic incentives include all of the following except

a. Effluent taxes
b. Marketable permits
c. Corporate income taxes
d. Deposit refund schemes

57 Economic incentives can

a. Promote least-cost solutions
b. Provide flexibility in pollution control technology
c. Stimulate the development of technology
d. All of the above

58 An essential component of a national sustainable development strategy is

a. Funding environmental research
b. Signing international protocols
c. Reducing pollutants in all sectors (agriculture, industry etc.)
d. Setting qualitative targets to be met at some unspecified time

59 The Montreal Protocol calls for

a. Information exchange on ozone depletion
b. Research on ozone depletion
c. Prior approval for the transboundary shipment of hazardous wastes
d. Limits on the production and consumption of ozone-depleting substances

60 A government action that directly encourages Cleaner Production is

a. A national strategy for sustainable development
b. Economic incentives
c. Negotiated environmental compliance that allows for innovation
d. Multimedia environmental permits

LU8 Sources of Information on Cleaner Production

61 The information system that supports 70 focal points around the world is

a. INTIB
b. IE/PAC
c. REED
d. ICPIC

62 Data on UNIDO energy- and environment-related industrialization activities in developing countries are obtained from UNIDO via

a. METADEX
b. REED
c. Energy Technology Clearinghouse
d. ICPIC

63 The name of the UNEP on-line pollution prevention clearinghouse is

a. Pollution Prevention Information Clearinghouse
b. Awareness and Preparedness for Emergencies at a Local Level (APELL)
c. ICPIC
d. Energy and Environment Information Systems

64 A United Nations-sponsored source of data on hazardous chemicals and health is

a. INTIB
b. IRPTC
c. International Occupational Safety and Health Information Centre
d. REED

65 One source of information in setting up a national environmental management association for enterprises is

a. World Environment Centre
b. Business Council for Sustainable Development
c. International Network for Environmental Management Organizations (INEM)
d. World Industry Council for the Environment (WICE)

LU9 Environmental Considerations in Project Design

66 The United Nations organization that has prepared guidelines for the rapid assessment of sources of air, water and land pollution is

a. World Health Organization (WHO)
b. UNIDO
c. UNEP
d. UNDP

67 The UNIDO *Guidelines for Environmental Appraisal* are most useful at which stage of the project cycle?

a. Design
b. Identification
c. Approval
d. Evaluation

68 All of the following measures might be appropriate environmental measures for projects without capital implications except

a. Environmental awareness
b. Technology change
c. Training
d. Information management

69 All of the following measures might be appropriate environmental measures for projects with capital implications except

a. Information management
b. Good housekeeping
c. Process changes
d. Treatment and disposal of wastes

70 The UNDP *Handbook and Guidelines for Environmental Management and Sustainable Development* focuses on

a. Identifying environmental problems
b. Assessing environmental impacts
c. Designing environmental management agencies
d. Planning technical assistance

Answers to questions 1-70

1-10 *b b c c a d a d b b*
11-20 *a b c d d c a c b a*
21-30 *c d a b c a d a b d*
31-40 *b c b a d c c a b a*
41-50 *a c d b d d a d c a*
51-60 *d b c d d c d c d c*
61-70 *a b c b c a a b a d*

Some Ideas to Think About

The following are some additional questions that you might think about. If possible, discuss them in a small group and try to achieve consensus.

1 What has this course inspired you to do.What will be your next steps?

2 How will this course change your activities as a professional in the development field?

3 How will it change your personal life?

4 What do you think are the most urgent environmental problems in your country? What can you personally begin to do about them?

Course Appraisal

Next Steps

1 On the following three pages are course appraisal sheets. Please tear them out and complete them now, taking some time to think about your reactions to the course.

2 When you have finished, either give them to your instructor or mail them to the Environment Coordination Unit of UNIDO.

Course Appraisal

Organizer's name:

Location and date completed:

Study method (alone, group or with instructor):

Your name and title:

Organization name, address, telephone and fax:

General functions of your organization:

Previous background in ESID:

Test scores at beginning and end of course:

Please evaluate each Learning Unit by making comments or suggestions for additions, deletions or improvements. Rate each Learning Unit with a score based on the following:

1 = excellent, 2 = good, 3 = fair, 4 = poor, 5 = very poor

Learning Unit 1 _________

Learning Unit 2 _________

Learning Unit 3 _________

Learning Unit 4 _________

Learning Unit 5 _________

Learning Unit 6 _________

Learning Unit 7 _________

Learning Unit 8 _________

Learning Unit 9 _________

Learning Unit 10 _________

Overall evaluation

- Content:
- Presentation:
- Administration:
- Usefulness:

Comments on course:

Suggestions for improvement:

Was enough guidance, briefing and help provided?	YES/NO
Did the learning stimulate you?	YES/NO
Did you know the learning objectives before you started?	YES/NO
Do you think you achieved the learning objectives?	YES/NO
Would you choose to learn this way again?	YES/NO
Were the materials practical and relevant to you?	YES/NO
Were the technical terms a block to your learning?	YES/NO
Would a more experienced teacher have improved the learning environment?	YES/NO
Did you find the materials too confusing at times?	YES/NO
Did the time constraints upset you?	YES/NO
Did something disturb your learning? What was it?	YES/NO

Next Steps

1 The real value of this training does not depend on what you think now; it depends more on what you actually do with what you have learned. Therefore, please find the learning recall tape (LRT) in the training kit and play it on day 1 after you have completed the course.

2 The introduction to the LRT will describe the three stages of the learning recall process. In stage one, which takes place on day 1, look through the material that you used for the course and spend five minutes thinking about what you learned.

3 In stage two, which is repeated on days 3, 6, 13 and 24 after completion of the course, play the full LRT (30 minutes).

4 In stage three, on day 28, take the final review test again and answer the questions below.

5 Please give your answers to the questions below to the course organizer, who will forward a copy to the Environment Coordination Unit of UNIDO at Vienna. If there was no organizer, please send them yourself.

6 You will receive copies of any learning research papers produced from the data.

Did you complete the LRT exactly as scheduled? Please explain any variations.

How have you actually used what you taught yourself in the programme? Please explain:

How efficient was the learning? Please explain:

How effective was the learning? Please explain:

Did you achieve your course objectives? Have they changed now? Do you have any other useful comments? Please answer overleaf.

Can you now offer one or two brief cases, with solutions, that might in future be used for this training course? Please outline them overleaf.

LU10

Further information may be obtained from:

Environment and Energy Branch, UNIDO
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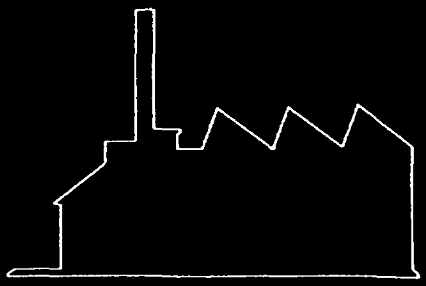
INDUSTRY AND ENVIRONMENT OFFICE

UNIDO - UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

TECHNICAL REPORT SERIES N°7

Audit and Reduction Manual for Industrial Emissions and Wastes



136p.
tables
diagrams

EVALUATION QUESTIONNAIRE

AUDIT AND REDUCTION MANUAL FOR INDUSTRIAL EMISSIONS AND WASTES

As part of its continuing review of the impact of the publications it supports, the United Nations Environment Programme (UNEP) and the United Nations Industrial Development Organization (UNIDO) would appreciate your co-operation in completing the following questionnaire.

Please complete the questionnaire in the order in which presented and do not correct and do not erase your initial answers.

1 Quality

Please rate the following aspects of the publication by ticking the appropriate box.

	Very good	Adequate	Poor
Objectivity	☐	☐	☐
Rigour of analysis	☐	☐	☐
Subject coverage	☐	☐	☐
Up-to-date	☐	☐	☐
Readability	☐	☐	☐
Organisation	☐	☐	☐
Presentation	☐	☐	☐

2 Usefulness

In general, how much of the content of the publications is:

	Most	About half	Little
Of technical/substantive value to you?	☐	☐	☐
Relevant to you?	☐	☐	☐
New to you?	☐	☐	☐
Will be used by you?	☐	☐	☐

3 Effectiveness in achieving the objective

The publication was designed to be a guide for carrying out a waste audit with the ultimate objective of waste reduction. In your opinion to what extent will the publication contribute to the achievement of this objective?

(Please tick one box only) fully ☐ adequately ☐ inadequately ☐

Please state reasons for your answer.

Please state how the publication will affect or contribute to your work illustrating your answers with examples.

Please indicate, in order of importance, (first, second, third) the usefulness of the publication to you:

for your own information ______________
as reference material ______________
guidelines for on-the-job application ______________

5 Distribution

Will others read your copy? Yes ☐ No ☐ Unknown ☐

If 'Yes', how many? ______________

Did you receive this publication directly from UNEP? Yes ☐ No ☐

Did you receive this publication directly from UNIDO? Yes ☐ No ☐

If 'No', who forwarded it to you? ______________

6 Features not included

Please indicate any changes in the publication which would have increased its value to you.

____
____
____
____

Please indicate, in order of importance, (first, second, third) which of the three items might have increased the value of the publication to you.

Translation in your own language ______________
Specific regional information ______________
Additional technical information ______________

7 Particulars for statistical analysis

Your name ______________
Professional background ______________
Position/function/occupation ______________
Government agency/organisation/institution ______________

Date ______________

Thank you for completing the questionnaire. Please fax or airmail it to:

The Director
Industry and Environment Office
United Nations Environment Programme
Tour Mirabeau
39-43 Quai Andre Citroen
75739 Paris Cedex 15
France

Fax: 33-1-40 588874

AUDIT AND REDUCTION MANUAL

for

INDUSTRIAL EMISSIONS AND WASTES

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This is the seventh publication in a new Technical Series that regroups the Guidelines, Overviews, Technical Reviews and Workshop Proceedings previously published by UNEP/IEO. The regrouping into a single series will ensure a greater cohesion among future publications, and allows a single document to include the various elements of IEO work that had earlier been presented separately.

As before, the Technical Series aims to meet the needs of a wide range of government officials, industry managers and environment protection associations, by providing information on the issues and methods of environmental management relevant to various industrial sections.

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FOREWORD

Sustainable development will only become a reality if we adopt methods of production that generate less waste and fewer emissions than traditional industrial processes. Sometimes the change involves the adoption of new, cleaner technologies of production. Even without new technologies however, improvements in operation can often dramatically reduce the level of release. A reduced level of emissions and wastes frequently means savings in costs of production, as less valuable raw material is squandered.

Accurate information about the origins and sources of environmental releases is a prerequisite for effective reduction of industrial emissions and wastes. Once the sources are identified, the most cost-effective options for avoiding, reducing and recovering wastes can be evaluated.

In order to assist in the diagnosis of emission and waste sources UNEP/IEO and UNIDO have joined forces to produce this audit manual. The manual is based on an earlier publication by the Ontario Waste Management Corporation in 1987. In order to adapt it to as wide an international audience as possible, UNEP/IEO and UNIDO obtained the advice of an international group of experts who met in Paris for the two days of 1, 2 August 1991.

The manual is a practical working document intended for use within industry. It can be used by:

- factory personnel at all levels interested in upgrading their own processes;
- consultants reporting to an industrial client;
- government personnel reviewing existing factory operations.

Depending on the outcome of the audit procedure, information on reduction options can come from a number of technical sources. In particular the International Cleaner Production Information Clearinghouse (ICPIC), established by UNEP/IEO under its Cleaner Production Programme with the support of the US EPA, allows rapid worldwide access to information on technologies, programmes and experts in a number of key industry sectors. UNEP/IEO and UNIDO are also able to provide direct advice and follow-up technical assistance in many cases. Further information about these programmes can be found in the appendices of this manual.

It is hoped that decision-makers in industry and government will find in this document the elements to develop waste audits as one of the new management tools that lead to cleaner industrial production becoming a reality in the future.

CHAPTER 1

INTRODUCTION TO WASTE AUDITING

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CHAPTER 1: INTRODUCTION TO WASTE AUDITING

In the context of this manual, waste is taken as a broad term to include any non-product discharge from a process. Thus, it describes discharges in the gaseous, liquid and solid phases.

In the past, waste management has concentrated on end-of-pipe waste treatment; designing waste treatment plants and installing pollution control equipment to prevent contamination of the environment.

A different philosophy has emerged in recent times, that of waste prevention and reduction. Now we ask how can we prevent the generation of this waste? How can we reduce this waste? Can we reuse or recover this waste?

This progressive shift from waste treatment towards waste prevention has the following benefits:

- waste quantities are reduced;
- raw material consumption and therefore costs are reduced;
- waste treatment costs are reduced;
- the pollution potential is reduced;
- working conditions are improved;
- process efficiency is improved.

In order to prevent or reduce waste generation you need to examine your process to identify the origins of wastes, the operational problems associated with your process and those areas where improvements can be made.

A waste audit is the first step in an on-going programme designed to achieve maximum resource optimisation and improved process performance. It is a common sense approach to problem identification and problem solving.

A waste audit enables you to take a comprehensive look at your site or process to facilitate your understanding of material flows and to focus your attention on areas where waste reduction and therefore cost saving is possible.

Undertaking a waste audit involves observing, measuring, recording data and collecting and analysing waste samples. To be effective it must be done methodically and thoroughly together will full management and operator support.

A good waste audit:

- defines sources, quantities and types of waste being generated;
- collates information on unit operations, raw materials, products, water usage and wastes;

- highlights process inefficiencies and areas of poor management;
- helps set targets for waste reduction;
- permits the development of cost-effective waste management strategies;
- raises awareness in the workforce regarding the benefits of waste reduction;
- increases your knowledge of the process;
- helps to improve process efficiency.

The waste audit procedure can be applied on various scales. A waste audit of a region can indicate problem industries. At the plant level, wastes can be traced to particular processes allowing allocation of treatment charges where necessary; and at the process level the exact origins of wastes can be identified enabling waste reduction measures to be established.

This manual is designed to be used by staff at all levels; technical as well as non-technical. It is a practical guide to help you understand your processes.

How To Use the Manual

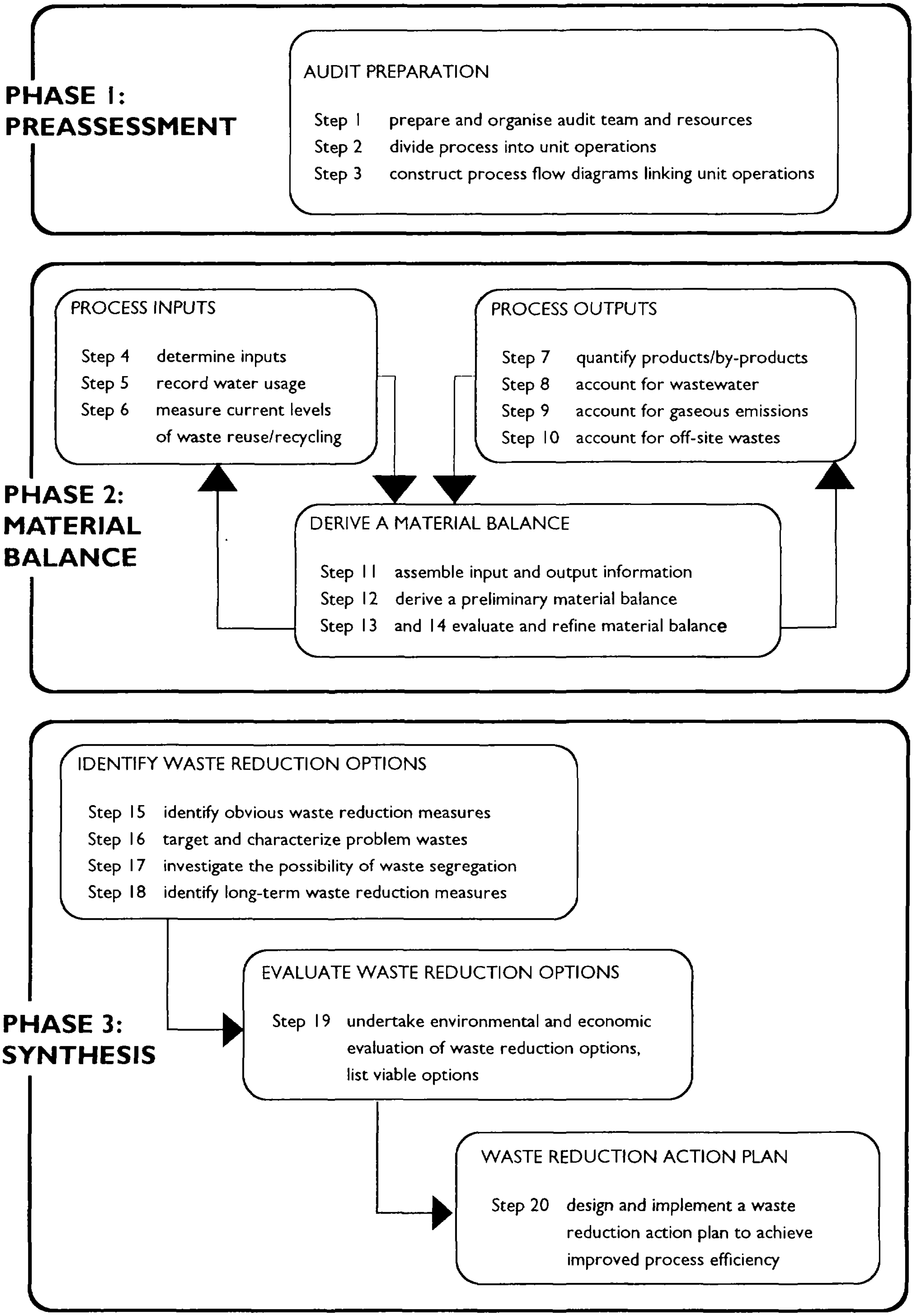
A waste audit approach leading to the implementation of a waste reduction action plan is illustrated in the form of a flow diagram overleaf (see also the pull-out Quick Reference Audit Guide at the back of the manual).

To undertake this approach use the Quick Reference Audit Guide and refer to the Audit Procedure in Chapter 2 for instructions for each step.

As a starting point reproduce tables along the lines of Tables 1 - 9 to give you a basis for your data collection and organisation.

Three case studies are included to illustrate the wide application of this waste audit and reduction approach.

QUICK REFERENCE AUDIT GUIDE



PHASE 1: PREASSESSMENT

AUDIT PREPARATION

Step 1 prepare and organise audit team and resources
Step 2 divide process into unit operations
Step 3 construct process flow diagrams linking unit operations

PHASE 2: MATERIAL BALANCE

PROCESS INPUTS

Step 4 determine inputs
Step 5 record water usage
Step 6 measure current levels of waste reuse/recycling

PROCESS OUTPUTS

Step 7 quantify products/by-products
Step 8 account for wastewater
Step 9 account for gaseous emissions
Step 10 account for off-site wastes

DERIVE A MATERIAL BALANCE

Step 11 assemble input and output information
Step 12 derive a preliminary material balance
Step 13 and 14 evaluate and refine material balance

PHASE 3: SYNTHESIS

IDENTIFY WASTE REDUCTION OPTIONS

Step 15 identify obvious waste reduction measures
Step 16 target and characterize problem wastes
Step 17 investigate the possibility of waste segregation
Step 18 identify long-term waste reduction measures

EVALUATE WASTE REDUCTION OPTIONS

Step 19 undertake environmental and economic evaluation of waste reduction options, list viable options

WASTE REDUCTION ACTION PLAN

Step 20 design and implement a waste reduction action plan to achieve improved process efficiency

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CHAPTER 2

THE AUDIT PROCEDURE

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CHAPTER 2: THE AUDIT PROCEDURE

This Chapter describes a step-by-step approach for carrying out a waste audit. It is designed to be generic to apply to a broad spectrum of industry. The approach comprises three phases; a preassessment phase for audit preparation; a data collection phase to derive a material balance; and a synthesis phase where the findings from the material balance are translated into a waste reduction action plan.

It is possible that not all of the audit steps will be relevant to every situation. Similarly, in some situations additional steps may be required. However, the following approach should form the basis of your investigations.

Use the Quick Reference Audit Guide at the back of the manual in conjunction with the following explanatory notes to carry out your audit.

PHASE 1: PREASSESSMENT

Step 1: *Audit Focus and Preparation*

A thorough preparation for a waste audit is a prerequisite for an efficient and cost-effective study. Of particular importance is to gain support for the audit from top-level management, and for the implementation of results; otherwise there will be no real action.

The waste audit team should be identified. The number of people required on an audit team will depend on the size and complexity of the processes to be investigated. A waste audit of a small factory may be undertaken by one person with contributions from the employees. A more complicated process may require at least 3 or 4 people: technical staff, production employees and an environmental specialist. Involving personnel from each stage of the manufacturing operations will increase employee awareness of waste reduction and promote input and support for the programme.

A waste audit will probably require external resources, such as laboratory analytical facilities and possibly equipment for sampling and flow measurements. You should attempt to identify external resource requirements at the outset of the project.

Analytical services and equipment may not be available to a small factory. If this is the case, investigate the possibility of forming a waste auditing association with other factories or industries; under this umbrella the external resource costs can be shared.

It is important to select the focus of your audit at the preparation stage. You may wish the waste audit to cover a complete process or you may want to concentrate on a selection of unit operations within a process. The focus will depend on the objectives of the waste audit. You may wish to look at waste minimisation as a whole or you may wish to concentrate on particular wastes, for example:

- raw material losses;
- wastes that cause processing problems;
- wastes considered to be hazardous or for which regulations exist;
- wastes for which disposal costs are high.

A good starting point for designing a waste audit is to determine the major problems/wastes associated with your particular process or industrial sector. The Rapid Assessment of Sources of Air, Water and Land Pollution published by the World Health Organisation (WHO, 1982) is a useful reference for identifying the type and typical quantities of wastes associated with particular industries. For example, Table 1 describes the likely waste quantities for the tanning industry.

Table 1: Manufacture of Leather and Products of Leather, Leather Substitutes and Fur, except Footwear and Wearing Apparel

		Pulp hair/ chrome tanning/ finishing	Save hair/ chrome tanning/ finishing	Save hair/ vegetable tanning finishing
Waste volume	(m^3/t of hides)	53	63	50
BOD_5	(kg/t of hides)	95	69	67
COD	(kg/t of hides)	260	140	250
Suspended Solids	(kg/t of hides)	140	145	135
Total Solids	(kg/t of hides)	525	480	345
Total Chromium	(kg/t of hides)	4.3	4.9	0.2
Sulphides	(kg/t of hides)	8.5	0.8	1.2
Oil and Grease	(kg/t of hides)	19	43	33
Total N	(kg/t of hides)	17	13	9.2
pH		1-13	4-12.6	2-13

(Source: WHO, 1982)

All existing documentation and information regarding the process, the plant or the regional industrial sector should be collated and reviewed as a preliminary step. Regional or plant surveys may have been undertaken; these could yield useful information indicating the areas for concern and will also show gaps where no data are available. The following prompts give some guidelines on useful documentation.

- Is a site plan available?
- Are any process flow diagrams available?
- Have the process wastes ever been monitored - do you have access to the records?
- Do you have a map of the surrounding area indicating watercourses, hydrology and human settlements?
- Are there any other factories/plants in the area which may have similar processes?

Other general data which can be collated quickly and which are useful orientation material are described below.

- What are the obvious wastes associated with your process?
- Where is water used in greatest volume?
- Do you use chemicals that have special instructions for their use and handling?
- Do you have waste treatment and disposal costs - what are they?
- Where are your discharge points for liquid, solid and gaseous emissions?

The plant employees should be informed that the audit will be taking place, and they should be encouraged to take part. The support of the staff is imperative for this type of interactive study. It is important to undertake the audit during normal working hours so that the employees and operators can be consulted, the equipment can be observed in operation and, most importantly, wastes can be quantified.

Step 2: Listing Unit Operations

Your process will comprise a number of unit operations. A unit operation may be defined as an area of the process or a piece of equipment where materials are input, a function occurs and materials are output, possibly in a different form, state or composition. For example, a process may comprise the following unit operations: raw material storage, surface treatment of components, rinsing, painting, drying, product storage and waste treatment.

An initial site survey should include a walk around the entire manufacturing plant in order to gain a sound understanding of all the processing operations and their interrelationships. This will help the audit team decide how to describe a process in terms of unit operations. During this initial overview, it is useful to record visual observations and discussions and to make sketches of process layout, drainage systems, vents, plumbing and other material transfer areas. These help to ensure that important factors are not overlooked.

The audit team should consult the production staff regarding normal operating conditions. The production or plant staff are likely to know about waste discharge points, unplanned waste generating operations such as spills and washouts, and can give the auditors a good indication of actual operating procedures. Investigations may reveal that night-shift procedures are different from day-shift procedures; also, a plant tour may disclose that actual material handling practices are different from those set out in written procedures.

A long-standing employee could give some insight into recurring process problems. In the absence of any historical monitoring this information can be very useful. Such employee participation must however be a non-blaming process; otherwise it will not be as useful as it could be.

During the initial survey, note imminent problems that need to be addressed before the audit is complete.

The waste audit team needs to understand the function and process variables associated with each unit operation. Similarly, all the available information on the unit operations and the process in general should be collated, possibly in separate files. It is useful to tabulate this information, as shown in Table 2.

Table 2: Identification of Unit Operations

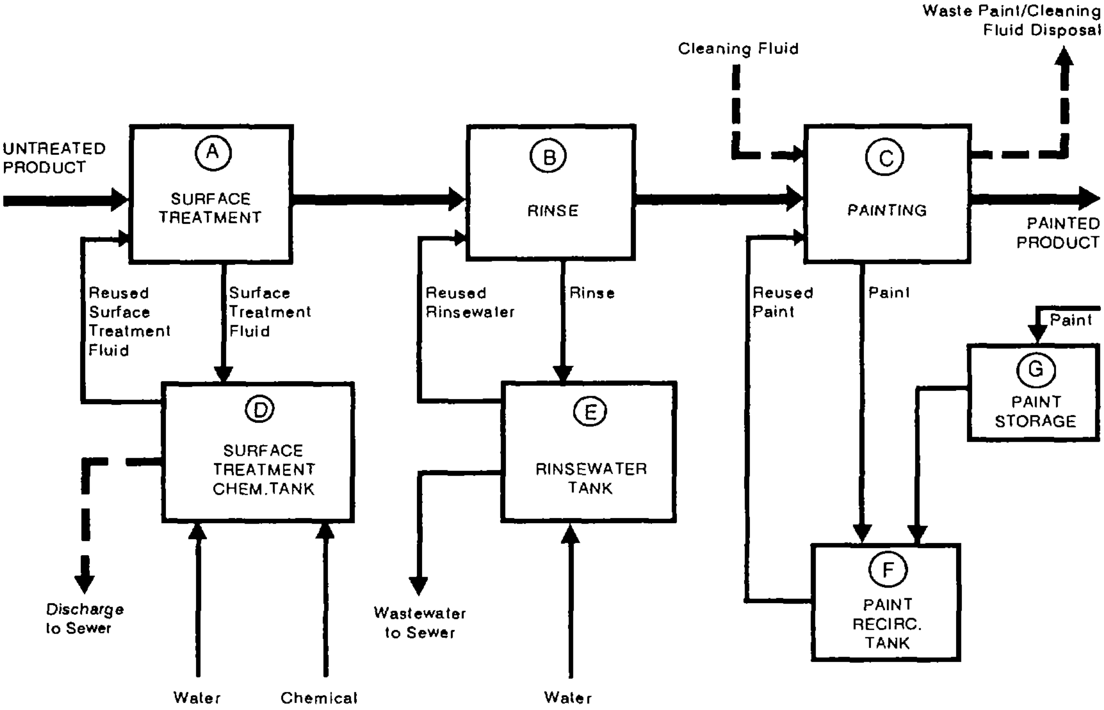
Unit Operation	Function	File Number
(A) Surface Treatment	Surface treatment of metal products 10 m^3 spray chamber, 6 jets, 100 l/min pump	1
(B) Rinsing	Washing metal products before painting	2

Identification of materials handling operations (manual, automatic, bulk, drums etc) covering raw materials, transfer practices and products is also an important aspect which could usefully be included in the above tabulation as a prelude to development of a materials balance (Phase 2).

Step 3: Constructing Process Flow Diagrams

By connecting the individual unit operations in the form of a block diagram you can prepare a process flow diagram. Intermittent operations such as cleaning, make-up or tank dumping may be distinguished by using broken lines to link the boxes. Figure 1 is an example of a simplified process flow diagram for a metal finishing process.

Figure 1 : A Process Flow Diagram for a Metal Finishing Process



For complex processes prepare a general flow diagram illustrating the main process areas and, on separate sheets of paper, prepare detailed flow diagrams for each main processing area. The printed circuit board manufacture case study in Chapter 3 shows how this can be done (Case Study 3).

Now you must decide on the level of detail that you require to achieve your objectives.

It is important to realise that the less detailed or larger scale the audit becomes, the more information is likely to be lost or masked by oversimplification. Establishing the correct level of detail and homing in on specific areas is very important at an early stage.

Pay particular attention to correcting any obvious waste arisings which can be reduced or prevented easily, before proceeding to the development of a material balance (Phase 2). By making simple changes at this early stage, the resultant benefits will help enlist the participation and stimulate the enthusiasm of employees for the total waste audit/reduction programme.

Phase 1 Summary

At the end of the waste audit preassessment stage the audit team should be organised and be aware of the objectives of the waste audit.

Plant personnel should have been informed of the audit purpose in order to maximise co-operation between all parties concerned.

Any required financial resources should have been secured and external facilities checked out for availability and capability.

The team should be aware of the overall history and local surroundings of the plant.

The scope and focus of the waste audit should have been established, and a rough timetable worked out to fit in with production patterns.

The audit team should be familiar with the layout of the processes within the plant and should have listed the unit operations associated with each process. Sources of wastes and their causes should also have been identified.

It should be possible to draw process flow diagrams highlighting those areas to be covered in the waste audit.

Any very obvious waste saving measures which can be introduced easily should be implemented immediately.

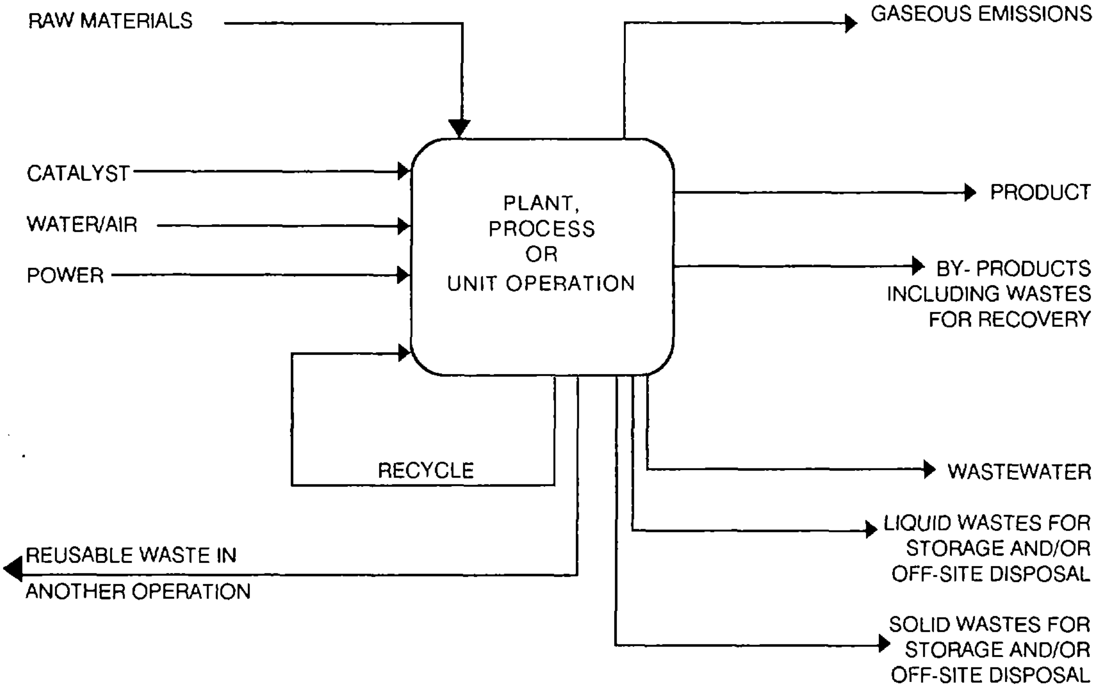
The findings of the Phase 1 investigations could usefully be presented to the management in the form of a brief preassessment report in order to reaffirm their commitment into the next phase.

PHASE 2: MATERIAL BALANCE: PROCESS INPUTS AND OUTPUTS

A material balance may be defined as a precise account of the inputs and outputs of an operation.

This phase describes a procedure for the collection and arrangement of input and output data. The procedure can be applied to derive the material balance of a plant, a process or a unit operation. Figure 2 is an example of a set of components that need to be quantified to derive a material balance. Note that infrequent outputs (eg the occasional dumping of an electroplating bath) may be as significant as continous daily discharges.

Figure 2: Typical Components of a Material Balance



The manual uses unit operations to illustrate the waste audit procedure.

Although the procedure is laid down in a step-by-step fashion it should be emphasised that the output information can be collected at the same time or before the input data; it is up to you to organise your time efficiently.

Step 4: Determining Inputs

Inputs to a process or a unit operation may include raw materials, chemicals, water, air and power (Figure 2). The inputs to the process and to each unit operation need to be quantified.

As a first step towards quantifying raw material usage, examine purchasing records; this rapidly gives you an idea of the sort of quantities involved.

In many situations the unit operations where raw material losses are greatest are raw material storage and transfer. You should look at these operations in conjunction with the purchasing records to determine the actual net input to the process.

Make notes regarding raw material storage and handling practices. Consider evaporation losses, spillages, leaks from underground storage tanks, vapour losses through storage tank pressure-relief vents and contamination of raw materials. Often these can be rectified very simply.

Record raw material purchases and storage and handling losses in a table in order to derive the net input to the process (Table 3).

Table 3: Raw Material Storage and Handling Losses

Raw Material	Qty of Raw Material	Qty of Raw Material Purchased (per annum)	Type of Storage Used in Production (per annum)	Average Length of Storage	Estimated Annual Raw Material Losses
Raw Material 1 (Surface treatment chemical)	100 kg	95 kg	Closed	1 month	5 kg
Raw Material 2					
Raw Material 3					

Once the net input of raw materials to your process has been determined you should proceed with quantifying the raw material input to each unit operation.

If accurate information about raw material consumption rates for individual unit operations is not available then you will need to take measurements to determine average figures. Measurements should be taken for an appropriate length of time. For example, if a batch takes one week to run, then measurements should be taken over a period of at least three weeks; these figures can be extrapolated for monthly or annual figures.

Some quantification is possible by observation and some simple accounting procedures.

- For solid raw materials, ask the warehouse operator how many sacks are stored at the beginning of the week or prior to a unit operation; then ask him again at the end of the week or unit operation. Weigh a selection of sacks to check compliance with specifications.

- For liquid raw materials such as water or solvents, check storage tank capacities and ask operators when a tank was last filled. Tank volumes can be estimated from the tank diameter and tank depth. Monitor the tank levels and the number of tankers arriving on site.

While investigating the inputs, talking to staff and observing the unit operations in action, the waste audit team should be thinking about how to improve the efficiency of unit operations. Consider the following questions.

- Is the size of the raw material inventory appropriate to ensure that material-handling losses can be minimised?
- Transfer distances between storage and process or between unit operations - could these be reduced to minimise potential wastage?
- Do the same tanks store different raw materials depending on the batch product? Is there a risk of cross-contamination?
- Are sacks of materials fully emptied or is some material wasted?
- Are viscous raw materials used on site - is it possible to reduce residual wastage in drums?
- Is the raw material storage area secure? Could a building be locked at night, or could an area be fenced off to restrict access?
- How could the raw materials be protected from direct sunlight or from heavy downpours?
- Is dust from stockpiles a problem?
- Is the equipment used to pump or transfer materials working efficiently? Is it maintained regularly?
- Could spillages be avoided?
- Is the process adequately manned?
- How could the input of raw materials be monitored?
- Are there any obvious equipment items in need of repair?
- Are pipelines self-draining?
- Is vacuum pump water recirculated?

The energy input to a unit operation should be considered at this stage; however, energy use deserves a full audit in its own right. For waste auditing purposes make a note of the energy source and whether waste reduction could reduce energy costs. If energy usage is a particularly prominent factor maybe you should recommend that an energy audit be undertaken.

Input data should be recorded on your process flow diagram or in tabular form as shown in Table 4.

Water is frequently used in the production process, for cooling, gas scrubbing, washouts, product rinsing and steam cleaning. This water usage needs to be quantified as an input.

Some unit operations may receive recycled wastes from other unit operations. These also represent an input.

Steps 5 and 6 describe how these two factors should be included in your waste audit.

Table 4: Input Data

Unit Operation	Raw Material 1 (m^3/annum)	Raw Material 2 (tonnes/annum)	Water (m^3/annum)	Energy Source
Surface Treatment (A)				
Rinse (B)				
Painting (C)				
Total Raw Material Used in All Unit Operations				

Step 5: Recording Water Usage

The use of water, other than for a process reaction, is a factor that should be covered in all waste audits. The use of water to wash, rinse and cool is often overlooked, although it represents an area where waste reductions can frequently be achieved simply and cheaply.

Consider these general points about the site water supply before assessing the water usage for individual units.

- Identify water sources? Is water abstracted directly from a borehole, river or reservoir; is water stored on site in tanks or in a lagoon?
- What is the storage capacity for water on site?
- How is water transferred - by pump, by gravity, manually?
- Is rainfall a significant factor on site?

For each unit operation consider the following.

- What is water used for in each operation? Cooling, gas scrubbing, washing, product rinsing, dampening stockpiles, general maintenance, safety quench etc.
- How often does each action take place?
- How much water is used for each action?

It is unlikely that the answers to these questions will be readily available - you will need to undertake a monitoring programme to assess the use of water in each unit operation. Again, the measurements must cover a sufficient period of time to ensure that all actions are monitored. Pay particular attention to intermittent actions such as steam cleaning and tank washouts; water use is often indiscriminate during these operations. Find out when these actions will be undertaken so that detailed measurements can be made.

Record water usage information in a tabular form - ensure that the units used to describe intermittent actions indicate a time period (Table 5).

Table 5: Water Usage

	Cleaning	Steam	Cooling	Other
Unit Operation A				
Unit Operation B				
Unit Operation C				

All measurements in standard units, for example m^3/annum or m^3/day.

Using less water can be a cost-saving exercise. Consider the following points while investigating water use:

- tighter control of water use can reduce the volume of wastewater requiring treatment and result in cost savings - in the extreme, it can sometimes reduce volumes and increase concentrations to the point of providing economic material recovery in place of costly wastewater treatment;
- attention to good house-keeping practices often reduces water usage and, in turn, the amount of wastewater passing to drain;
- the cost of storing wastewater for subsequent reuse may be far less than the treatment and disposal costs;
- counter-current rinsing and rinsewater reuse are highlighted in the case studies as useful tips for reducing water usage.

Step 6: Measuring Current Levels of Waste Reuse/Recycling

Some wastes lend themselves to direct reuse in production and may be transferred from one unit to another (eg reuse of the final rinse in a soft-drink bottle washing plant as the initial rinse); others require some modification before they are suitable for reuse in a process. These reused waste streams should be quantified.

If reused wastes are not properly documented double-counting may occur in the material balance particularly at the process or complete plant level; that is, a waste will be quantified as an output from one process and as an input to another.

The reuse or recycling of wastes can reduce the amount of fresh water and raw materials required for a process. While looking at the inputs to unit operations think about the opportunities for reusing and recycling outputs from other operations.

Steps 4, 5 and 6 Summary

By the end of Step 6 you should have quantified all your process inputs.

The net input of raw materials and water to the process should be established having taken into account any losses incurred at the storage and transfer stages.

Any reused or recycled inputs should be documented.

All notes regarding raw material handling, process layout, water losses, obvious areas where problems exist should all be documented for consideration in Phase 3.

Step 7: Quantifying Process Outputs

To calculate the second half of the material balance the outputs from unit operations and the process as a whole need to be quantified.

Outputs include primary product, by-products, wastewater, gaseous wastes (emissions to atmosphere), liquid and solid wastes which need to be stored and/or sent off-site for disposal and reusable or recyclable wastes (Figure 2). You may find that a table along the lines of Table 6 will help you organise the output information. It is important to identify units of measurement.

Table 6: Process Outputs

Unit Operation	Product	By-Product	Waste to be Reused	Wastewater	Gaseous Emissions	Stored Wastes	Liquid/ Solid Wastes Off-Site
Unit Operation A							
Unit Operation B							
Unit Operation C							
Total							

The assessment of the amount of primary product or useful product is a key factor in process or unit operation efficiency.

If the product is sent off-site for sale, then the amount produced is likely to be documented in company records. However, if the product is an intermediate to be input to another process or unit operation then the output may not be so easy to quantify. Production rates will have to be measured over a period of time. Similarly, the quantification of any by-products may require measurement.

Hints on how to approach the quantification of wastewater, gaseous emissions and wastes for off-site removal are described in Steps 8, 9 and 10.

Step 8: Accounting for Wastewater

On many sites significant quantities of both clean and contaminated water are discharged to sewer or to a watercourse. In many cases, this wastewater has environmental implications and incurs treatment costs. In addition, wastewater may wash out valuable unused raw materials from the process areas.

Therefore, it is extremely important to know how much wastewater is going down the drain and what the wastewater contains. The wastewater flows, from each unit operation as well as from the process as a whole, need to be quantified, sampled and analysed.

Here are some suggestions on how to carry out a thorough survey of wastewater flows on your site.

- Identify the effluent discharge points; that is, where does wastewater leave the site? Wastewater may go to an effluent treatment plant or directly to a public sewer or watercourse. One factor that is often overlooked is the use of several discharge points - it is important to identify the location, type and size of all discharge flows.

- Identify where flows from different unit operations or process areas contribute to the overall flow. In this way, it is possible to piece together the drainage network for your site. This can lead to startling discoveries of what goes where!

- Once the drainage system is understood it is possible to design an appropriate sampling and flow measurement programme to monitor the wastewater flows and strengths from each unit operation.

- Plan your monitoring programme thoroughly and try to take samples over a range of operating conditions such as full production, start up, shut down and washing out. In the case of combined stormwater and wastewater drainage systems, ensure that sampling and flow measurements are carried out in dry weather.

- For small or batch wastewater flows it may be physically possible to collect all the flow for measurement using a pail and wristwatch. Larger or continuous wastewater flows can be assessed using flow measurement techniques. A method using a simple triangular notch (V-notch) or rectangular weir arrangement is outlined in Appendix 1.

The sum of the wastewater generated from each unit operation should be approximately the same as that input to the process. As indicated in Step 6, note that double-counting can occur where wastewater is reused. This emphasises the importance of understanding your unit operations and their interrelationships.

The wastewater should be analysed to determine the concentration of contaminants.

- You should include wastewater analyses such as pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), suspended solids and grease and oil.

- Other parameters that should be measured depend on the raw material inputs. For example, an electroplating process is likely to use nickel and chromium. The metal concentrations of the wastewater should be measured to ensure that the concentrations do not exceed discharge regulations, but also to ensure that raw materials are not being lost to drain. Any toxic substances used in the process should be measured.

- Take samples for laboratory analysis. Composite samples should be taken for continuously-running wastewater. For example, a small volume, 100 ml, may be collected every hour through a production period of ten hours to gain a 1 litre composite sample. The composite sample represents the average wastewater conditions over that time. Where significant flow variations occur during the discharge period, consideration should be given to varying the size of individual samples in proportion to flow rate in order to ensure that a representative composite sample is obtained. For batch tanks and periodic draindown, a single spot sample may be adequate (check for variations between batches before deciding on the appropriate sampling method).

Wastewater flows and concentrations should be tabulated (Table 7).

Table 7: Wastewater Flows

	Discharge to									
	Public Sewer		Stormwater Drain		Reuse		Storage		Total Waste-water Output	
Source of Wastewater	Flow	Conc'n	Flow	Conc'n	Flow	Conc'n	Flow	Conc'n	Flow	Conc'n
Unit Operation A										
Unit Operation B										
Unit Operation C										

Flows in m^3/d; concentrations of contaminants of concern in mg/l

Step 9: Accounting for Gaseous Emissions

To arrive at an accurate material balance some quantification of gaseous emissions associated with your process is necessary.

It is important to consider the actual and potential gaseous emissions associated with each unit operation from raw material storage through to product storage.

Gaseous emissions are not always obvious and can be difficult to measure. Appendix 1 outlines a possible method of measuring gaseous emissions through vents using a bag orifice. Where quantification is impossible, estimations can be made using stoichiometric information. The following example illustrates the use of indirect estimation.

Consider coal burning in a boiler house. The auditor may not be able to measure the mass of sulphur dioxide leaving the boiler stack due to problems of access and lack of suitable sampling ports on the stack. The only information available is that the coal is of soft quality containing 3% sulphur by weight and, on average, 1000 kg of coal is burnt each day.

First calculate the amount of sulphur burned:

1000 kg coal x 0.03 kg sulphur/kg coal = 30 kg sulphur/day.

The combustion reaction is approximately:

$S + O_2 = SO_2$

The number of moles of sulphur burned equals the number of moles of sulphur dioxide produced. The atomic weight of sulphur is 32 and the molecular weight of sulphur dioxide is 64. Therefore:

kg-moles S = 30 kg/32 kg per kg-mole = kg-mole of SO_2 formed

kg SO_2 formed = (64 kg SO_2/kg-mole) x kg-moles SO_2 = 64 x 30/32 = 60 kg

Thus, it may be estimated that an emission of 60 kg sulphur dioxide will take place each day from the boiler stack.

Record the quantified emission data in tabular form and indicate which figures are estimates and which are actual measurements.

The waste auditor should consider qualitative characteristics at the same time as quantifying gaseous wastes.

- Are odours associated with a unit operation?

- Are there certain times when gaseous emissions are more prominent - are they linked to temperature?
- Is any pollution control equipment in place?
- Are gaseous emissions from confined spaces (including fugitive emissions) vented to the outside?
- If gas scrubbing is practised, what is done with the spent scrubber solution? Could it be converted to a useful product?
- Do employees wear protective clothing, such as masks?

Step 10 : Accounting for Off-Site Wastes

Your process may produce wastes which cannot be treated on-site. These need to be transported off-site for treatment and disposal. Wastes of this type are usually non-aqueous liquids, sludges or solids.

Often, wastes for off-site disposal are costly to transport and to treat. Therefore, minimisation of these wastes yields a direct cost benefit.

Measure the quantity and note the composition of any wastes associated with your process which need to be sent for off-site disposal. Record your results in a table (see Table 8).

Table 8: Wastes for Off-site Disposal

	Liquid		Sludge		Solid	
Unit Operation	Qty	Composition	Qty	Composition	Qty	Composition
Unit Operation A						
Unit Operation B						
Unit Operation C						

Quantities in m^3/annum or t/annum

You should ask several questions during the data collection stage.

- Where does the waste originate?
- Could the manufacturing operations be optimised to produce less waste?
- Could alternative raw materials be used which would produce less waste?
- Is there a particular component that renders the whole waste hazardous - could this component be isolated?
- Does the waste contain valuable materials?

Wastes for off-site disposal need to be stored on-site prior to dispatch. Does storage of these wastes cause additional emission problems? For example, are solvent wastes stored in closed tanks? How long are wastes stored on-site? Are stockpiles of solid waste secure or are dust storms a regular occurrence?

Steps 7, 8, 9 and 10 Summary

At the end of Step 10 the waste audit team should have collated all the information required for evaluating a material balance for each unit operation and for a whole process.

All actual and potential wastes should be quantified. Where direct measurement is impossible, estimates based on stoichiometric information should be made.

The data should be arranged in clear tables with standardised units. Throughout the data collection phase the auditors should make notes regarding actions, procedures and operations that could be improved.

Step 11: Assembling Input and Output Information for Unit Operations

One of the basic laws applied to chemical engineering is that of the material balance which states that the total of what goes into a process must equal the total of what comes out. Prepare a material balance at a scale appropriate for the level of detail required in your study. For example, you may require a material balance for each unit operation or one for a whole process may be sufficient. In this manual the preparation of a material balance for the unit operation scale is illustrated.

Preparing a material balance is designed to gain a better understanding of the inputs and outputs, especially waste, of a unit operation such that areas where information is inaccurate or lacking can be identified. Imbalances require further investigation. Do not expect a perfect balance - your initial balance should be considered as a rough assessment to be refined and improved.

Assemble the input and output information for each unit operation and then decide whether all the inputs and outputs need to be included in the material balance. For example, this is not essential where the cooling water input to a unit operation equals the cooling water output.

Standardise units of measurement (litres, tonnes or kilogrammes) on a per day, per year or per batch basis.

Summarise the measured values in standard units by reference to your process flow diagram. It may have been necessary to modify your process flow diagram following the in-depth study of the plant.

Step 12: Deriving a Preliminary Material Balance for Unit Operations

Now it is possible to complete a preliminary material balance. For each unit operation utilise the data developed in Steps 1 - 10 and construct your material balance. Display your information clearly. Figure 3 is one way of presenting the material balance information.

Figure 3: Preliminary Material Balance for Each Unit Operation

Inputs (amounts in standard units per annum)

Raw Material 1
Raw Material 2
Raw Material 3
Waste Reuse
Water
Total

↓

Unit Process A

↓

Outputs (amounts in standard units per annum)

Product
By-product
Raw Material Storage and Handling Losses
Reused Wastes
Wastewater
Gaseous Emissions
Stored Wastes
Hazardous Liquid Waste Transported Off-Site
Hazardous Solid Waste Transported Off-Site
Non-Hazardous Liquid Waste Transported Off-Site
Non-Hazardous Solid Waste Transported Off-Site
Total

Note that a material balance will often need to be carried out in weight units since volumes are not always conserved. Where volume measurements have to be converted to weight units, take account of the density of the liquid, gas or solid concerned.

Once the material balance for each unit operation has been completed for raw material inputs and waste outputs it might be worthwhile repeating the procedure with respect to each contaminant of concern. It is highly desirable to carry out a water balance for all water inputs and outputs to and from unit operations because water imbalances may indicate serious underlying process problems such as leaks or spills. The individual material balances may be summed to give a balance for the whole process, a production area or factory.

Step 13: Evaluating the Material Balance

The individual and sum totals making up the material balance should be reviewed to determine information gaps and inaccuracies. If you do have a significant material imbalance then further investigation is needed. For example, if outputs are less than inputs look for potential losses or waste discharges (such as evaporation). Outputs may appear to be greater than inputs if large measurement or estimating errors are made or some inputs have been overlooked.

At this stage you should take time to re-examine the unit operations to attempt to identify where unnoticed losses may be occurring. It may be necessary to repeat some data collection activities.

Remember that you need to be thorough and consistent to obtain a satisfactory material balance. The material balance not only reflects the adequacy of your data collection, but by its very nature, ensures that you have a sound understanding of the processes involved.

Step 14: Refining the Material Balance

Now you can reconsider the material balance equation by adding those additional factors identified in the previous step. If necessary, estimates of unaccountable losses will have to be calculated.

Note that, in the case of relatively simple manufacturing plants, preparation of a preliminary material balance and its refinement (Steps 13 and 14) can usefully be combined. For more complex waste audits however, two separate steps are likely to be more appropriate.

Remember, the inputs should ideally equal the outputs but in practice this will rarely be the case and some judgement will be required to determine what level of accuracy is acceptable.

In the case of high-strength or hazardous wastes, accurate measurements are needed to design waste reduction options.

It is possible that the material balance for a number of unit operations will need to be repeated. Again, continue to review, refine and, where necessary, expand your database. The compilation of accurate and comprehensive data is essential for a successful waste audit and subsequent waste reduction action plan. You cannot reduce what you do not know is there.

Steps 11, 12, 13 and 14 Summary

By the end of Step 14, you should have assembled information covering process inputs and process outputs. These data should be organised and presented clearly in the form of material balances for each unit operation.

These data form the basis for the development of an action plan for waste minimisation.

PHASE 3: SYNTHESIS

Phases 1 and 2 have covered planning and undertaking a waste audit, resulting in the preparation of a material balance for each unit operation.

Phase 3 represents the interpretation of the material balance to identify process areas or components of concern.

The material balance focuses the attention of the auditor. The arrangement of the input and output data in the form of a material balance facilitates your understanding of how materials flow through a production process.

To interpret a material balance it is necessary to have an understanding of normal operating performance. How can you assess whether a unit operation is working efficiently if you do not know what is normal? A member of your team must have a good working knowledge of the process. This knowledge can be supported by texts such as the Rapid Assessment of Sources of Air, Land and Water Pollution (WHO, 1982).

To a trained eye the material balance will indicate areas for concern and help to prioritise problem wastes.

You should use the material balance to identify the major sources of waste, to look for deviations from the norm in terms of waste production, to identify areas of unexplained losses and to pinpoint operations which contribute to flows that exceed national or site discharge regulations. Process efficiency is synonymous with waste minimisation.

Different waste reduction measures require varying degrees of effort, time and financial resources. They can be categorised as two groups.

- Obvious waste reduction measures, including improvements in management techniques and house-keeping procedures that can be implemented cheaply and quickly.

- Long-term reduction measures involving process modifications or process substitutions to eliminate problem wastes.

Increased reuse/recycling to reduce waste falls between the immediate and the more substantial waste reduction measures.

Steps 15, 16 and 17 describe how to identify waste reduction measures.

Step 15: Examining Obvious Waste Reduction Measures

It may have been possible to implement very obvious waste reduction measures already, before embarking on obtaining a material balance (ref Step 3). Now consider the material balance information in conjunction with visual observations made during the whole of the data collection period in order to pinpoint areas or operations where simple adjustments in procedure could greatly improve the efficiency of the process by reducing unnecessary losses.

Use the information gathered for each unit operation to develop better operating practices for all units.

Significant waste reductions can often be achieved by improved operation, better handling and generally taking more care. The following list of waste reduction hints can be implemented immediately with no or only small extra costs.

Specifying and Ordering Materials

- Do not over-order materials especially if the raw materials or components can spoil or are difficult to store.
- Try to purchase raw materials in a form which is easy to handle, for example, pellets instead of powders.
- It is often more efficient and certainly cheaper to buy in bulk.

Receiving Materials

- Demand quality control from suppliers by refusing damaged, leaking or unlabelled containers. Undertake a visual inspection of all materials coming on to the site.
- Check that a sack weighs what it should weigh and that the volume ordered is the volume supplied.
- Check that composition and quality are correct.

Material Storage

- Install high-level control on bulk tanks to avoid overflows.
- Bund tanks to contain spillages.
- Use tanks that can be pitched and elevated, with rounded edges for ease of draining and rinsing.
- Dedicated tanks, receiving only one type of material, do not need to be washed out as often as tanks receiving a range of materials.
- Make sure that drums are stored in a stable arrangement to avoid damaging drums while in storage.
- Implement a tank checking procedure - dip tanks regularly and document to avoid discharging a material into the wrong tank.
- Evaporation losses are reduced by using covered or closed tanks.

Material and Water Transfer and Handling

- Minimise the number of times materials are moved on site.
- Check transfer lines for spills and leaks.
- Is flexible pipework too long?
- Catch drainings from transfer hoses.
- Plug leaks and fit flow restrictors to reduce excess water consumption.

Process Control

- Feedback on how waste reduction is improving the process motivates the operators - it is vital that the employees are informed of why actions are taken and what it is hoped they will achieve.
- Design a monitoring programme to check the emissions and wastes from each unit operation.
- Regular maintenance of all equipment will help to reduce fugitive process losses.

Cleaning Procedures

- Minimise the amount of water used to wash out and rinse vessels - on many sites indiscriminate water use contributes a large amount to wastewater flows. Ensure that hoses are not left running by fitting self-sealing valves.
- Investigate how washing water can be contained and used again before discharge to drain. The same applies to solvents used to clean; these can often be used more than once.

Tightening up house-keeping procedures can reduce waste considerably. Simple, quick adjustments should be made to your process to achieve a rapid improvement in process efficiency. Where such obvious reduction measures do not however solve the entire waste disposal problem, more detailed consideration of waste reduction options will needed (Steps 16 - 18).

Step 16: Targetting and Characterizing Problem Wastes

Use the material balance for each unit operation to pinpoint the problem areas associated with your process.

The material balance exercise may have brought to light the origin of wastes with high treatment costs or may indicate which wastes are causing process problems in which operations. The material balance should be used to focus your priorities for long-term waste reduction.

At this stage, it may be worthwhile considering the underlying causes as to why wastes are generated and the factors which lead to these; for example, poor technology, lack of maintenance and non-compliance with company procedures.

Additional sampling and characterization of your wastes might be necessary involving more in-depth analysis to ascertain the exact concentrations of contaminants.

List the wastes in order of priority for reduction actions.

Step 17: Segregation

Segregation per se is arguably not properly part of a waste audit's step-by-step sequence, being but one of numerous measures which can lead to waste reduction activities. It is however the most central of such options and is a universal issue which needs to be addressed.

Segregation of wastes can offer enhanced opportunities for recycling and reuse with resultant savings in raw material costs. Concentrated simple wastes are more likely to be of value than dilute or complex wastes.

Mixing wastes can enhance pollution problems. If a highly-concentrated waste is mixed with a large quantity of weak, relatively uncontaminated effluent the result is a larger volume of waste requiring treatment. Isolating the concentrated waste from the weaker waste can reduce treatment costs. The concentrated waste could be recycled/reused or may require physical, chemical and biological treatment to comply with discharge consent levels whereas the weaker effluent could be reused or may only require settlement before discharge.

Therefore, waste segregation can provide more scope for recycling and reuse while at the same time reducing treatment costs.

Review your waste collection and storage facilities to determine if waste segregation is possible. Adjust your list of priority wastes accordingly.

Step 18: Developing Long-Term Waste Reduction Options

Waste problems that cannot be solved by simple procedural adjustments or improvements in house-keeping practices will require more substantial long-term changes.

It is necessary to develop possible prevention options for the waste problems.

Process or production changes which may increase production efficiency and reduce waste generation include:

- changes in the production process - continuous versus batch;
- equipment and installation changes;
- changes in process control - automation;

- changes in process conditions such as retention times, temperatures, agitation, pressure, catalysts;
- use of dispersants in place of organic solvents where appropriate;
- reduction in the quantity or type of raw materials used in production;
- raw material substitution through the use of wastes as raw materials or the use of different raw materials that produce less waste or less hazardous waste;
- process substitution with cleaner technology.

Waste reuse can often be implemented if materials of sufficient purity can be concentrated or purified. Technologies such as reverse osmosis, ultrafiltration, electrodialysis, distillation, electrolysis and ion exchange may enable materials to be reused and reduce or eliminate the need for waste treatment.

Where waste treatment is necessary, a variety of technologies should be considered. These include physical, chemical and biological treatment processes. In some cases the treatment method can also recover valuable materials for reuse. Another industry or factory may be able to use or treat a waste that you cannot treat on-site. It may be worth investigating the possibility of setting up a waste exchange bureau as a structure for sharing waste treatment and reuse facilities. The Resource Section (Chapter 4) cites sources of technical information relating to recovery, reuse, waste treatment and associated technologies.

Consider also the possibilities for product improvements or changes yielding cleaner, more environmentally-friendly products, both for existing products and in the development of new products.

Steps 15, 16, 17 and 18 Summary

At the end of Step 18 you should have identified all the waste reduction options which could be implemented.

Step 19: Environmental and Economic Evaluation of Waste Reduction Options

In order to decide which options should be developed to formulate a waste reduction action plan each option should be considered in terms of environmental and economic benefits.

a) *Envrionmental Evaluation*

It is often taken for granted that reduction of a waste will have environmental benefits. This is generally true; however, there are exceptions to the rule. For example, reducing one waste may give rise to pH imbalances or may produce another which is more difficult to treat, resulting in a net environmental disadvantage.

In many cases, the benefits may be obvious such as the removal of a toxic element from an aqueous effluent by segregating the polluted waste or by changing the process in such a way that the waste is prevented.

In other cases the environmental benefits may be less tangible. Creating a cleaner, healthier workplace will increase production efficiency but this may be difficult to quantify.

For each option a series of questions should be asked.

- Consider the effect of each option on the volume and degree of contamination of process wastes.
- Does a waste reduction option have cross-media effects? For example, does the reduction of a gaseous waste produce a liquid waste?
- Does the option change the toxicity, degradability or treatability of the wastes?
- Does the option use more or less non-renewable resources?
- Does the option use less energy?

b) *Economic Evaluation*
A comparative economic analysis of the waste reduction options and the existing situation should be undertaken. Where benefits or changes cannot be quantified (eg reduction in future liability, worker health and safety costs) some form of qualitative assessment should be made; it may be necessary to consult an expert for advice on how to judge a change.

Economic evaluations of waste reduction options should involve a comparison of operating costs to illustrate where cost savings would be made. For example, a waste reduction measure that reduces the amount of raw material lost to drain during the process results in reduced raw
material costs. Raw material substitution or process changes may reduce the amount of solid waste that has to be transported off-site. Therefore, the transport costs for waste disposal would be reduced.

In many cases, it is appropriate to compare the waste treatment costs under existing conditions with those associated with the waste reduction option.

The size of treatment plant and the treatment processes required may be altered significantly by the implementation of waste reduction options. This should be considered in an economic evaluation.

Calculate the annual operating costs for the existing process including waste treatment and estimate how these would be altered with the introduction of waste reduction options. Tabulate and compare the process and waste treatment operating costs for both the existing and proposed future waste management options. Table 9 shows the typical cost components. In addition, if there are any monetary benefits (eg recycled or reused materials or wastes), then these should be subtracted from the total process or waste treatment costs as appropriate.

Now that you have determined the likely savings in terms of annual process and waste treatment operating costs associated with each option, consider the necessary investment required to implement each option.

Investment can be assessed by looking at the payback period for each option. Payback period is the time taken for a project to recover its financial outlay. A more detailed investment analysis may involve an assessment of the internal rate of return (IRR) and net present value (NPV) of the investment based on discounted cash flows.

Analysis of investment risk allows you to rank options.

Consider the environmental benefits and the savings in process and waste treatment operating costs along with the payback period for an investment, to decide which options are viable.

Table 9: Annual Process and Waste Treatment Operating Costs

Process Operating Costs	Annual Cost
Raw Material 1	
Raw Material 2	
Water	
Energy	
Labour	
Maintenance	
Administration	
Other	
Total	

Waste Treatment Operating Costs	Annual Cost
Raw Material eg Lime	
Raw Material eg Flocculant	
Water	
Energy	
Trade Effluent Discharge Costs	
Transportation	
Off-Site Disposal	
Labour	
Maintenance	
Administration	
Other, eg violation, fires	
Total	

Step 19 Summary

At the end of Step 19 you should be able to list those waste reduction options that are environmentally and economically viable.

Step 20: Developing and Implementing An Action Plan: Reducing Wastes and Increasing Production Efficiency

Consider the immediate reduction measures identified in Step 15 along with the long-term waste reduction measures that have been evaluated in Steps 18 and 19. These measures should form the basis of the waste reduction action plan. Discuss your findings with members of staff and develop a workable action plan.

Prepare the ground for the waste reduction action plan. Its implementation should be preceded by an explanation of the ethos behind undertaking a waste audit: Waste Prevention Makes Sense.

It is necessary to convince those who must work to new procedures that the change in philosophy from end-of-pipe treatment to waste prevention makes sense and serves to improve efficiency.

Use posters around the site to emphasise the importance of waste reduction to minimise production and waste treatment/disposal costs and, where appropriate, for improving the health and safety of company personnel.

Set out the intended action plan within an appropriate schedule. Remember it may take time for the staff to feel comfortable with a new way of thinking. Therefore, it is a good idea to implement waste reduction measures slowly but consistently to allow everyone time to adapt to these changes.

Set up a monitoring programme to run alongside the waste reduction action plan so that actual improvements in process efficiency can be measured. Relay these results back to the workforce as evidence of the benefits of waste reduction. Adopt an internal record-keeping system for maintaining and managing data to support material balances and waste reduction assessments.

It is likely that you will have highlighted significant information gaps or inconsistencies during the waste audit investigations. You should concentrate on these gaps and explore ways of developing the additional data. Is outside help required?

A good way of providing waste reduction incentives is to set up an internal waste charging system, those processes that create wastes in great volume or that are difficult and expensive to handle having to contribute to the treatment costs on a proportional basis. Another method of motivating staff is to offer financial reward for individual waste-saving efforts, drawing on the savings gained from implementing waste reduction measures.

Waste auditing should be a regular event - attempt to develop a specific waste audit approach for your own situation, keeping abreast of technological advances that could lead to waste reduction and the development of 'cleaner' products. Train process employees to undertake material balance exercises.

Training people who work on the process to undertake a waste audit will help to raise awareness in the workforce. Without the support of the operators waste reduction actions will be ineffectual - these are the people who can really make a difference to process performance.

Step 20 Summary

Prepare the ground for the waste reduction action plan, ensuring that support for the audit, and implementation of the results, is gained from senior management. Implement the plan slowly to allow the workforce to adjust.

Monitor process efficiency.

Relay results back to the workforce to show them the direct benefits.

Train personnel to undertake your own waste audit for waste reduction.

CHAPTER 3
CASE STUDIES

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CASE STUDY 1: BEER PRODUCTION

Company A operates a modern brewery in western Europe, producing beer in bottles, kegs and bulk tankers. The essence of beer production is the processing and fermentation of malt and hops in the presence of added sugar. Considerable volumes of wastewater containing high BOD/ COD and suspended solids (SS) concentrations are produced as a result of washing of vessels and associated equipment between production batches.

Company A has been in operation some four years. During this time wastewater flows and pollution loads have increased significantly with production increases, resulting in consent limits for discharge to the public sewer (pH 6-10 and 500 mg/l SS) being exceeded on a regular basis.

The regional water authority recently indicated however that the brewery flows could continue to be accepted into the public sewer without pretreatment other than possibly pH control and flow/ load balancing at some future date, primary settlement and biological treatment being undertaken at an extended local municipal sewage treatment works.

The water authority also informed Company A that a capital cost contribution towards the planned sewage works' extensions would not be necessary and that the normal trade effluent charging system would be applied whereby charges varied according to variations in flow and pollution loads (COD and SS).

The current trade effluent charges amount to US$332,000 per annum and are expected to increase by 10% shortly. After considering the likely implications of the increase in effluent charges, the company decided to appoint a firm of consultants to carry out a waste audit and waste reduction study to investigate the possible ways of minimising waste disposal costs.

The following case study describes the waste audit/waste reduction procedures carried out.

PHASE 1: PREASSESSMENT

Step 1: Audit Focus and Preparation

Two chemists from the consulting firm's staff were allocated to carry out the required investigations, assisted as necessary by one of Company A's brewing technologists.

With the support of senior management, the audit team first organised an in-house seminar. This enabled the study procedures and objectives to be outlined and helped to ensure the full co-operation of production staff.

With the help of the brewery's engineering staff, a V-notch weir was then installed in a manhole where all the various effluents combined so that the flow could be monitored continuously using an available ultrasonic level/flow meter and associated chart recorder.

Since an automatic sampler was not readily available, it was decided that composite samples would be taken daily by combining manually-taken samples in proportion to flow. It was also established that the brewery's laboratory was well-equipped to carry out the required wastewater analyses.

In view of the scale of the brewery operations and the time and budget constraints imposed on the project, it was decided that the study should concentrate on:

- water usage aspects (rather than attempt to obtain a complete materials balance);
- investigate methods of reducing COD and SS loads discharging to drain.

In order to put the brewery operations in perspective from a waste management viewpoint, a preliminary check on wastewater and pollution loads discharged per cubic metre of beer produced was carried out based on past records of water usage and product data together with some limited information on combined wastewater strength.

It was concluded that, in general, the brewery operated with a very low degree of water wastage with most of the useful by-products or wastes already being recycled or recovered for off-site disposal. These aspects had been considered at an early stage in the design of the brewery and had clearly paid dividends in reducing waste volumes and pollution loads discharged. Nevertheless, it was considered that there was still scope for further waste saving measures to be implemented.

The success of the measures already practised can be illustrated as follows:

Table 1: Waste Contributions from Beer Production

	Company A	Typical Brewery (a)	Old Brewery (b)
Wastewater Flow (m^3/m^3 beer)	2	7	-
BOD Load (kg/m^3 beer)	4.1	4.5	7.5

(a) Based on the consulting firm's project experience elsewhere
(b) Based on data published by WHO, 1982

Another factor in favour of Company A is that most of the beer is transported from the brewery in road tankers rather than bottles or kegs, both of which give rise to more waste being produced. This simplifies the brewery operations and makes for more efficient and economical operation in terms of water consumption.

Step 2: Listing Unit Operations

The study team started off the waste audit/waste reduction programme by becoming familiar with all the various production stages. This was done by walking around the plant with the brewery technologist and collecting relevant information from departmental records. It was found that so much data were being collected that a file was opened for each key area within the brewery.

The various unit operations were listed as in Table 2.

Table 2: Major Unit Operations and Brief Functional Description

Unit Operation	Brief Functional Description	File No.
Brewhouse	Processing of malt, hops and sugar to produce 'wort'	1
Fermentation	Fermentation of chilled 'wort'	2
Product Treatment	Centrifugation, filtration, carbonation, colouring and final polishing and pasteurising	3
Dispatch	Bottling, kegging and bulk tanker filling	4

Step 3: Constructing Process Flow Diagrams

A schematic flow diagram was then compiled to illustrate the various unit operations within the brewery (Figure 1).

Once all the unit operations had been identified and described, the audit team proceeded to gather data on water usage, wastewater output and waste recovery.

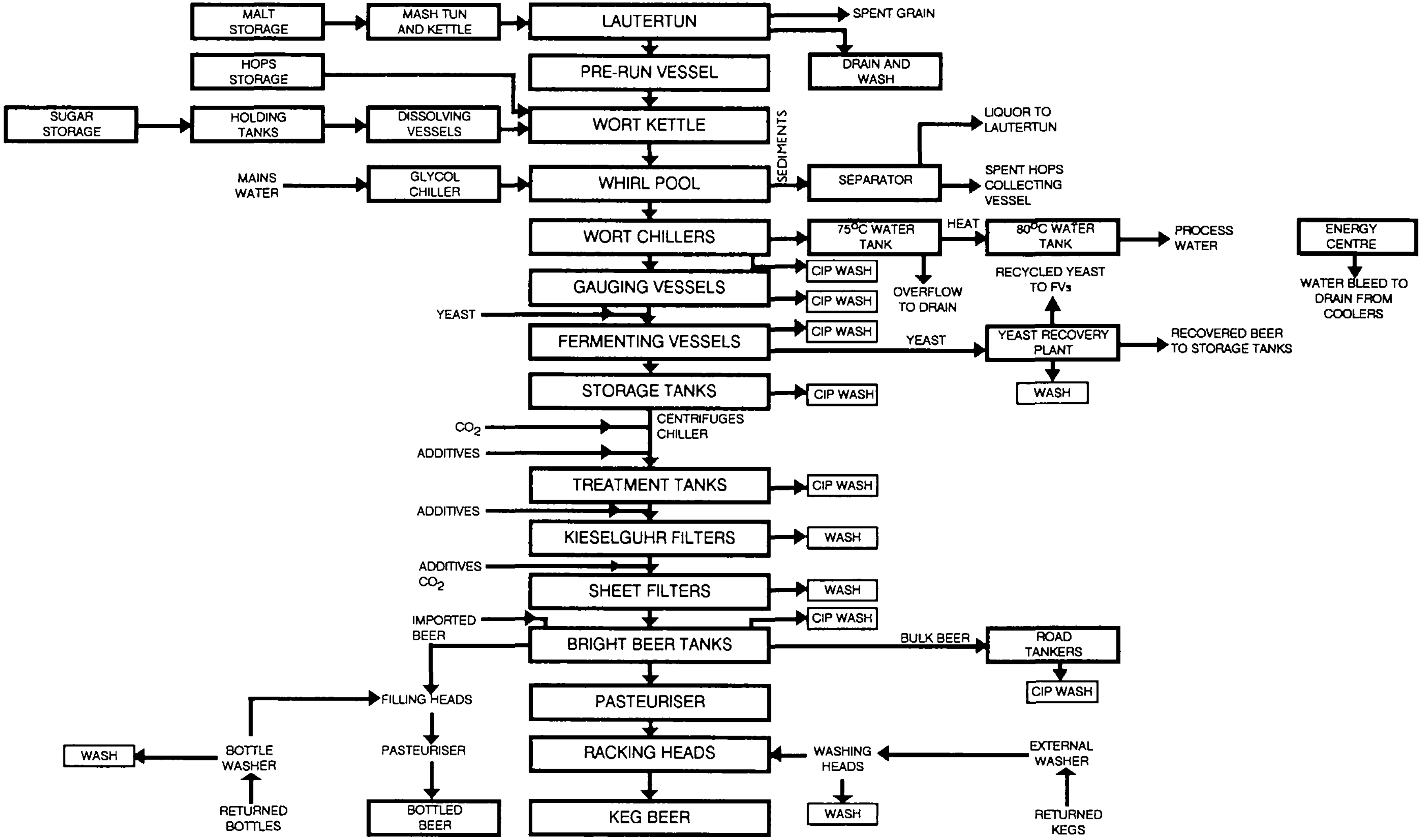


Figure 1: General Flow Diagram for the Brewery

PHASE 2: MATERIAL BALANCE: PROCESS INPUTS AND OUTPUTS

Step 4: Determining Inputs

The audit team first proceeded to gather data on material inputs, concentrating on water usage, both for the brewery process as a whole and for individual unit operations. These activities are described further in Step 5.

Step 5: Recording Water Usage

The total water consumption from water meter readings for the previous three month period was found to be 247,500 m^3, equivalent to an average 2,750 m^3/d.

This included a small domestic water allowance, evaporation make-up and water entering the beer products as well as general washdown water for equipment for cleaning operations.

The audit team then proceeded to examine how water usage was split between the various unit operations.

Step 6: Measuring Current Levels of Waste Reuse/Recycling

No attempt to quantify the extent of current waste reuse/recycling was made during the waste audit programme since it was felt that this would have involved a considerable time input disproportionate to the likely benefits obtained.

However, it was noted that reuse of caustic and sterilant rinses following discharge to drain of initial water rinses generally formed an integral part of the automatic cleaning-in-place (CIP) system employed for equipment washing.

Step 7: Quantifying Process Outputs

The principal process outputs of concern were the wastewater discharges arising from production operations and also the beer products themselves.

It was also noted that minor domestic sewage contributions discharged to the same drainage network as the brewery process wastewaters.

The audit team then proceeded to quantify these outputs.

Step 8: Accounting for Wastewater

The total wastewater flow recorded during a two-week monitoring period averaged 1,730 m^3/d. It was noted, however, from the flow patterns during each day that wastewater discharges were extremely variable with a peak flow rate of up to 100 m^3/h occurring when a hot water tank overflow was discharged. On the basis of this and a number of other assumptions, the audit team estimated that the maximum flow on any one day could reach 2,600 m^3/d.

The corresponding combined wastewater pollution loads averaged 5,980 kg COD/d and 1,500 kg SS/d. These figures equated to waste quantities per cubic metre of beer produced of 2.1 m^3, 7.1 kg COD and 1.8 kg SS. Assuming an average COD:BOD ratio of 1.7, the corresponding BOD waste load was 4.2 kg/m^3 beer produced. These unit wastewater flow and BOD load contributions proved to be similar to the approximate estimates calculated in Step 1.

An estimate of domestic water usage and hence domestic sewage discharges to the trade effluent drainage system were also made, together with an assessment of the quantity of water entering the beer products. Calculations indicated that these additional outputs averaged a total of 850 m^3/d, of which only 10 m^3/d (140 employees at 70 litres per head per day) related to domestic sewage.

Studies were then carried out to develop a breakdown of the main process outputs (wastewater and product) for each key unit operation. This involved sampling and flow measurement of individual discharges around the brewery. Since the volume and composition of some of these discharges varied considerably with the type of beer produced, the survey was undertaken over several weeks to allow a realistic assessment of the situation to be made.

Step 9: Accounting for Gaseous Emissions

Gaseous emissions were not of particular concern in the context of the terms of reference drawn up by Company A for the study. However, it was noted that the brewery boilers were gas-fired and that boiler flue-gas emissions were discharged via a tall stack such that they were not likely to give rise to any concern.

It was noted that if control of alkaline wastewater discharges associated with use of caustic soda in the CIP systems proved to be necessary in the future (a possibility if alkaline waste discharges could not be controlled at source), then use of acidic flue-gas (a source of carbon dioxide) could be considered for this purpose.

The audit team also observed that pockets of carbon dioxide in the fermentation areas could cause problems of drowsiness amongst the brewing staff and that improved ventilation would help to ensure their general health and safety.

Step 10: Accounting for Off-Site Wastes

At the time of the survey, wastes produced for transportation and disposal off-site were limited to spent grain and hops generated in the brewhouse as by-products. These were disposed of off-site by a local farmer, for cattle food and as a soil conditioner respectively, at no cost to the brewery. Total quantities were estimated at some 25,000 tonnes (wet weight) per annum.

Step 11: Assembling Input and Output Information for Unit Operations

As previously indicated, the prime interest in this waste audit and reduction programme was to concentrate on the potential for reducing wastewater and associated pollution loads.

Hence, for the purposes of the project in question, the material balance was confined to consideration of water issues only.

Step 12: Deriving a Preliminary Material Balance for Unit Operations

It was decided to conduct a preliminary material balance for the brewery as a whole, based on water usage, before embarking on the more complicated step of obtaining a balance for each key unit operation. This was then constructed as set out in below.

Inputs	m^3/d
Water	2,750

↓

Overall Brewery Operations

↓

Outputs	m^3/d
Domestic Sewage	10
Product	840
Wastewater	1,730
Total	2,580

Step 13: Evaluating the Material Balance

The material balance with respect to overall water usage showed a remarkably good agreement, the average daily water input amounting to 6.6% above the daily water output assessed.

Although raw materials in the form of malt, hops, sugar, additives and other process chemicals - and also wastes disposed of off-site - had not been included in the balance, it was noted that these items are relatively small in the case of breweries where water is the dominant raw material used.

Step 14: Refining the Material Balance

On studying the data collated, it was observed that no allowance for evaporation had been included in the material balance and that, from the consultant's previous experience of brewery operations, evaporation alone could account for up to 5% of total water usage. This allowance therefore effectively closed the small difference between water input and output indicated in Step 13.

The waste audit team then proceeded to build up material balances for all the major unit operations within the brewery. When this work had been completed, they felt that they had gained considerable knowledge about the various production activities, their inputs, outputs, wastes and operational problems.

PHASE 3: SYNTHESIS

Step 15: Examining Obvious Waste Reduction Measures

The audit team considered that the cost of wastewater disposal at the brewery could be minimised in two ways:

- reduction in volume, BOD* and/or SS load of the wastewater produced in the brewery;
- reduction in the BOD* and/or SS load of the wastewater discharged to sewer by pretreatment.

(* or rather COD, as used in the water authority's charging formula)

In the light of a comprehensive examination of the waste producing areas, it was possible to study both these alternatives. To assist the investigations into waste saving possibilities, reference was made to available information (including database) sources, as well as the consultant's own experience of undertaking similar projects.

The various sections of the brewhouse were studied in turn as follows.

a) Brewhouse

The two principal discharges in the brewhouse were the drain from the Lautertuns and a 75°C hot water tank overflow. Together these contributed 12% of the total wastewater flow from the brewery.

Study of the flow and analytical data obtained indicated that the Lautertun drain contributed 3.5% of the flow, 23% of the COD and 4% of the SS load. Discussions with the company indicated that it should be possible to store this waste flow for use as make-up water for the subsequent brew and that this should be possible without detriment to brewing standards. A 15 m^3 stainless-steel storage tank with associated pumps, valves and pipework would need to be installed with the advantage that the system would:

- reduce raw water costs;
- eliminate effluent charges previously incurred by this discharge;
- reduce energy requirements since the liquor returned as make-up water would not need heating;
- eliminate existing shock load discharges from this source which should remove any need for flow/load balancing of the total site wastewater flow.

The hot water tank overflow accounted for nearly 9% of the total wastewater flow. Since this water was clean and hot, continual reuse was the obvious possibility. Unfortunately this proved to be impossible owing to the spasmotic production of this water.

proved to be impossible owing to the spasmotic production of this water.
As the 75°C tank was very large however, it was considered that its inherent balancing capacity could be utilised if the supply for reuse was taken part way down the tank rather than from the overflow when it occurred.

Reuse of this water would be preferable in a process that consumed hot water at approximately the same rate as the 75°C hot water production, that is 150 m^3/d. The only process in the brewery which utilised this quantity of hot water was the pasteurising machine which had a water consumption of some 170 m^3/d. However, all of this flow was not hot water since a temperature gradient had to be maintained within the pasteuriser to ensure that bottles were not warmed up or cooled down too rapidly.

It was considered that the 75°C hot water should be injected directly into the pasteuriser to replace the heating of cold water to 60°C. In addition, the hot water could be blended with the supply of cold water that already existed to give the required temperature profile thoughout the pasteuriser. It was estimated that such a system would enable at least 75 m^3 of the excess hot-water to be reused each day.

b) *Fermentation Cellar*
The majority of waste produced in this area of the brewery originated from the CIP systems, the discharges from which contained a high COD load due principally to the high yeast content. With the exception of the initial rinse from pre-fermentation stage gauging vessels, the initial rinses from other tanks - fermentation tanks, storage vessels and yeast recovery vessels - all exceeded 6,000 mg/l COD and together accounted for over 90% of the COD load produced in the fermentation cellar.

Proposals for reducing/treating these discharges were developed as follows.

Gauging Vessels

Possibilities for reducing the pollution load from this source of CIP effluent were limited as no yeast was present which could be filtered out. However, reuse of the relatively-clean final rinse as the initial rinse for the next CIP wash would reduce the effluent flow to drain by a total of 26 m^3/d from 8 vessels.

It was also noted that the caustic wash from the brewhouse which occurred usually every week was discharged to drain from these gauging vessels every weekend and that this, together with the acid wash from Wort Kettle No.2 discharged via a fermentation (balancing) tank, had a major effect on the combined wastewater pH giving values frequently outside the allowable pH range for discharge to the public sewer of 6-10.

Tests showed that if the acid and caustic discharges were run to drain together, the neutralising effect of the acid on the caustic was neglible owing to the different volumes, strengths and neutralise the predominant caustic load, it was envisaged that closing up the system by providing additional holding tank capacity would be suitable. This could be achieved using a similar arrangement to the existing closed CIP units in order to standardise on equipment; it would reduce effluent flows to drain, raw water costs and also chemical-cleaning costs.

Fermentation Tanks

The load produced by the initial rinse was found to be 210 kg COD/d and 150 kg SS/d which could be reduced by at least 75% by passing the rinse through a yeast press. It was considered that the final CIP rinse could also be reused as the initial rinse, reducing effluent flow by 25 m^3/d from 8 tanks.

As referred to above, acid washes from the brewhouse were being discharged from the fermentation tanks; on occasions, these depressed the pH to 2.4. Containment and recirculation via a new CIP unit was considered to be the most suitable and practicable control measure.

Storage Tanks

The initial rinse in the CIP sequence was found to contain 75 kg COD/d and 10 kg SS/d. It was estimated that passing these rinses through a yeast press would reduce overall loads from this source to 22 kg COD/d and 3 kg SS/d. Also, reuse of the final rinse as the initial rinse of the next sequence would reduce effluent flows by 5 m^3/d.

Yeast Recovery Plant

Discharges from centrifuge cleaning were difficult to arrange at the time of the waste audit and reduction investigations. However, from visual observations the initial rinse clearly contained a significant quantity of yeast and so it was recommended that such wastes should also be passed to a yeast filter press. Similarly, recovery of the final rinse and reuse as a subsequent initial rinse was proposed. It was also suggested that the initial rinses from yeast storage vessels should be filtered through a yeast press.

Company A had already purchased a new yeast press to filter yeast liquors which at the time were stored until press capacity became available. This proposal was expected to reduce storage requirements, allowing a small amount of beer recovery (press filtrate) and elimination of the frequent storage tank overflow.

Therefore, instead of treating each of the fermentation cellar discharges separately which would be uneconomic, the audit team considered that the proposed filter-press installation for the yeast recovery area should be arranged to filter the initial rinses from fermentation tanks, storage vessels and yeast recovery equipment. This would not only prevent the majority of yeast from flowing to drain but would enable its recovery for resale to a food manufacturer.

In addition, any other liquor containing yeast that had to be dumped to drain, such as the initial drop from the storage tanks when the yeast storage vessels were full, could be filtered and the yeast and beer recovered. The expected increase in flow to the proposed filter press was estimated at 50 m^3/d containing 100 kg SS/d, well within the unit's design capacity.

c) *Treatment Cellar*
A number of waste saving options were recommended for this area. The principal measures proposed related to the bottling and kegging areas. The possibilities of utilising the 75°C hot water tank overflow for the pasteuriser supply have already been highlighted in the brewhouse section above. The audit team felt that the water flowing out of the pasteuriser could be used as an initial rinse in the bottle washer.

The existing bottle washer system used 9 m^3/h fresh deionised water. It was proposed that the final sparge pipes should continue to be supplied with deionised water but that the pasteuriser water be used to supply the remainder and also for continual replenishment of the water in the final rinse tank. Mains water would be provided as a standby supply in the event for any reason that the pasteuriser water ceased.

In the kegging area, dumping of returned beer to drain was occurring periodically giving a very significant rise in BOD and COD load during the dumping periods. It was indicated to the company that separate disposal, possibility directly to land, should be seriously considered as often adopted by other breweries. It was noted, however, that this would require the permission of Customs and Excise officials and be subject to the beer being destroyed in an approved manner such as by dyeing.

Step 16: Targetting and Characterizing Problem Wastes

Following completion of Step 15, the audit team realised that significant reductions in wastewater flows and pollution loads could be achieved by carrying out all the improvement measures highlighted, all of which were relatively straightforward to implement.

It was decided it would be useful to obtain an overall picture of the waste savings which could be achieved. Thus, a summary of the existing and proposed reduced waste contributions for the unit operations highlighted in Step 15 was drawn up as presented in Table 3. At this stage, no allowance was made for the benefits of avoiding returned beer being discharged to drain since this was dependent on future discussions with Customs and Excise personnel.

Table 3: Summary of Existing and Proposed Reduced Waste Contributions

Unit Operation	Waste Description	Existing Composition			Recommendation	Predicted Composition		
		m^3	kg COD	kg SS		m^3	kg COD	kg SS
Lautertun	Final run to Drain	60	1392	60	Reuse	0	0	0
75°C Hot Water Tank	Overflow	150	-	-	50% reuse as make-up for pasteuriser	75	0	0
Brewhouse Vessels	Caustic and acidic wash at weekends	36	152	16	Installation of CIP unit	0	0	0
Gauging Vessels	CIP wash	26	-	-	Reuse rinsewater	0	0	0
Fermenting Vessels	CIP wash	65	248	188	Reuse and yeast separation	40	62	44
Storage Tanks	CIP wash	17	89	13	Reuse of rinsewaters and pressing of initial rinse	12	22	3
Yeast Storage and recovery	CIP wash	2	17	1	Yeast recovery	2	4	0.2
Pasteuriser	Process water	100	-	-	Reuse in bottlewasher	0	0	0
Total		456	1898	278		129	88	47.2

For flow, COD and SS load savings of 327 m^3/d, 1,810 kg COD/d and 230 kg SS/d (ref. Table 3), the predicted reductions on the total wastewater discharges assessed in Step 8 were approximately 19%, 30% and 15% respectively.

Step 17: Segregation

In formulating a series of recommendations for waste reuse and recovery which could be implemented relatively quickly (ref. Step 16), the waste audit team had recognised at an early stage that waste segregation would form an integral part of the waste reduction strategy.

The proposals were discussed with the management who, in principle, were in agreement that the various measures put forward were sensible and practicable, subject to the audit team being able to demonstrate that the likely long-term cost savings to be achieved would be appreciable.

Step 18: Developing Long-Term Waste Reduction Options

Prior to the water authority stating that the increase in local sewage treatment works capacity would not require a capital contribution from Company A, the brewery's waste management consultants had prepared preliminary plans for an on-site pretreatment plant based on pH control, balancing and oxygen activated sludge treatment.

This compact treatment option had been selected in view of the limited spare land area available on site. An additional attraction was the reduced risk of developing filamentous, poorly-settling sludges compared with conventional air activated sludge systems treating brewery, or similar wastes, having a high soluble carbohydrate content.

However, in the light of the water authority's subsequent proposals and a comparative economic assessment of the two alternatives - discharge of untreated combined wastewaters (or, at worst, following preliminary treatment only) plus payment of trade effluent charges, or partial biological pretreatment plus payment of reduced trade effluent charges - plans for pretreatment facilities on-site were shelved pending the outcome of the waste audit and reduction investigations.

The audit team considered that if the good housekeeping measures as outlined in Step 16 were implemented, particularly those relating to the reuse of the significant pollution load associated with the Lautertun drain and the control of caustic and acidic discharges, then future pH control and flow/load balancing of combined flows in order to ensure compliance with discharge standards would not be necessary.

Step 19: Environmental and Economic Evaluation of Waste Reduction Options

From the waste saving studies which were orientated around possibilities for reuse/recycling and recovery, it was clear that following implementation of the measures drawn up the net discharge of wastes to the environment would be significantly reduced. Thus, there would be a clear environmental benefit.

The audit team then tabulated the estimated trade effluent charges with and without allowance for the proposed waste saving measures (Table 4). This enabled the potential savings in these charges to be identified.

Table 4: Estimated Trade Effluent Charges

Unit Operation	Waste Description	Estimated Current Charges US$/annum	Estimated Reduced Charges US$/annum	Estimated Savings in Charges US$/annum
Lautertun	Final run to drain	58,000	0	58,000
75° Hot Water Tank	Overflow	7,000	3,500	3,500
Brewhouse Vessels	Caustic and Acidic Wash at Weekends	7,800	0	7,800
Gauging Vessels	CIP Wash	1,200	0	1,200
Fermenting Vessels	CIP Wash	25,000	7,000	18,000
Storage Tanks	CIP Wash	5,000	1,500	3,500
Yeast Storage and Recovery	CIP Wash	800	200	600
Pausteriser	Process Water	4,300	0	4,300
Total		109,100	12,200	96,900

The trade effluent charges listed in Table 4 were then compared with the expected total trade effluent charge for the existing combined wastewaters, estimated at US$365,000 per annum for the forthcoming year. This indicated a 26% reduction resulting from implementation of the flow/ load reduction proposals.

Based on the data set out for Step 16, the reduced average flows and loads would be some 1,400 m^3/d, 4,170 kg COD/d and 1,270 kg SS/d. This corresponded to reduced average waste quantities per cubic metre of beer produced of 1.7 m^3, 5.0 kg COD and 1.5 kg SS.

Further examination of all the waste audit data obtained indicated that peak wastewater flows and loads on any one production day could rise to 70% above these average discharge levels. However, the assessment of trade effluent charges based on average discharges was considered to give a realistic estimate of the savings which could be expected over a full production year.

The audit team appreciated that in addition to savings in trade effluent charges, there would be other cost benefits which were difficult to quantify during the time-frame of the consultant's brief but which included costs associated with raw water, energy and the probable elimination of combined wastewater treatment which would otherwise be required to meet discharge consent conditions consistently.

It was also recognised that some capital expenditure would be required to implement the proposed waste reduction programme. It was agreed with the brewery management that this aspect was best costed by their own engineering staff but that since the capital sums involved would be relatively small compared to the company's capital expenditure budget for the current year, and related to progressive improvements in the brewery production operations, the company would be likely to accept the waste savings proposals on the basis of the significantly reduced trade effluent charge savings alone.

Step 20: Developing and Implementing an Action Plan: Reducing Wastes and Increasing Production Efficiency

The results of the waste audit and waste reduction studies were formally presented to Company A's management in the form of a technical report. The recommendations made were accepted and plans were then made to implement the recommendations.

The waste audit had provided a sound understanding of all principal sources of waste arising within the brewery. Furthermore, the brewery technologist assigned to assist the waste audit team had benefitted greatly from being involved in the step-by-step approach adopted by the company's consultants.

It was considered that the experience gained by the brewery would enable company staff to take the lead in any future waste audit programme, particularly the assessment of the actual waste reductions achieved following commissioning of the plant modifications and additions proposed.

CASE STUDY 2: LEATHER MANUFACTURE

Company B operates a tannery in south-east Asia processing cattle hides into finished leather, mainly for side upper leather in shoe manufacture. Treatment of the hides involves a series of batch operations involving application of a wide range of physical and chemical processes. Wastewaters discharged contain pollutants from the hides, products from their decomposition, and chemicals and various spent solutions used for hide preparation and during the tanning process. Solid wastes and some atmospheric emissions also arise.

The company was required to meet new government standards for discharge of wastewater to the local watercourse. This necessitated improvements to existing treatment facilities which were then limited to crude settlement in three lagoons operated in series. Primary sludge produced was disposed of in liquid form on a large area of surrounding land.

In the light of this situation, the company engaged a local consulting engineering firm to assist their staff in carrying out a waste audit and waste reduction programme with a view to developing the best and most cost-effective solution to the waste treatment and disposal problems.

The principal tannery operations carried out, typical of many tanneries throughout the world, may be summarised as follows.

Pretanning (or Beamhouse) Operations

- soaking of the imported, preserved (wet-salted) hide in water overnight to remove blood, dung, curing salt and water-soluble and saline-soluble proteins;

- unhairing (complete dissolving of all hair) by immersion in lime and sodium sulphide - and subsequent reliming;

- trimming and mechanical removal of extraneous tissue from the flesh side of the hides - and subsequent splitting (lime splitting) of the upper two-thirds grain layer from the lower, less valuable split layer;

- deliming by treatment with a weak acid (lactic acid) and bating with an enzyme-based chemical to remove hair remnants and degraded proteins;

- pickling using salt and sulphuric acid solutions to give the required acidity to the skins to prevent subsequent precipitation of chromium salts on the skin fibres - pickled splits are then sold to other tanneries for further processing, only the grain layers being tanned and finished by Company B.

Thus, wastewaters from the beamhouse contain high levels of suspended solids and dissolved organic matter, curing salt and grease, in addition to unused process chemicals (particularly sulphides); they will also be alkaline, having a high oxygen demand.

Tanning

Chrome tanning is carried out using chromic sulphate. The tanning process stabilises the proteineous (collagen) network of the hide. Acidic effluents are produced which contain unused trivalent chromium salts.

Post-Tanning Operations

These involve:

- pressing (samming) to remove moisture;
- a second levelling by shaving;
- dyeing and softening of the tanned hide with emulsified oils (fatliquoring), preceded by occasional secondary tanning using synthetic tannins (syntans) and tanning extracts;
- drying and final trimming;
- surface coating and buffing (finishing)

The following case study describes the waste audit/waste reduction approach taken.

PHASE 1: PREASSESSMENT

Step 1: Audit Focus and Preparation

It was decided that the study investigations would be carried out by a chemical engineer from the consulting firm's staff who had previous experience of carrying out waste audits, assisted by the tannery's plant chemist.

Company B's own laboratory was not equipped to carry out many of the tests normally associated with wastewater analysis and so arrangements had to be made to deliver samples to a local private company providing laboratory analytical services.

In view of government pressures, it was decided to concentrate on wastewater discharges arising from the beamhouse and subsequent tanning operations. However, atmospheric emissions were also investigated having particular regard to health and safety. Solid waste arisings, in particular wastewater treatment plant sludges, were also studied.

The waste audit team was keen to gain the support of production personnel in order to ensure that comprehensive information on all tannery operations could be readily obtained. As a first step therefore, the study objectives were fully explained to selected staff responsible for the various production activities.

The investigations were initiated by gathering relevant information from company files. This preliminary search yielded site and drainage plans, raw material purchase records and water meter records associated with on-site borehole abstraction.

A preliminary check on water usage was carried out by calculating the water usage per tonne of wet-salted hide processed. This was found to be 61 m^3/tonne. It was noted that this was some 22% higher than the typical average working figure of 50 m^3/tonne reported in technical literature, suggesting that ways of introducing considerable water savings should be possible as a result of the waste audit/waste reduction study.

Step 2: Listing Unit Operations

The consultant and the plant chemist started the tannery study by walking around the processing and waste treatment areas, listing all the unit processes and making notes on their function and use. Help was also sought from various plant operators who were familiar with the day to day plant operations. The unit operations were listed in Table 1, with processes which did not produce liquid waste shown in brackets.

Table 1: Unit Operations

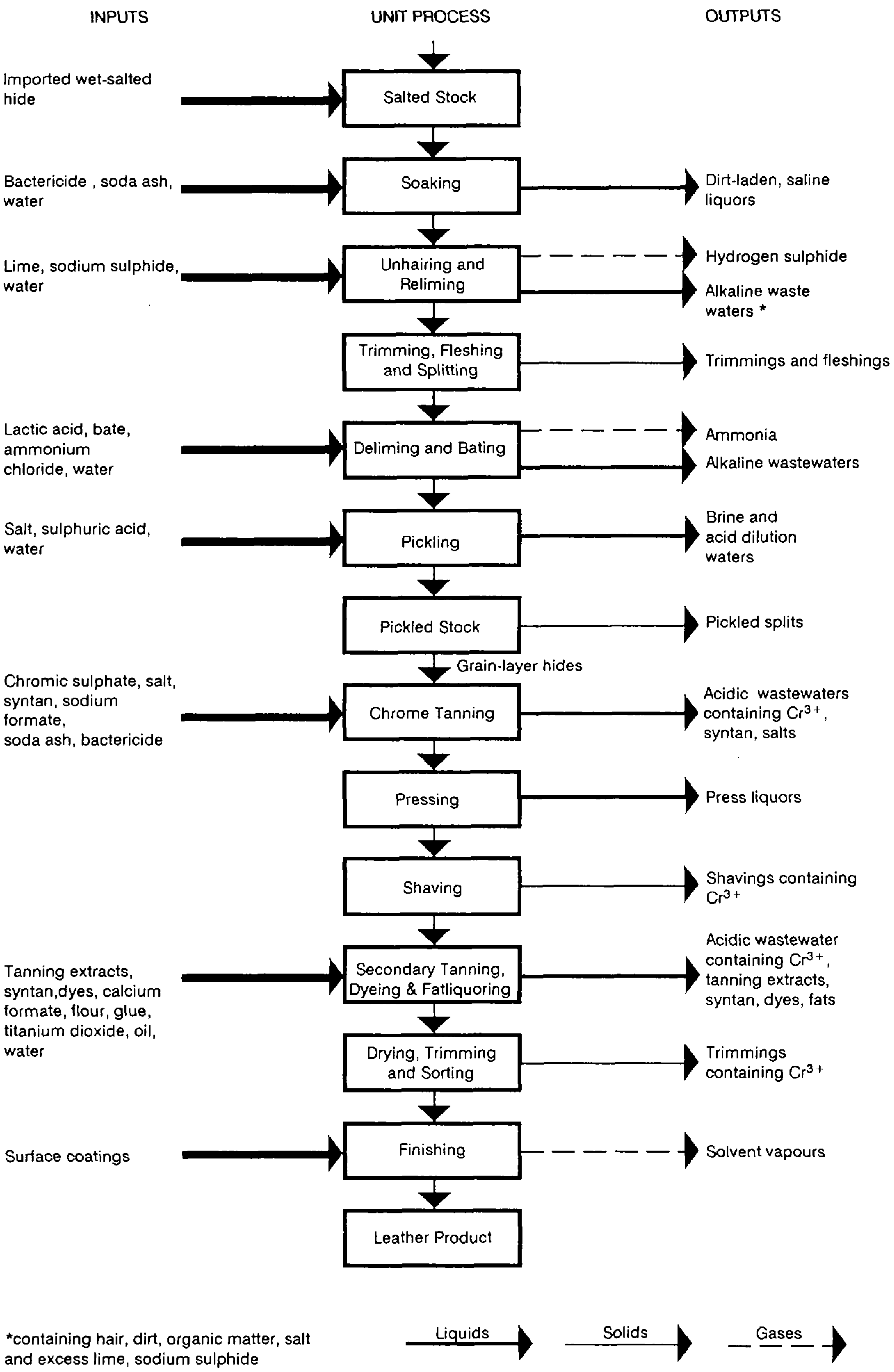
Soaking
Unhairing and Reliming
(Trimming, Fleshing and Splitting)
Deliming and Bating
Pickling
Chrome Tanning
Pressing
(Shaving)
Secondary Tanning, Dyeing and Fatliquoring
(Drying, Trimming and Sorting)
(Finishing)

As part of the company's long-term planning, the plant chemist noted that consideration was being given to moving the hide splitting operations further downstream the process line (after tanning) in order to improve the accuracy of splitting and hence overall process control, as commonly practised at other tanneries. The existing arrangement and design of process units, many of which were relatively old, did not however lend themselves to this change being implemented rapidly.

Step 3: Constructing Process Flow Diagrams

A flow diagram was then prepared to illustrate the interrelationship between the various unit operations (Figure 1).

Figure 1: Schematic Diagram of Tannery Operations



*containing hair, dirt, organic matter, salt and excess lime, sodium sulphide

PHASE 2: MATERIAL BALANCE: PROCESS INPUTS AND OUTPUTS

Step 4: Determining Inputs

The audit preparation phase (Step 1) had already highlighted the availability of well-documented raw material purchasing records. The data produced also proved to be a good check on the raw material quantities quoted by the plant foremen per unit operation.

The raw material usage data obtained were set out as in Table 2.

Table 2: Annual Consumption of Process Chemicals

Process Chemicals	tonnes/annum
Sodium Chloride (other than curing salt present in raw hide)	622
Hydrated Lime	1,123
Sodium Sulphide (62% Na_2S)	445
Sulphuric Acid	160
Soda Ash (anhydrous sodium carbonate)	74
Bate (95% ammonium sulphate, 5% enzymes)	65
Calcium Formate	40
Lactic Acid (30%)	35
Sodium Formate	26
Bactericide	19
Ammonium Chloride	9
Sub-total	2,618
Chemicals Absorbed by the Hide (i)	
Tanolin (16% chromium)	760
Syntans A & B	424
Dyes	77
D-1 Oil	17
Other Oils	295
Tannin Extracts	190
Soyarich Flour	45
Titanium Dioxide	30
Methyl Cellulose	9
Semi-Sol Glue	17
Sub-total	1,864
Total	4,482

(i) Absorption estimated at 90%, 10% discharged to waste - except for Tanolin, absorption 75%, 25% discharge to waste

Due to the nature of the raw materials and the well-organised materials storage system which was found to be in operation, no significant handling losses were occurring.

It was noted that the company incurred no charges for consumption of water drawn from a site borehole. A separate town water (potable) supply was available for domestic use. Domestic wastewater passed to the nearby watercourse via a septic tank.

Having already tabulated the key production stages (Step 2), raw material usage listed in Table 2 was used to derive average quantities per unit operation throughout the tannery, on both a daily basis and per tonne of hide processed.

The data compiled were set out in Table 3.

Table 3: Chemical Inputs per Tannery Unit Operation

Unit Operation	kg/tonne hide (at unit operation)	kg/tonne wet-salted hide	kg/d
Soaking:			
Bactericide	1.6 (i)	1.6	64
Sodium Carbonate	0.8 (i)	0.8	32
Unhairing/Reliming:			
Hydrated Lime (unhairing)	48 (i)	48	1,920
Sodium Sulphide (62% Na_2S)	43 (i)	43	1,720
Hydrated Lime (reliming)	58 (i)	58	2,320
Deliming/Bating:			
Lactic Acid	5 (ii)	4.3	172
Bate	10 (ii)	8.7	348
Ammonium Chloride	1.3 (ii)	1.1	44
Pickling:			
Sodium Chloride	60 (ii)	51.9	2,076
Sulphuric Acid	21 (ii)	18.2	728
Chrome Tanning:			
Tanolin (basic chromic sulphate, 16% Cr^{3+})	60 (ii)	51.9	2,076
Sodium Chloride	60 (ii)	51.9	2,076
Syntan A	25 (ii)	21.6	864
Sodium Formate	8.9 (ii)	7.7	308
Sodium Carbonate	10 (ii)	8.7	348
Bactericide	1 (ii)	0.9	36
Syntan B	41 (ii)	35.5	1,420
Secondary Tanning, Dyeing and Fatliquoring:			
Dyes	20 (iii)	7.0	280
Calcium Formate	10.3	3.6	145
Syntan B	44 (iii)	15.4	616
Soyarich Flour	16 (iii)	5.6	224
Titanium Dioxide	8 (iii)	2.8	112
Glue/Methyl Cellulose	8 (iii)	2.8	112
Tannin Extracts & Oils	118 (iii)	41.3	1,652
Total			19,693

(i) Based on 40 tonnes wet-salted hide per day
(ii) Based on fleshed, split/trimmed hide, after reliming - 34.6 tonnes per day
(iii) Based on chrome tanned leather, after pressing/shaving - 14.0 tonnes per day

Step 5: Recording Water Usage

The next step was to record the water usage at the tannery and determine how it was used. It was noted that water obtained by the company from the site borehole was pumped to a covered storage tank at ground level and then pumped again to a high-level storage tank. Water then gravitated to the site distribution mains under static head via a water meter, readings for which were recorded weekly in a log book.

Analysis of these records indicated a daily average total water consumption for the site of 2,450 m^3/d. This figure was then broken down into average water usage per tannery unit operation in a similar manner to that carried out for the process chemicals. Since the tannery wet processes were all carried out in revolving vessels of known capacity, providing mechanical agitation to accelerate the wet-chemical operations, batch process water inputs were readily quantifiable. Rinsewater usage which was continuous for a fixed duration per batch was also known from previous work carried out by the company. This had involved checking the time taken to fill a vessel of known volume for a given water valve setting.

The results were summarised as set out in Table 4.

Table 4: Water Inputs per Tannery Operation

Unit Operation	m^3/tonne hide (at unit operation)	m^3/tonne wet-salted hide	m^3/d
Soaking:			
Prewash	4.3 (i)	4.3	172.0
Process Water	1.9 (i)	1.9	76.0
Rinse Water	2.1 (i)	2.1	84.0
Unhairing/Reliming:			
Process Water	1.9 (i)	1.9	76.0
Rinse Water	11.0 (i)	11.0	440.0
Soak Water (reliming)	1.9 (i)	1.9	76.0
Rinse Water	2.1 (i)	2.1	84.0
Deliming/Bating:			
Pre-rinse	4.2 (ii)	3.635	145.4
Process Water	1.0 (ii)	0.865	34.6
Rinse Water	1.385 (ii)	1.2	48.0
Pickling:			
Brine Water	2.49 (ii)	0.215	8.6
Acid Dilution Water	0.84 (ii)	0.073	2.9
Chrome Tanning:			
Process Water	0.586 (ii)	0.507	20.3
Rinsing	4.51 (ii)	3.9	156.0
Pressing:	0.202 (ii)	0.175	7.0
Secondary Tanning, Dyeing and Fatliquoring:			
Prerinse	9.15 (iii)	3.2	128.0
Process Water	0.4 (iii)	0.14	5.6
Rinse Water	18.6 (iii)	6.5	260.0
Process Water	0.4 (iii)	0.14	5.6
General Floor and Plant Washwater		15.5	620.0
Total - Process Waters	-	12.115	484.6
- Rinse Waters	-	33.635	1,345.4
- General Washdown	-	15.500	620.0
- Total	-	61.250	2,450.0

(i) Based on 40 tonnes wet-salted hide per day
(ii) Based on fleshed, split/trimmed hide, after reliming - 34.6 tonnes per day
(iii) Based on chrome tanned leather, after pressing/shaving - 14.0 tonnes per day

Step 6: Measuring Current Levels of Waste Reuse/Recycling

It was noted that no wastes were reused/recycled at the tannery.

Step 7: Quantifying Process Outputs

The audit team listed the process outputs from each tannery unit operation as set out in Table 5 below.

Table 5: Process Outputs

Unit Operation	Wastewater	By-Product/ Waste Reuse	Atmospheric Emissions
Soaking	Process and Wash/Rinse Waters	-	-
Unhairing/Reliming	Process and Rinse Waters	-	Hydrogen Sulphide
Trimming, Fleshing and Splitting	-	Trimmings and Fleshings	-
Deliming/Bating	Process and Rinse Waters	-	Ammonia
Pickling	Process Brine/ Acid Dilution Waters	-	-
Pickled Hide Storage	-	Pickled Splits	-
Chrome Tanning	Process and Rinse Waters	-	-
Pressing and Shaving	Press Liquors	Shavings	-
Secondary Tanning, Dyeing and Fatliquoring	Process and Rinse Waters	-	-
Drying, Trimming and Sorting	-	Trimmings	-
Finishing	-	-	Solvent Vapours
Final Product	-	Finished Leather (grain layer)	-

Action was then taken to quantify these outputs in Steps 8, 9 and 10.

Step 8: Accounting for Wastewater

Process wastewater flows were based on totalling up batch water inputs and making allowances where appropriate for water retention by the hide at each process stage based on percentages reported in technical literature.

Composite samples of the various discharges were also taken for laboratory analysis.

The results of this exercise were summarised in Table 6.

Table 6: Average Flows, Strengths and Pollution Loads of Strong Liquors

Unit Operation	Flow			BOD			SS		
	m^3/d	% of total	pH	mg/l	kg/d	% of total	mg/l	kg/d	% of total
Soaking	276	42.1	6.8	2,200	607	19.8	4,400	1,215	30.0
Unhairing	103	15.7	11.5	15,500	1,597	52.0	22,100	2,276	56.1
Reliming	103	15.7	11.7	650	67	2.2	1,650	170	4.2
Delime and Bating	66	10.1	9.5	6,000	396	12.9	2,100	139	3.4
Pickling	37	5.6	2.7	2,900	108	3.5	5,200	192	4.7
Chrome Tan & Press Liquors	33	5.0	3.6	6,500	215	7.0	1,100	36	0.9
Secondary Tanning, Dyeing & Fatliquoring									
- 1st dump	19	2.9	4.0	2,000	38	1.2	600	11	0.3
- 2nd dump	19	2.9	3.7	2,200	42	1.4	850	16	0.4
Total	656	100.0	-	-	3,070	100.0	-	4,055	100.0

It was decided that having quantified the main, strong-liquor pollution loads per unit operation, separate quantification of running rinsewater pollution loads per unit operation was not justified since this would have meant setting up numerous V-notch weirs and many additional sampling points, thus increasing significantly the time input and analytical work required.

The relatively weak continuous-flow rinse waters were thus monitored using a V-notch weir located in a common drain within the tannery and combining frequent spot samples to give a daily composite for the whole tannery. Total rinsewater flow including general floor and plant washdown was estimated to be 1,944 m^3/d with an associated BOD and SS strength of 273 mg/l and 396 mg/l SS. Corresponding pollution loads (flow x strength) were thus 530 kg BOD/d and 770 kg SS/d.

The overall wastewater flows and BOD and SS strengths and pollution loads were then tabulated in Table 7.

Table 7: Combined Wastewater Flows, Strengths and Pollution Loads

Wastewater	Flow m^3/d	BOD		SS	
		mg/l	kg/d	mg/l	kg/d
Strong Liquors	656	4,680 (i)	3,070	6180 (i)	4,055
Rinse Waters/General Washdown	1,944	273	530	396	770
Total	2,600	1,430 (i)	3,600	1,950 (i)	4,825

(i) Concentrations calculated from flow/pollution load data

Based on an average 40 tonnes of wet-salted hide processed, it was noted that these overall figures equate to 65 m^3 wastewater/tonne, 90 kg BOD/tonne and 121 kg SS/tonne, ie fairly typical unit loads compared with average figures for similar tanneries elsewhere but some 20-25% high in terms of wastewater flow.

An assessment was also made of chromium and sulphide pollution loads based on selected additional wastewater analyses carried out. This yielded pollution loads of 198 kg Cr/d and 412 kg S"/d, equivalent to 4.9 kg Cr/tonne and 10.3 kg S"/tonne. Again, it was noted that these loads were fairly typical in the consultant's experience even for well operated tanneries, although somewhat higher (14% and 21% respectively) with respect to figures reported by WHO, 1982.

A number of other checks were also made. It was noted that while it was difficult to measure combined wastewater flows entering the wastewater treatment system, the final lagoon effluent discharged via a rectangular weir. In order to obtain some cross-check on the combined raw wastewater flow set out in Table 7, the final effluent flow to the nearby watercourse was monitored using this weir. An average flow over the study period of 2,200 m^3/d was recorded.

A limited number of samples of the lagoon effluent were taken and results compared with the raw wastewater analyses tabulated in Table 7. These indicated pollution load reductions averaging 40% BOD and 70% SS. Based on an average sludge concentration of 6% dry solids, calculations indicated that the volume of primary sludge generated averaged 56 m^3/d. The audit team noted that while this sludge was periodically being disposed of on surrounding land, this practice would not be allowed to continue in the future as liquid run-off caused additional pollution problems in the nearby watercourse, particularly during wet weather.

Step 9: Accounting for Gaseous Emissions

It was decided that consideration of atmospheric pollution issues in the context of this project did not justify the need for making use of portable gas detection equipment, such facilities in any case not being readily available. It was also considered that resources required to quantify gaseous emissions would be out of proportion to the extent of the problems occurring. However, various useful observations were made during the site survey.

A strong smell of hydrogen sulphide (H_2S) gas was evident at the primary sedimentation stage of the wastewater treatment plant. H_2S was also evident, although only to a limited extent, within the tannery processing areas where alkaline beamhouse liquors combined with subsequent acidic streams within the internal drainage system.

The plant chemist knew that the hydrogen sulphide was a highly-toxic gas having a threshold limit value (TLV) of 15 mg/m^3 (100 ppm by volume) in air. He also knew that the extent to which H_2S could be released from solution to atmosphere was pH dependent, high pHs favouring the ionised form (HS') and hence reduced risk of sulphide stripping. He therefore noted that any future wastewater treatment scheme would be best designed to allow pretreatment of alkaline beamhouse liquors (pH at least 10) before they were allowed to mix with other, acidic waste flows.

No release of ammonia associated with deliming/bating was apparent but it was noted that release of some solvent vapours in the working areas associated with leather finishing could be a potential health risk to production staff. Discussions with the management subsequently revealed that plans were already underway to install forced-ventilation equipment to cater for this problem.

Step 10: Accounting for Off-Site Wastes

The only wastes which were recycled were fleshings which were transported to a local rendering company; these amounted to an average of 9,200 kg/d.

Trimmings and shavings were disposed of to a local municipal landfill site and amounted to 14,600 kg/d.

No sale costs associated with disposal of the fleshings could be readily identified at the time of the waste audit. It was later established that no charge was levied by the tannery in return for the rendering company providing transportation facilities at their cost.

Trimmings and shavings were disposed of at an annual cost of US$14,000.

Step 11: Assembling Input and Output Information for Unit Operations

From the information collected the preliminary material balances were started by assembling the input and output data for the tannery and the wastewater treatment plant. These were tabulated under Step 12.

Step 12: Deriving a Preliminary Material Balance for Unit Operations

A preliminary material balance of data associated with operations within the tannery was first drawn up on an overall input/output materials basis. The information was tabulated as set out below.

Inputs	kg/d
Raw Hide	40,000
Chemicals (other than curing salt present in raw hides)	19,693
Water	2,450,000
Total	2,509,693

Overall Tannery Operations

Outputs	kg/d
Trimmings and Shavings	14,600
Fleshings	9,200
Pickled Split Layer	13,500
Finished Leather	5,600
Wastewater	2,600,000
Gaseous Emissions	Not quantified but not considered to be a major output
Total	2,642,900

A material balance was then drawn up on a unit operation basis with specific reference to chromium and sulphide. A material balance for the wastewater treatment plant was also compiled.

Inputs	kg/d S"	
Unhairing	430	(a)

(a) Based on 1,720 kg/d sodium sulphide containing 25% S"

Unhairing

Outputs	kg/d S"	
Unhairing Reliming Delime and Bating	412	(a)
Rinsewaters	5	(b)
Total	417	

(a) Based on 103 m^3/d unhairing liquors at 4,000 mg/l S"
(b) Based on 1,944 m^3/d rinsewaters containing 2.5 mg/l S"

Inputs	kg/d Cr	
Chrome Tanning	332	(a)

(a) Based on 2,076 kg/d Tanolin containing 16% Cr^{3+}

↓

Chrome Tanning

↓

Outputs	kg/d Cr	
Chrome Tan & Press Liquors	83	(a)
Chrome Leather	249	(b)
Rinsewaters	3	(c)
Total	335	

(a) Based on 33 m^3/d chrome liquors at 2,500 mg/l Cr^{3+}
(b) Based on 2,076 kg/d Tanolin containing 16% Cr^{3+} and 75% chrome absorption into hide
(c) Based on 1,944 m^3/d rinsewaters containing 1.5 mg/l Cr^{3+}

Inputs	m^3/d
Raw Wastewater	2,600

↓

Wastewater Treatment Plant

↓

Outputs	m^3/d
Primary Effluent	2,200
Primary Sludge	56
Total	2,256

Step 13: Evaluating the Material Balance

The waste audit team were confident that they had obtained an adequate material balance (within 5-10%) for the tannery as a whole as well as for the specific chromium and sulphide chemicals used.

The material balance for the wastewater treatment plant was also considered reasonable taking into account that some water seepage was possibly occurring through the base of the crude lagoons, thus contributing to the 13% difference between inflow and total outflows recorded.

Step 14: Refining the Material Balance

It was considered that the material balance information obtained was sufficient to meet immediate requirements but that it would be useful to carry out a further waste audit once any waste reduction measures had been implemented.

Step 15: Examining Obvious Waste Reduction Measures

It was noted that the rinsewater usage following unhairing was appreciable, amounting to some 18% of the total water usage throughout the tannery.

It was considered that significant savings could be achieved at this stage by changing from a 4-hour running rinse to a two-stage batch wash operation, each of 20-25 minutes duration. It was anticipated following a short-term trial that it should be possible to achieve a consistent 60% reduction in rinsewater usage, that is, from 440 m^3/d to 176 m^3/d.

The audit team also realised that considerable water wastage was taking place by tannery staff leaving numerous hoses running in between general floor and equipment washdown operations. On the basis of an average of 15 hoses in continuous use, it was estimated that water passing to drain surplus to actual requirements could be as much as 136 m^3/d, some 5% of the total waste-water flow. Recommendations were therefore made for the fitting of pistol-grip self-closing valves on all hoses in use throughout the tannery.

Thus, it was concluded that total wastewater flows could be reduced from 2,600 m^3/d to 2,200 m^3/d, reducing the wastewater production to a more respectable 55 m^3/tonne wet-salted hide processed.

Step 16: Targetting and Characterizing Problem Wastes

a) *Sulphide Liquors*

As indicated in Step 9, it was evident that pretreatment of all sulphide-containing liquors was needed before they became mixed with other acidic flows; the possibility also existed of at least partial recycle of fine-screened sulphide liquors in subsequent unhairing operations.

The management favoured a flexible approach with the treatment system designed to handle the total daily sulphide liquor flow if required, conscious that sulphide liquor recycle would probably require a higher level of surveillance of the efficiency of the unhairing operation which might not be readily achieved on a consistent basis in practice.

The audit team then proceeded to draw up design flow and strength data for the pretreatment of sulphide-bearing waste streams; and also for the subsequent combined wastewater treatment facility required to meet the government's new discharge requirements.

Sulphide-bearing liquors were taken as being all the process and rinsewaters associated with the unhairing process and all wastewater associated with deliming/bating other than the final rinse. The resultant average design flow and sulphide load assessed were as shown in Table 8.

Table 8: Characteristics of Sulphide-Bearing Wastewaters

Parameter	Actual		Design	
Flow	590 m^3/d	*	600 m^3/d	
Sulphide	412 kg/d	(700 mg/l)	420 kg/d	(700 mg/l - ave.)
			600 kg/d	(1,000 mg/l - max.)

* assuming unhairing-stage rinsing carried out on a 2-stage batch basis to reduce water usage (equivalent to 27% of total wastewater flows following instigation of water saving)

An assessment was made of the likely BOD reduction due to oxidation of sulphide. The theoretical oxygen uptake rate due to oxidation of sulphide was taken as 0.75-2.0 kg O_2/kg S" depending on the ratio of the thiosulphate:sulphate oxidation products. Taking an average 1.4 kg O_2/kg S" and a 97% S" reduction (down to 20 mg/l S"), this gave a BOD reduction of 560 kg/d.

With reference to Table 7, the combined wastewater BOD load can be expected to reduce from 3,600 kg/d to 3,040 kg/d, equivalent to 1,380 mg/l BOD in a reduced flow of 2,200 m^3/d. Regarding the effect on suspended solids loads as a result of fine-screening of sulphide liquors, actual removals were difficult to predict accurately without further test work. As a conservative approach therefore, it was decided that the calculated total SS load of 4,825 kg/d (Table 7) should be carried forward as a design SS load for sizing and budgetary costing of the combined wastewater treatment plant; this gave a concentration of 2,190 mg/l SS at the predicted future reduced flow.

b) *Chrome Liquors*

The audit team considered the possibility of recovering chrome from the chrome-bearing liquors by fine screening, addition of sodium carbonate to precipitate chrome hydroxide (at pH 8-8.5), filter-plate pressing of the resultant sludge and then conversion of the chrome precipitate to soluble chromic sulphate using sulphuric acid.

Discussions with the management revealed that this possibility had been considered in the past but was not favoured on overall technical and cost grounds unless the benefits of economy of scale could be introduced by providing a centralised chrome recovery plant to serve all tanneries in the local area. While some preliminary discussions had been held through the national tannery association, such a scheme was not foreseen at this stage.

It was agreed therefore that for the present, the design of a new wastewater treatment plant should assume that chrome would be precipitated and disposed of off-site as part of the primary sludge generated.

Step 17: Segregation

In order to segregate sulphide liquors for separate pretreatment, it was decided to divert existing drainage outlets in the unhairing area to a batch treatment plant located within the existing tannery process building.

Treated flows would then be combined with all other wastewaters at a new treatment plant located close to the existing settlement lagoon facility.

Step 18: Developing Long-Term Waste Reduction Options

The waste audit consultant was responsible for drawing up outline proposals for the required new wastewater treatment facilities.

Consideration was given to available methods of sulphide treatment. These included:

- acidification to pH 2-3 and aeration, with absorption of the resultant hydrogen sulphide gas in caustic soda solution within packed-tower scrubbers prior to discharge of the resultant liquor to drain or reuse;
- precipitation with ferrous or ferric salts;
- oxidation using chlorine or hydrogen peroxide;
- oxidation using aeration with a manganese catalyst.

The latter method was considered the most technically satisfactory and cost-effective solution following fine screening. This view was supported by reference to available information sources concerning operational experience elsewhere.

It was decided to divert existing drainage outlets in the unhairing area to a mechanical self-cleaning screen (1 mm) located in a modified floor channel, the upper end being designed to convey screenings to an adjacent skip.

Screened flows would then gravitate to a submersible pumping station to lift flows into one of two batch-treatment oxidation tanks, one to be used for treatment and the other to be available for receiving the next batch of liquor. A diffused-air system, using non-clog coarse-bubble diffusers, was selected to provide mixing and aeration in each tank and a facility for dosing a solution of manganese sulphate catalyst was incorporated.

The main treatment plant for pretreated sulphide liquors combined with all other wastewater flows involved the following features:

- flow/pollution load balancing incorporating coarse-bubble aeration/mixing;
- pH correction (if required), chemical flocculation with alum and polyelectrolyte and subsequent primary settlement;
- extended aeration treatment using low-speed mechanical surface aerators (sized to provide a robust biological system capable of withstanding fluctuating loads);
- batch storage/thickening of mixed primary and surplus secondary sludges prior to pumping to drying beds and subsequent disposal of sludge cake to landfill.

Provision for iron salt dosing to the sludge storage/thickening tank was incorporated to precipitate any sulphide formed as a result of anaerobic activity within the tank and hence to minimise odour problems occurring.

A schematic diagram of the proposed treatment plant was compiled as illustrated in Figure 2.

Step 19: Environmental and Economic Evaluation of Waste Reduction Options

Company B was placed in a position of having to upgrade its wastewater treatment system in order to comply with new discharge standards imposed by the government, part of a new emphasis on the need to control pollution of the environment.

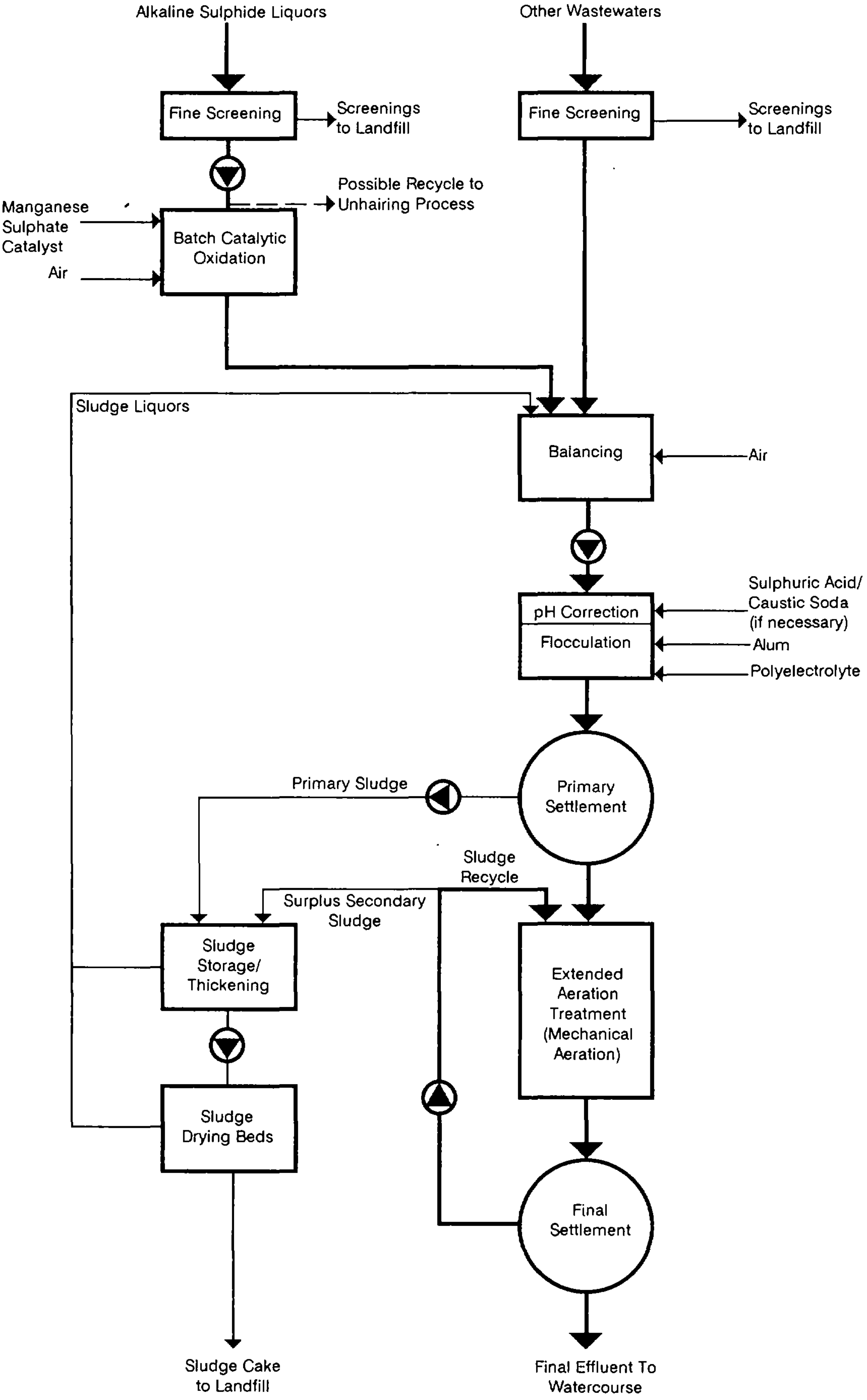
The new effluent discharge standards laid down were 40 mg/l BOD and 60 mg/l SS. Hence, provision of a new treatment facility designed to meet these standards consistently was expected to improve the quality of the local watercourse substantially.

There was a clear need to minimise capital and operating costs of the treatment scheme to ensure the overall financial viability of the company's operations. Therefore, in preparing outline designs for budgetary purposes, particular attention was paid to providing a plant which would be robust and relatively simple to operate.

The cost of the treatment scheme drawn up was estimated at US$500,000 including contingencies and design/construction supervision fees. This reflected a conservative approach to the sizing of the activated sludge process, particularly in terms of aeration capacity. It also took into account the availability of two redundant water storage vessels suitable for use as sulphide-liquor treatment tanks.

This approach was adopted to provide some flexibility over the mode of operation of the plant with a view to minimising operating costs - it would allow the primary settlement stage to operate without addition of chemical flocculants if desired, with consequent higher strength effluent

Figure 2: Schematic Diagram of Proposed Wastewater Treatment Plant



passing forward to the biological stage; overall sludge yields requiring ultimate disposal off-site would also be minimised. Provision for chemical flocculants at the primary stage was included however since it was felt that their use could enable the required final effluent quality to be achieved more consistently.

Step 20: Developing and Implementing an Action Plan: Reducing Wastes and Increasing Production Efficiency

The consultants engaged to carry out the waste audit/waste reduction studies presented the results of their findings to Company B's management. The data presented were used as a basis for submitting a planning application to the local government office for approval to design and install the proposed wastewater treatment plant.

During a subsequent meeting with the government concerning timing of the proposed design and construction work, Company B was informed that the introduction of a charging system for borehole abstraction was under consideration for possible implementation the following year. This development emphasised to the tannery management the importance of having carried out the waste audit/waste reduction investigations and the need to be alive to further water-saving possibilities in the future.

The waste audit/waste reduction investigations achieved the following objectives.

- A thorough appreciation of all the sources of waste at the tannery.
- Identification and quantification of the major sources of wastewater including waste sulphide and chromium contributions.
- Evaluation of processing efficiencies from assembled information on unit operations, raw materials, water usage, products and waste generation.
- Reduction of water usage and associated wastewater disposal problems.
- Identification of problem wastes (ie sulphide liquors) requiring special attention.
- Development of a waste management system which would comply with discharge regulations and result in a much-improved local environment.

CASE STUDY 3: PRINTED CIRCUIT BOARD MANUFACTURE

Company C manufactures double-sided and multi-layered circuit boards for the telecommunications and computer markets. The manufacturing of printed circuit boards involves a complex series of physical and chemical processing stages and as a result the wastewaters which are generated are complex, of variable composition and difficult to treat. To compound the treatment problems, many of the processing solutions contain proprietary chemicals whose composition is not readily available.

The main pollutants in printed circuit board manufacturing wastewaters are heavy metals, particularly copper. Company C's wastewater frequently exceeded the local authority's standards for discharges to the public sewerage system. Although the company had implemented some improvements to its wastewater treatment system in recent years, discharges in excess of the 5 mg/l limit on copper continued to occur and the local authority eventually decided to take legal action.

In response to these problems the company decided to conduct a waste audit in order to:

- bring to the attention of production personnel the importance of minimising wastage at source with a view to improving overall production efficiency while at the same time reducing both raw material costs and waste treatment costs;
- identify the sources of contamination;
- develop a waste reduction strategy to minimise contaminants at source;
- develop a sound understanding of the wastewater problems to facilitate the design of a cost-effective wastewater treatment system to comply with discharge standards.

The printed circuit board material is composed of a glass-fibre sheet with copper laminated on both sides. The uncut boards are received from the suppliers in large sheets and pass through a shearing stage to cut them to the desired size. The boards are then drilled and pass through a surface conditioning stage (deburring) before undergoing a series of treatments in the sensitising area (electroless plating). This treatment essentially coats copper into the holes and prepares the holes for electroplating.

The next stage involves the application of a photopolymer-resist material which masks off areas which do not need to be electroplated. The printed circuit areas are subsequently developed (to remove unexposed resist areas which are to be plated) and pass through microetching, copper electroplating, solder electroplating, resist stripping, copper etching and a number of other selected finishing treatments as specified by the customer. The last stages of manufacture involve final fabrication and electrical testing.

It can thus be seen that the printed circuit board manufacturing plant is complex and a great number of different process wastes are generated. The following case study describes the approach taken to overcome the long-standing waste treatment problems encountered by the company. The investigations were based on the step-by-step approach described in this waste audit manual and the studies highlighted a number of areas where processing and treatment efficiencies could be improved.

PHASE 1: PREASSESSMENT

Step 1: Audit Focus and Preparation

The waste audit programme was initiated by selecting an investigating team to carry out the required work and compiling all existing documentation and information relevent to the project.

In view of the scale of the investigatory work required, the audit team included representatives from each key manufacturing section. This not only increased employee awareness of and support for the study programme but enabled a full understanding of the factory processes and particular problem areas to be developed.

The audit team studied the practical aspects of initiating the required studies. It was decided that wastewater flow measurements and sampling could be readily conducted using internal resources but that it would be necessary to engage a contract laboratory to carry out the numerous wastewater analyses required.

Step 2: Listing Unit Operations

Due to the complex nature of the printed circuit board plant it was not considered appropriate to list all the unit operations in fine detail. Instead, following a detailed walk around the factory, the various manufacturing stages were compiled in terms of processing areas. Furthermore, as copper was by far the major contaminant of interest, it was decided at this stage to conduct the waste audit with specific reference to copper.

Figure 1 shows the general schematic process flow diagram which was constructed from the initial plant investigations. The areas where waste copper was generated were found to be the:

- deburring operation (sensitising);
- sensitising line (electroless plating);
- electroplating line (copper electroplating, solder electroplating, moist strip and copper etch);
- oxide coating area (including oxide deburring, oxide coating, solder stripping and lacquer finishing).

Step 3: Constructing Process Flow Diagrams

Once the main processing areas which generated waste copper had been identified the process flow diagrams were constructed for each area. This involved a more detailed study of each processing area and the identification of process inputs and outputs. In addition to the four processing areas mentioned, a process flow diagram of the existing wastewater treatment plant was also developed. Figures 2 - 6 show the process flow diagrams for these main processing areas. It should be noted that some diagrams are simplified for the purposes of the case study.

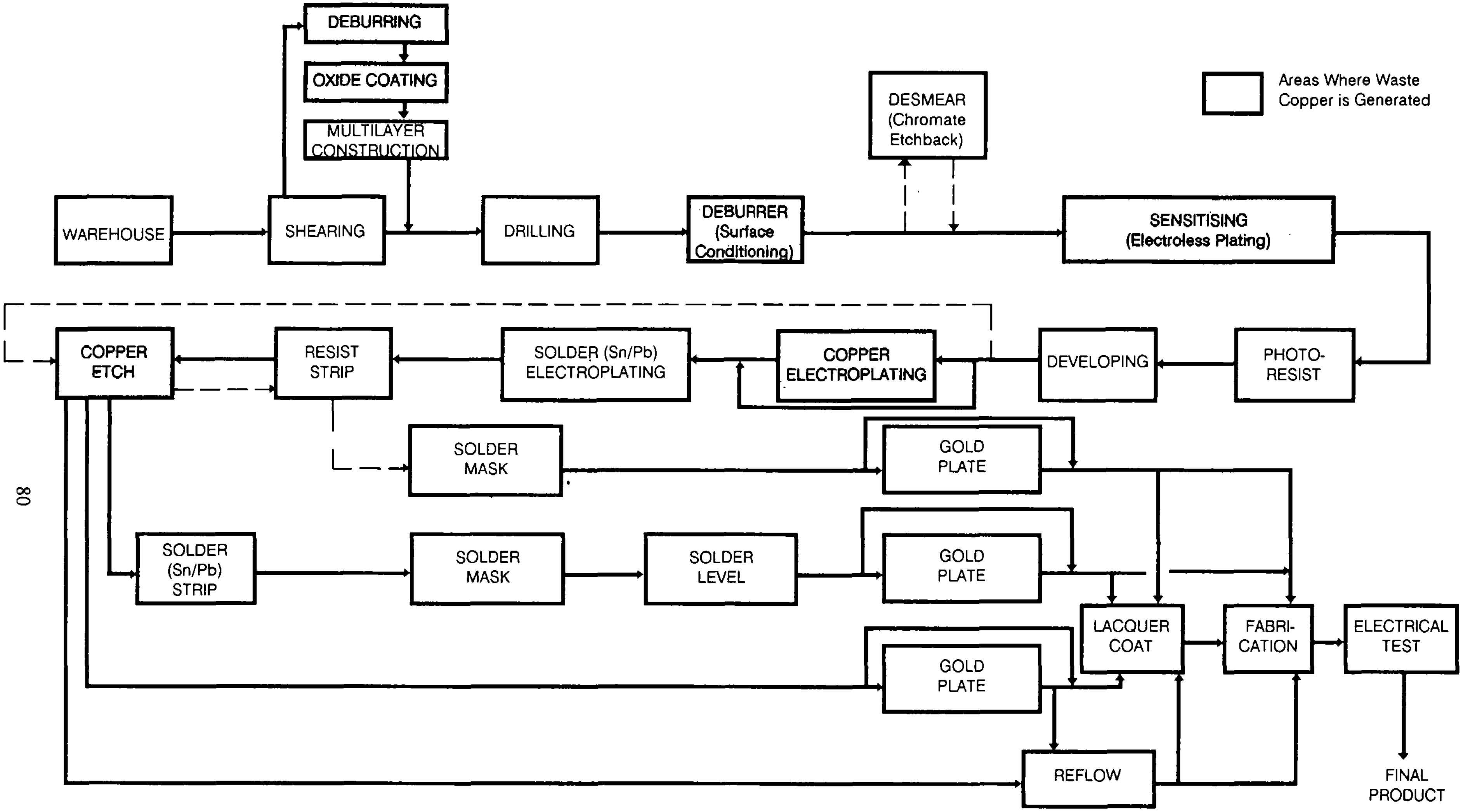


Figure 1: General Flow Diagram for the Printed Circuit Board Manufacturing Plant

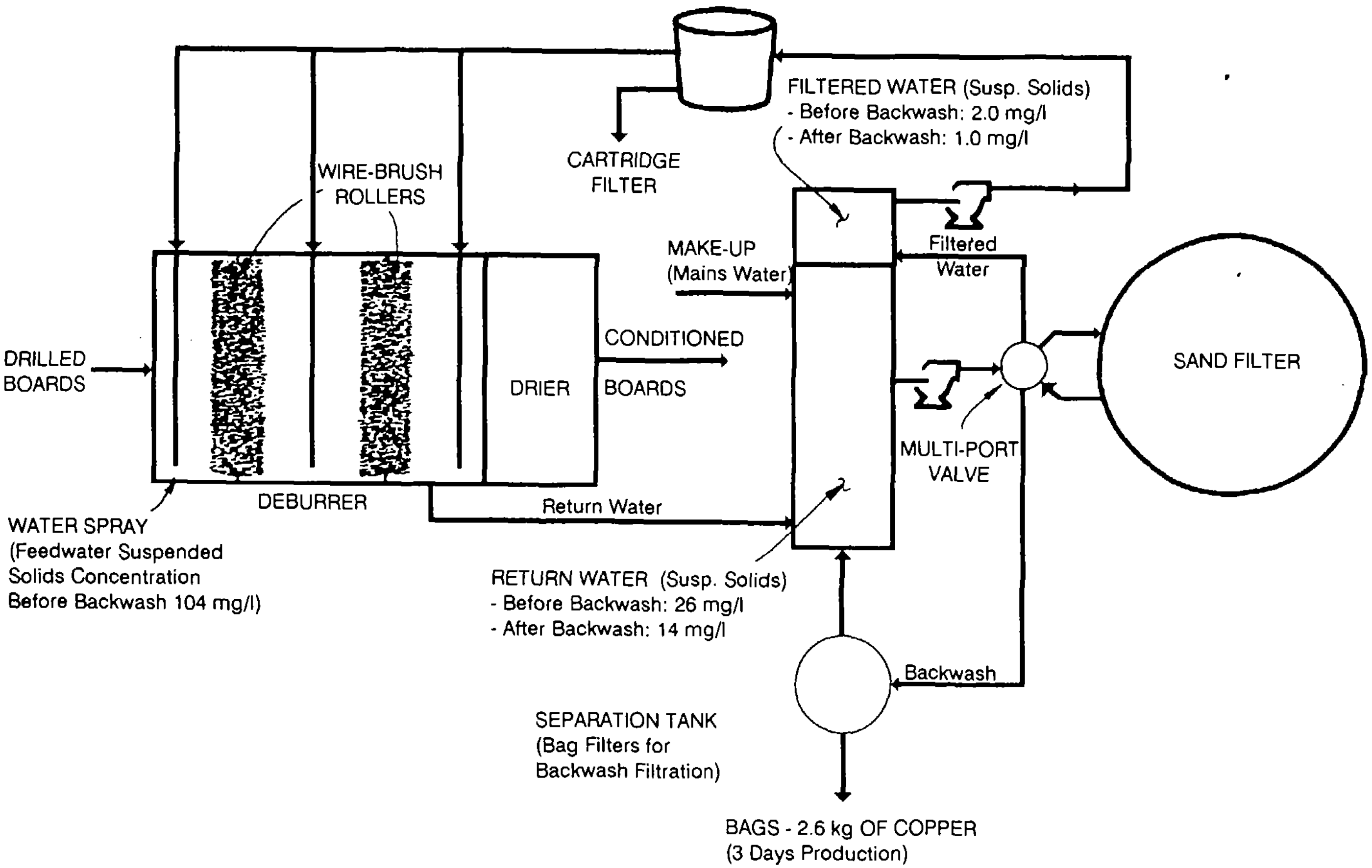
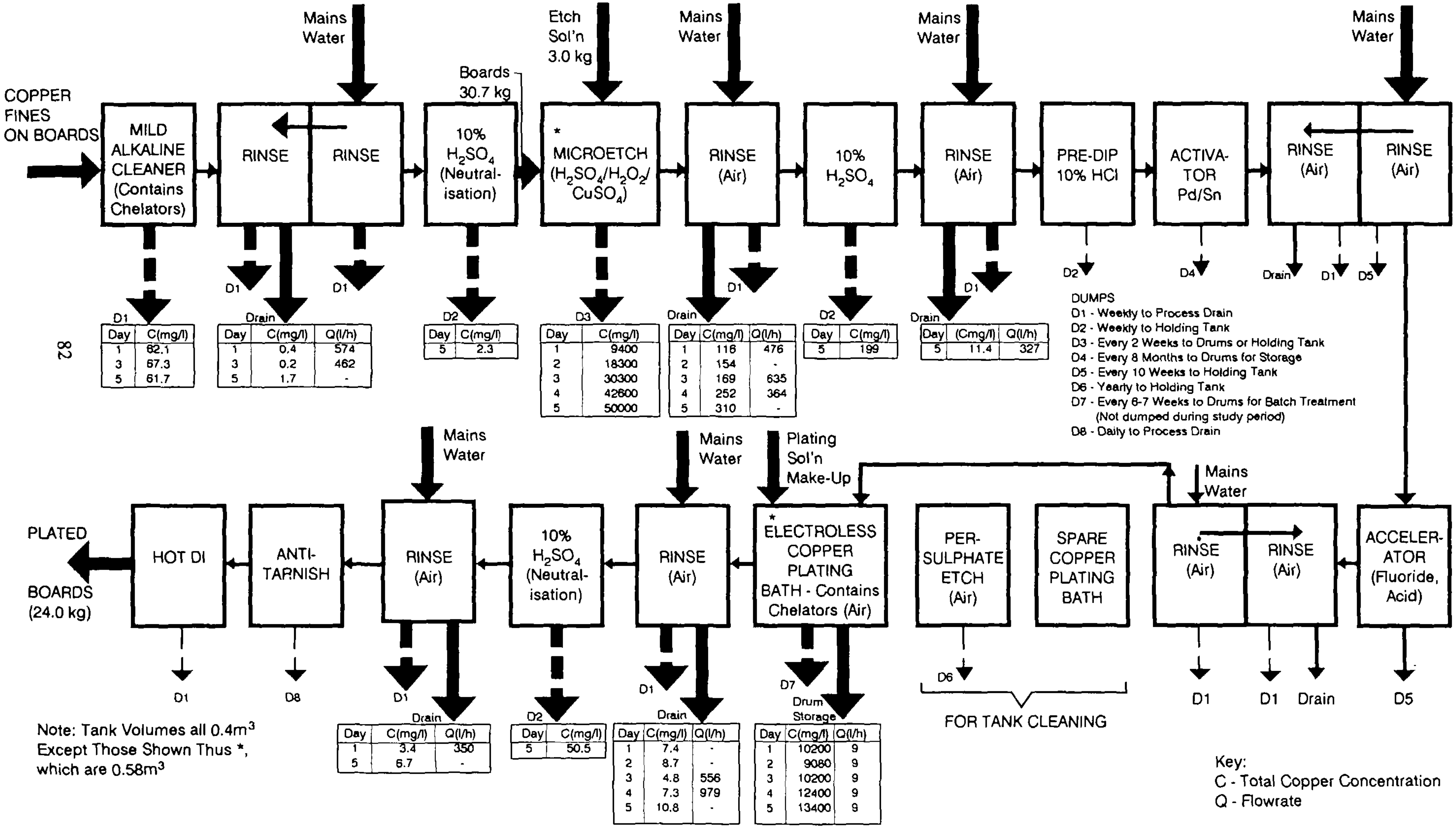


Figure 2: Process Flow Diagram for Sensitising Deburrer



D1 (Mild alkaline cleaner)

Day	C(mg/l)
1	62.1
3	67.3
5	61.7

Drain (Rinse)

Day	C(mg/l)	Q(l/h)
1	0.4	574
3	0.2	462
5	1.7	-

D2

Day	C(mg/l)
5	2.3

D3

Day	C(mg/l)
1	9400
2	18300
3	30300
4	42600
5	50000

Drain

Day	C(mg/l)	Q(l/h)
1	116	476
2	154	-
3	169	635
4	252	364
5	310	-

D2

Day	C(mg/l)
5	199

Drain

Day	(Cmg/l)	Q(l/h)
5	11.4	327

DUMPS
D1 - Weekly to Process Drain
D2 - Weekly to Holding Tank
D3 - Every 2 Weeks to Drums or Holding Tank
D4 - Every 8 Months to Drums for Storage
D5 - Every 10 Weeks to Holding Tank
D6 - Yearly to Holding Tank
D7 - Every 6-7 Weeks to Drums for Batch Treatment
(Not dumped during study period)
D8 - Daily to Process Drain

Drain

Day	C(mg/l)	Q(l/h)
1	3.4	350
5	6.7	-

D2

Day	C(mg/l)
5	50.5

Drain

Day	C(mg/l)	Q(l/h)
1	7.4	-
2	8.7	-
3	4.8	556
4	7.3	979
5	10.8	-

Drum Storage

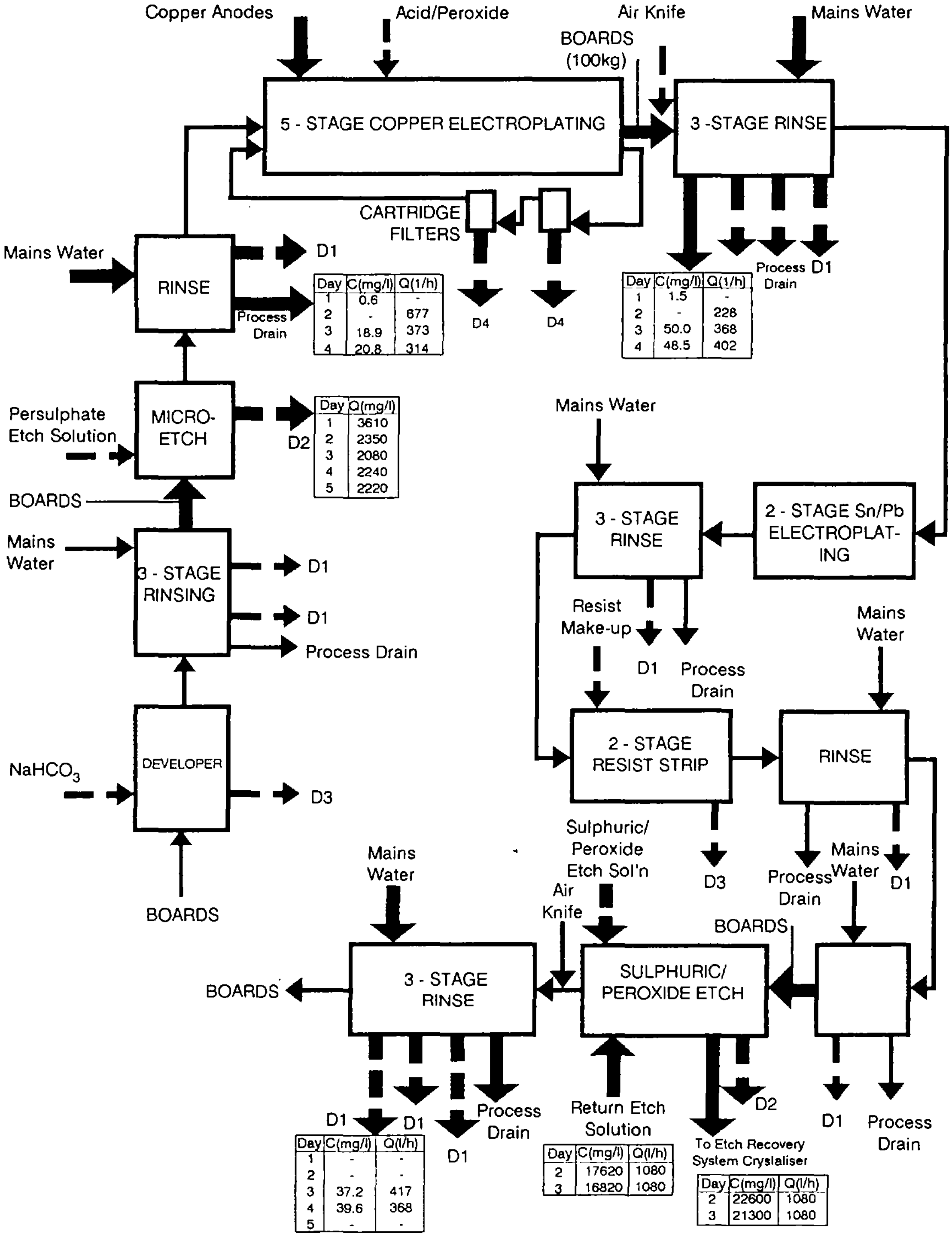
Day	C(mg/l)	Q(l/h)
1	10200	9
2	9080	9
3	10200	9
4	12400	9
5	13400	9

Note: Tank Volumes all 0.4m^3
Except Those Shown Thus *,
which are 0.58m^3

Key:
C - Total Copper Concentration
Q - Flowrate

Figure 3: Process Flow Diagram for Sensitising (Electroless Plating) Area

Figure 4: Process Flow Diagram for 9000 Line (Cu Electroplating Sn/Pb Electroplating, Resist Strip and Etching



Day	C(mg/l)	Q(1/h)
1	0.6	-
2	-	677
3	18.9	373
4	20.8	314

Day	Q(mg/l)
1	3610
2	2350
3	2080
4	2240
5	2220

Day	C(mg/l)	Q(1/h)
1	1.5	-
2	-	228
3	50.0	368
4	48.5	402

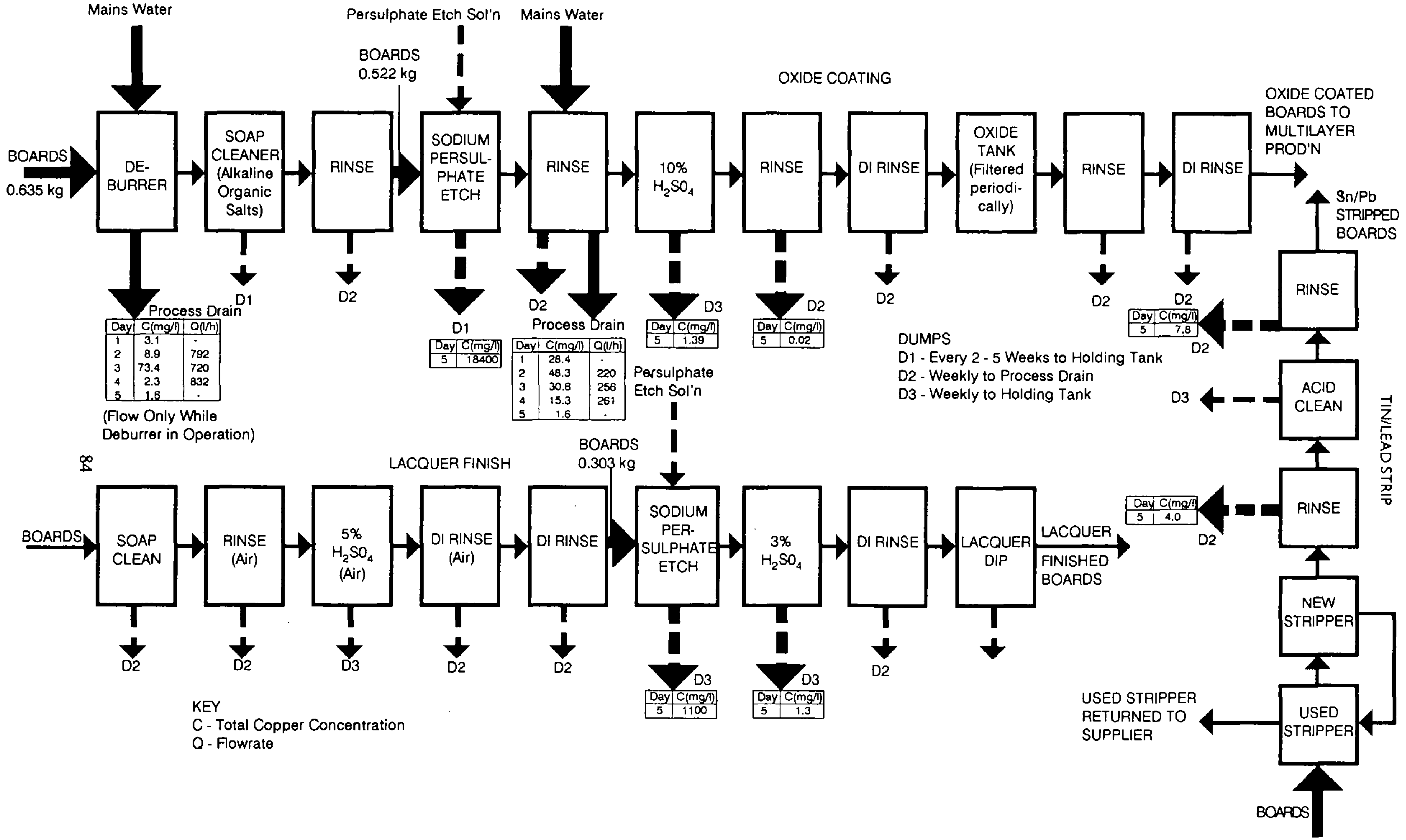
Day	C(mg/l)	Q(l/h)
1	-	-
2	-	-
3	37.2	417
4	39.6	368
5	-	-

Day	C(mg/l)	Q(l/h)
2	17620	1080
3	16820	1080

Day	C(mg/l)	Q(l/h)
2	22600	1080
3	21300	1080

KEY
C - Total Copper Concentration
Q - Flowrate

DUMPS
D1 - Daily to process sewer
D2 - Monthly to holding tank
D3 - Daily to holding tank
D4 - Change filters quarterly



Process Drain (Deburrer)

Day	C(mg/l)	Q(l/h)
1	3.1	-
2	8.9	792
3	73.4	720
4	2.3	832
5	1.6	-

D1 (Sodium Persulphate Etch)

Day	C(mg/l)
5	18400

Process Drain (Rinse)

Day	C(mg/l)	Q(l/h)
1	28.4	-
2	48.3	220
3	30.8	256
4	15.3	261
5	1.6	-

D3 (10% H_2SO_4)

Day	C(mg/l)
5	1.39

D2 (Rinse)

Day	C(mg/l)
5	0.02

D2 (Rinse, Tin/Lead Strip, upper)

Day	C(mg/l)
5	7.8

D2 (Rinse, Tin/Lead Strip, lower)

Day	C(mg/l)
5	4.0

D3 (Sodium Persulphate Etch, Lacquer Finish)

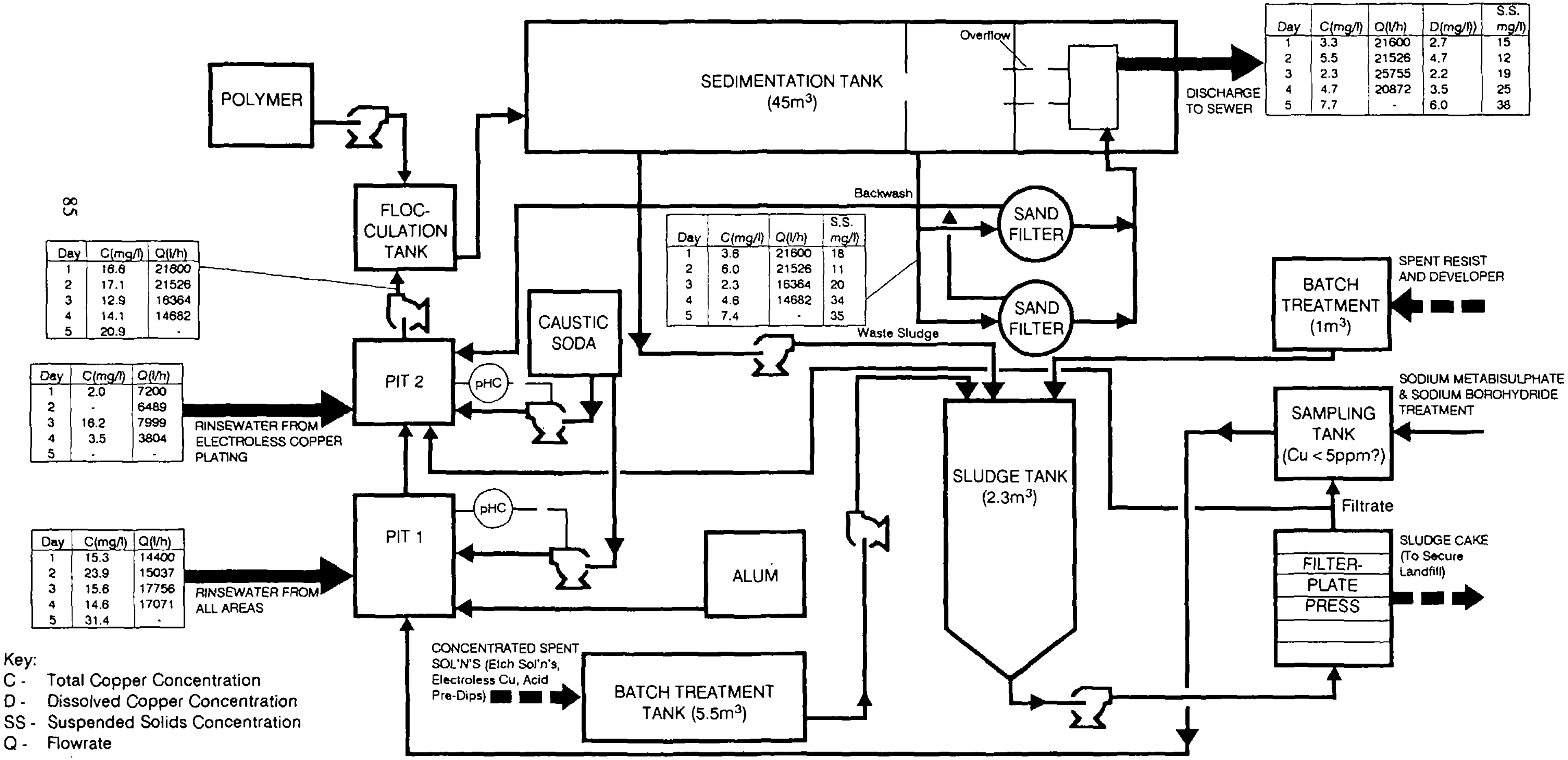
Day	C(mg/l)
5	1100

D3 (3% H_2S0_4)

Day	C(mg/l)
5	1.3

Figure 5: Process Flow Diagram for Oxide Coating, Lacquer Finish and Tin/Lead Strip

Figure 6: Process Flow Diagram for Wastewater Treatment Plant



Day	C(mg/l)	Q(l/h)	D(mg/l))	S.S. mg/l)
1	3.3	21600	2.7	15
2	5.5	21526	4.7	12
3	2.3	25755	2.2	19
4	4.7	20872	3.5	25
5	7.7	-	6.0	38

Day	C(mg/l)	Q(l/h)	S.S. mg/l)
1	3.6	21600	18
2	6.0	21526	11
3	2.3	16364	20
4	4.6	14682	34
5	7.4	-	35

Day	C(mg/l)	Q(l/h)
1	16.6	21600
2	17.1	21526
3	12.9	16364
4	14.1	14682
5	20.9	-

Day	C(mg/l)	Q(l/h)
1	2.0	7200
2	-	6489
3	16.2	7999
4	3.5	3804
5	-	-

Day	C(mg/l)	Q(l/h)
1	15.3	14400
2	23.9	15037
3	15.6	17756
4	14.6	17071
5	31.4	-

Key:
C - Total Copper Concentration
D - Dissolved Copper Concentration
SS - Suspended Solids Concentration
Q - Flowrate

PHASE 2: MATERIAL BALANCE: PROCESS INPUTS AND OUTPUTS

Due to the relative complexity of the printed circuit board plant the inputs and output information collected for the unit operations were recorded on the process flow diagrams based on Steps 4 - 10 of the waste audit manual. Any areas of inefficient operation and any opportunities for waste reduction were also noted. These opportunities are discussed later in Steps 15 -18.

Step 4: Determining Inputs

Input information was obtained from measuring chemical additions and water use and recording the area of copper circuit boards processed (etched);etching of the copper circuit boards involves acid treatment for surface conditioning, or finishing, and represents a significant copper input. In the case of the electroplating line the weight of copper anode used (the source of copper for electroplating) was estimated from past data. The wastewater treatment plant inputs were determined by measuring the total wastewater flows and concentrations.

Copper input information for the five processing areas was then recorded on the process flow diagrams in Figures 2 - 6.

Due to the nature of the copper raw materials (copper sulphate solutions and copper laminated boards) no handling losses were considered to occur prior to the processing operations.

Step 5: Recording Water Usage

The rinsewater flowrates were measured at the inlet to the rinse tanks by measuring the time to fill a known volume container or by draining down the rinse tanks and measuring the time to refill. The company had recently installed flow restrictors on the rinsewater feed pipes, a good water conservation measure, in order to limit the amount of water being used in the rinsing operations. In general, the flowrates measured were in accordance with the ratings for the flow restrictors.

The water usage data was also recorded on the process flow diagrams (Figures 3 - 6).

Step 6: Measuring Current Levels of Waste Reuse/Recycling

Copper-containing wastes were not generally reused at the plant. However, there was an on-line crystalliser on the sulphuric/peroxide etch stage of the electroplating line. The etch solution is pumped from the etch tank through the heat exchanger and into the copper sulphate crystalliser where the spent etch solution is cooled to 16°C. Copper sulphate crystals are precipitated and then conveyed to storage tanks, drained and subsequently sold to a local plating shop. The recovered etch solution is returned to the etch feed tank. The quantity of etchant reused is described as an input in Figure 4.

Step 7: Quantifying Process Outputs

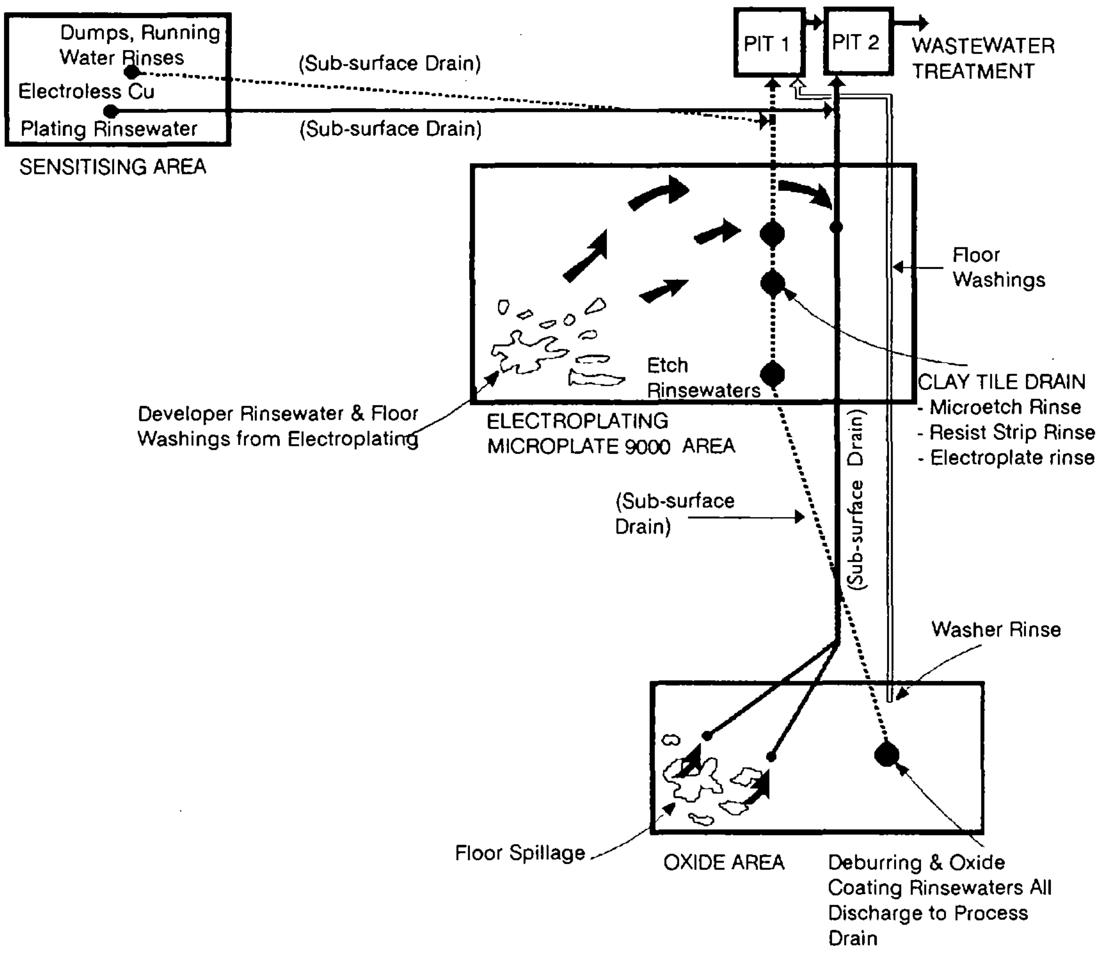
The copper-related process outputs were identified and then quantified from copper plating records and the measurement of waste masses, volumes and concentrations. Apart from the quantity of copper plated on to the printed circuit boards, which was determined from production information and plating thickness used, the process output information was obtained from measurements taken in the plant.

Step 8: Accounting for Wastewater

All the wastewater streams which were identified as containing copper (from Steps 1 and 7) were investigated in a thoroughly planned and conceived sampling programme. The sampling was performed over a production week in order to cover the full range of operating conditions and to ensure representative data. Composite samples were taken for all running wastewater streams whereas spot samples were obtained in the case of bath tanks and dumpings. Samples were also taken of the outputs from the wastewater treatment plant. The samples were carefully labelled, logged and sent out to an independent laboratory for copper and supporting analyses. Wastewater flows and tank volumes were also recorded. The wastewater information is described in Figures 2 - 6.

In addition, a process flow diagram describing the layout of the process drains was constructed (Figure 7). Dye tests were performed to determine the fate of the wastewater streams and the layout and interconnections of the surface drains. These studies highlighted some unnecessary and complex rinsewater piping arrangements which were subsequently modified by plant engineering staff.

Figure 7: Layout of Process Drains



Step 9: Accounting for Gaseous Emissions

The site investigations indicated evidence of a number of gaseous emissions. These were largely associated with forced-ventilated fume hoods to remove air-borne particulates from grinding operations and also acid and solvent fumes from subsequent process areas.

As wastewater issues were considered to be of priority concern for the current waste audit, it was decided that gaseous emissions would be a subject for further study at a later date.

Step 10: Accounting for Off-Site Wastes

The quantity of waste material stored on site and transported off-site for disposal was estimated from in-plant investigations and study of company records. The registerable wastes disposed of off-site included copper fines (270g/100m^2 of board), cartridge filters, and filter-press cake (1360 kg/week). The tin lead activator dump (0.7 m^3/annum) was stored on-site as registerable liquid waste.

Step 11: Assembling Input and Output Information for Unit Processes

The material balances were started by assembling the complete input and output data, converted to standard units, on the process flow diagrams (Figures 2 - 6).

Step 12: Deriving a Preliminary Material Balance for Unit Processes

From the collated information the preliminary balances were constructed for each processing area.

a) *Sensitising Deburrer*

The deburrer located in the sensitising area is operated in a recycle mode (see Figure 2). Return water is continuously filtered to remove copper fines before being fed back to the deburrer. Captured copper fines are subsequently backwashed from the sand filter and collected in the bag filter. Essentially the copper inputs are from the brushed boards and the outputs are from the sand filter backwash bag filter and the cartridge filter. An accurate mass balance could not be constructed from the available information as the thickness of copper removed from the boards could not be determined precisely. However, the company did plan to purchase a high-resolution microscope in the near future which would enable accurate determination and control of copper thicknesses removed.

b) Sensitising (Electroless Plating)

The preliminary material balance for the electroless plating line is shown below.

Copper Inputs (kg/week)	
Copper fines from deburrer	0.040
Boards (microetch)	30.700
Etch solution	3.000
Electroless plating solution	25.000
Total	58.743

Electroless Plating

Copper Outputs (kg/week)	
Boards (plated)	21.283
Rinsewaters	4.867
Dumps	0.261
Microetch dump	29.000
Electroless copper (storage)	4.400
Total	60.811

c) Electroplating Line (Microplate 9000 line)

Copper Inputs (kg/week)	
Boards (microetch)	0.667
Boards (sulphuric/peroxide etch)	209.586
Copper anodes	124.500
Return etch solution	743.904
Total	1078.657

Microplate 9000 Line

Copper Outputs (kg/week)	
Boards (plated)	100.078
Rinsewaters	1.474
Dumps	0.523
To etch recover (18 l/min) including 217.000 kg crystallised copper)	948.240
Total	1050.315

No make-up or dump of the sulphuric acid/peroxide etch tanks was made during the study period and as the crystalliser maintains a constant copper concentration in the etch tank these inputs and outputs were not considered in the material balance study.

d) Oxide coating area

Copper Inputs (kg/week)	
Boards (deburring)	0.653
Boards (microetches 10x10^{-6} inch)	0.825
Total	1.478

↓

Deburrer, Oxide Coating and Lacquer Finish

↓

Copper Outputs (kg/week)	
Rinsewaters	0.195
Dumps (drain)	0.003
Dumps (holding tank)	0.311
Copper fines (to drain)	0.632
Estimated copper increase in oxide Microetch bath	0.347
Total	1.488

e) Wastewater treatment

Copper Inputs (kg/week)	
Pit 1 Influent	12.493
Pit 2 Influent	12.893
*Concentrated spent solution	1.095
Total	26.481

↓

Wastewater Treatment System

↓

Copper Outputs (kg/week)	
Sewer discharge	5.239
Filter-plate press sludge (Estimated by difference)	21.242
Total	26.481

* No concentrated copper solutions treated in the study period

The volume of the filter-plate press sludge was estimated by difference as the sludge was withdrawn from the clarifier on an irregular and infrequent basis.

In addition, a material balance was constructed from all the rinsewaters and daily dumps to the process drains and the feed to the wastewater treatment system over days 1 - 4. (This mass balance primarily represents the rinsewaters as most of the dumps are carried out on day 5.)

Copper Inputs (kg)	
Rinses	
Sensitising	
Alkaline cleaner rinse	0.014
Microetch rinse	4.404
Acid rinse	0.115
Electroless	0.259
Acid rinse	0.019
Electroplating Line	
Mircoetch	0.191
Floor capture	0.276
Electroplating	0.607
Etch rinse	0.600
Oxide Area	
Deburrer	0.653
Etch	0.025
Dumps	
Electroplating Line	
Mircoetch rinse	0.048
Electroplate rinse	0.235
Etch rinse	0.180
Total	8.346

Drains

Copper Outputs (kg)	
Treatment plant influent (total)	9.192

Step 13: Evaluating the Material Balance

Each material balance drawn up showed a good agreement considering the complexity of the printed circuit board manufacturing plant and the large number of waste copper sources. Approximately 91 percent of the copper loading into the treatment plant during production days 1 - 4 was accounted for by the measured wastewater sources. The extra 9 percent was probably due to copper being washed from contaminated floor areas and further minor sources of copper which were not included in the survey (eg gold plating line).

The following conclusions were made.

- The microetch rinse accounted for approximately 90 percent of the total sensitising area copper loading.
- The microetch rinse accounted for approximately 56 percent of the plant's total rinsewater copper loading on the treatment plant.
- Other major sources of rinse water contamination were electroplating rinse, sulphuric/peroxide etch rinse and the deburrer (oxide area) rinse.

PHASE 3: SYNTHESIS

Step 14: Refining the Material Balance

The preliminary material balance work, while giving very satisfactory results, had included a number of assumptions and estimates (by difference) had to be made; this particularly applied to the oxide-coating and wastewater treatment areas. A decision was therefore made to refine the material balance backing up the estimates by further monitoring and information gathering.

Step 15: Examining Obvious Waste Reduction Measures

From the information accumulated from the waste audit and observations which were made while investigating the plant in detail a number of obvious waste reduction and efficiency improving measures were identified. These again split into the four processing areas and the wastewater treatment plant.

a) Deburring operations (sensitising area)

It was noted that the sand filter associated with deburring operations was backwashed with return (dirty) water which would lead to entrainment of copper fines throughout the sand bed. This could lead to fines being released into the filtered water. The deburred spray water had a suspended solids concentration of 104 mg/l. This high concentration probably accounted for the fine powder layer which was observed on the printed circuit boards after the deburrer drier. While this only represented a small input of copper into the sensitising line (0.04 kg/week), it created a potential adverse effect on product quality control.

The waste copper fines which were collected on the backwash bag filter system (2.6 kg per 3 days production) are transported to a secure landfill site together with sludge cake from the filter press. However, the fines are relatively pure copper and investigations confirmed them to have a value of approximately US$0.9/kg corresponding to a small potential income of US$275 per annum.

b) The sensitising line (electroless plating)

As discussed previously, the results of the wastewater characterisation showed that a very high copper loading was from the microetch rinse (90 percent of the sensitising rinsewater copper load). The sensitising line is a manually-operated plating line and it was observed that no drip time was used after the microetch. A one minute drip time was thus introduced and a monitoring programme initiated to record improved waste loadings. It was subsequently concluded that a static-rinse drag-out tank should be installed in the longer term to reduce further the running rinsewater loading from this source.

c) Electroplating line

It was noted that the recirculation pumps on the copper electroplating line had leaking mechanical seals leading to copper crystallisation on the pump shafts and surrounding floor areas. This copper material was subsequently picked up by the developer rinse, which flowed directly onto the floor, and discharged to the floor drain leading to Pit 12. The copper loading from this source at one floor drain closed to the electroplate rinse was approximately 70 g/d.

It was considered that although this pollution load passing to a drain was small, a satisfactory maintenance programme to prevent all such leaks and installation of drip trays and general cleanliness in the copper electroplating areas could reduce this source of waste loading on the treatment plant. Good housekeeping in all copper processing and handling areas could prevent copper waste loading from other areas (eg copper etch and crystallisation) from reaching the drain system.

d) *Oxide coating area*

The rinsewater from the deburrer in the oxide coating area was discharged directly to the process drain. A bag filter was attached to the pipe at the outlet to the drain but during the in-plant study the capturing device was inefficient leading to significant quantities of copper fines being released to the drain system. Contact with acid wastewaters would subsequently dissolve the fines in the process drains. Using existing equipment stocks, a closed-loop filtration system similar to the one in the sensitising area was added as a relatively simple control measure, eliminating this source of waste copper.

e) *Wastewater treatment system*

A number of inefficient operations in the wastewater treatment system were highlighted in the waste audit. First, alum was added to the pH corrected (pH 8.5) wastewater in Pit 1. Alum is an effective coagulant for colloidal material but is not necessary for metal hydroxide precipitation and increases the volume of sludge produced.

Second, the existing sedimentation basin was of poor design. Inadequate sludge removal capability and floating sludge were creating effluent discharge problems.

Third, in an effort to overcome the periodic high levels of copper being discharged to the public sewer, two sand filters were installed in parallel after the sedimentation tank. However, from the results in Figure 6 it can be seen that the sand filters were not effective in removing suspended solids or copper from the wastewater.

Assuming a 50 percent reduction of copper loading from the sensitising microetch rinse through improved rinsing, and elimination of the copper loading from the deburrers and electroplating area floor drain, a 40 percent reduction in rinsewater loading to the wastewater treatment plant could be achieved.

Step 16: Targeting and Characterizing Problem Wastes

From Figure 6 it can be seen that the sand filter input concentrations of suspended solids and copper are approximately equal to the output concentrations from the filter. Furthermore, the copper discharged to the public sewer was primarily dissolved (75 - 95 percent of total copper concentration) and in excess of the sewer discharge limits on days 2 and 5. Previous experience with the treatability of the printed circuit board wastewaters had established that the electroless copper wastewaters were particularly difficult to treat because of the presence of chelating agents in the electroless copper plating solution. In addition, chelating agents were present in the resist stripping solution. It was noted that when the treated resist strip was dumped to Pit 2 on days 2 and 4, significantly higher copper concentrations were observed in the discharge to the public sewer than on days 1 and 3. Day 5 (Friday) represents an atypical waste treatment day as weekly dumping of tanks in the sensitising and oxide areas occurs on this day.

The chelate containing copper wastewater and combinations of copper and chelate containing wastewaters were therefore considered to be 'problem wastes'.

Wastewater treatability tests using alum, sodium hydroxide, lime and a range of flocculants were conducted on samples from each individual pollutant source and on combined samples. The tests indicated that most copper containing wastewaters could be treated very successfully by metal hydroxide precipitation. However, the chelating agents in the electroless rinse and resist strip rinse affected copper hydroxide precipitation and should therefore be segregated and treated separately.

As indicated in Table 1, the tests on the influent wastewater treatment plant indicated that copper could be reduced from relatively high concentrations to less than the 5 mg/l standard using lime and anionic polymer flocculant. In general, lime produced a more dense and settleable precipitate than sodium hydroxide although it generated more sludge.

Table 1: Treatability Tests using Lime and Anionic Polymer

Sample	Raw/Treated	Total Copper in Supernatant (mg/l)
Sensitising		
Microetch rinse	Raw	260.0
	Treated	0.3
Electroless rinse	Raw	9.1
	Treated	9.0
Electroplating Line		
Microetch rinse	Raw	22.0
	Treated	0.2
Copper electroplate rinse	Raw	33.0
	Treated	0.2
Copper electroplate rinse Resist strip rinse (50:50)	Raw Treated	19.0 20.0
Electroplate floor drain	Raw	44.0
	Treated	0.1
Sulphuric/peroxide etch rinse	Raw	40.0
	Treated	0.1
Oxide Coating		
Microetch rinse	Raw	150.0
	Treated	1.1
Wastewater Treatment		
Influent	Raw	11 74 13 73 8.4*
	Treated	0.4 0.6 0.4 4.0 0.7

*Hourly spot samples

Step 17: Segregation

It was clear from the findings of the waste audit investigations that waste segregation would form a necessary part of any long-term waste reduction programme in order to develop a technically satisfactory and cost-effective system. This aspect will be described in Step 18 below.

Step 18: Developing Long-Term Waste Reduction Options

While the waste reduction alternatives described in Step 15 will reduce pollutant loadings and result in significant cost savings, an efficiently designed and operated end-of-pipe treatment section describes the wastewater treatment and recovery system design which was developed from the waste audit and treatability studies with the assistance of a consultant engineering company.

The major points for consideration in the system design were as follows.

- Segregation of all the chelate-containing wastewaters from the conventional metal hydroxide precipitation system.
- Segregation and separate treatment/recovery of all the chelate-containing rinsewaters and concentrated bath-dumps.
- Collection of all general bath dumps (non-chelate containing) in a holding tank for metering back to the conventional treatment system at a controlled rate (to prevent surges in copper loading).
- Upgrading of existing pH adjustment, polymer addition, clarification and sand filtration systems for efficient metal hydroxide precipitation and subsequent discharge of high quality effluent.

Information on the type of chelator or chelate concentration was not readily available from the chemical suppliers.

The sources of chelate containing wastewaters were as follows:

Source	Flowrate (l/h) or Volume (litres)	Copper Concentration (mg/l)
Mild Alkaline Cleaner Bath	400 litres	63.7
Mild Alkaline Cleaner Rinse	518 litres	0.8 (max 1.7 mg/l)
Electroless Plating Bath	588 litres	11000
Electroless Plating Bleed	10 l/h	11000
Electroless Plating Rinse	770 l/h	7.7 (max 10.3 mg/l)
Resist Strip Bath	920 litres	Less than 5.0
Resist Strip Rinse	390 l/h	-

The proposed treatment system incorporates the following key elements.

- Collection of all non-complexed rinsewaters in a common sump for pH adjustment with caustic (or lime) to pH 9.0 - 9.5.
- Installation of a static-rinse tank after the electroless copper plating bath. The static-rinse tank will collect most of the drag-out loading from the electroless plating bath and will then be dumped daily for electrolytic recovery. The subsequent continuous-flow rinsewater (chelate-containing), operated on a counter-current principle, will then be discharged directly to the public sewer.
- Segregation, cartridge filtration and direct discharge of resist strip rinsewaters (chelate-containing) to the clarified water storage tank.
- Segregation and direct discharge of electroless plating running rinsewaters and cleaner rinsewaters (chelate-containing) to the clarified water storage tank.

- Segregation and collection of resist strip and developer dumps (or bleed) in a separate holding tank for pH adjustment and direct discharge.
- Segregation and collection of electroless copper (chelate-containing) bath dumps, controlled bleed and drag-out tank contents together with alkaline cleaner (chelate-containing) and microetch (sensitising) bath dumps in a separate batch recirculation tank for electrolytic copper recover. Possible alternatives involving sulphide precipitation or sodium borohydride treatment were also considered but discounted on technical and cost grounds.
- Polishing of electrolytically treated solutions in a chelating ion exchange resin bed prior to discharge to the clarified water storage tank.
- Segregation and collection of general bath dumps (eg microetches, predips, acids, alkalis, etc.) in a holding tank for subsequent metering into the pH adjustment sump.
- Modification of the existing sedimentation tank to incorporate a clarified water storage tank and provision for capture of accidental spills and emergency waste storage.
- Provision of an inclined-plate clarifier following existing pH control and flocculation units with sludge pumped to a sludge storage/thickening tank. Thickened sludge will then be periodically pumped from the storage tank for dewatering in the filter-plate press. The reduced volume of sludge cake will then be disposed of in a secure landfill site.
- Although it is considered that the effluent copper concentration from the proposed treatment system will comply with the existing discharge standard of 5 mg/l, it was recommended that the company's sand filters be upgraded and included in the treatment scheme in anticipation of the proposed lowering of the standard to 2 mg/l of copper. In this case, the clarified wastewater should be polished through a sand/anthracite dual-media bed to increase the solids loading capacity of the filters.

Step 19: Environmental and Economic Evaluation of Waste Reduction Options

As Company C was facing legal action from the local authority with respect to violation of discharge standards, the return on investment was not of prime concern in this case study; of more importance was the development of the most cost-effective reduction/waste treatment system available, and a quality of final effluent for sewer discharge compatible with the local authority's environmental pollution control requirements.

From Step 18 a number of waste treatment recovery alternatives were identified and a process design subsequently derived on the basis of technical considerations. However, through the waste reduction opportunities described and the segregation and recovery of copper from the chelate-containing and microetch (sensitising) wastes it was estimated that a cost saving of US$22,000 per annum on sludge transportation and secure landfill disposal costs could be realised. In addition, it was estimated that approximately US$3,500 per annum of copper could be recovered using the electrolytic recovery unit.

The total installed cost of the proposed system including the major equipment items (inclined-plate clarifier, sludge storage/thickening tank, filter-plate press, electrolytic copper recovery unit, ion exchange unit) segregation pumping and piping, instrumentation and control and 40 m^2 building was US$265,000. However, considering the company's history of pollution problems, the impending legal action and the amount of time being spent by senior personnel on day to day waste management problems, the implementation of the waste segregation and treatment/recovery system could be considered money well spent and an investment for the future.

Step 20: Developing and Implementing an Action Plan: Reducing Wastes and Increasing Production Efficiency

The results of the waste audit and the waste reduction/treatment studies were presented to the company's management and plans were made to implement the recommended waste reduction measures and the treatment/recovery system.

The waste audit-reduction approach achieved the following objectives.

- A sound understanding of all the sources of waste copper at the manufacturing plant.
- Identification and quantification of the major sources of waste copper.
- Evaluation of processing efficiencies from assembled information on unit processes, raw materials, water usage, products and waste generation.
- Identification of waste reduction opportunities.
- Elimination of some wastes and associated disposal problems.
- Identification of problem wastes requiring special attention.
- The development of a cost-effective, integrated waste segregation and wastewater treatment/recovery system.
- The development of a waste management system which would comply with discharge regulations and result in improved public relations.

CHAPTER 4
RESOURCE SECTION

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APPENDIX 1: WASTEWATER FLOW AND GAS MEASUREMENT METHODS

Wastewater Flow Measurements

This section describes simple methods of measuring flows in open channels using triangular-notch (V-notch) or rectangular thin-plate weirs.

The discharge over thin-plate weirs is a function of the depth (head) of liquid on the weir, the size and shape of the discharge area, and an experimentally determined coefficient.

Thin-plate weirs should be vertical and perpendicular to the walls of the channel, constructed in steel, wood or similar smooth-surfaced robust material.

The intersection of the weir plate with the walls and floor of the channel should be watertight and firm, putty or other suitable material being used as a sealant as appropriate. Weirs are best installed under no-flow conditions to ensure that a good seal is obtained. Where wastewater flows normally arise 24 hours per day, 7 days per week, this can create problems unless production can be temporarily stopped. In such circumstances, the weir should at least be installed under low-flow conditions in order to facilitate the installation procedure and to minimise risk of leaks around or under the weir occurring.

In general, the weir should be located in a straight, horizontal, rectangular channel if possible. Ideally the length of the approach channel should not be less than 10 times the width of the jet (nappe) formed by the flow over the weir at maximum head.

The shape and size of the channel downstream from the weir is of no significance, but the level of the water in the downstream channel should be a sufficient vertical distance below the crest to ensure free, fully-ventilated discharges.

V-notch weirs permit the accurate measurement of much lower discharges than do rectangular weirs. Also, the discharge over a V-notch increases more rapidly with the head than in the case of a rectangular weir. Thus, where flow variations over a working day are large, use of a triangular-notch (V-notch) weir is preferable. For large flows however, a broad-crested rectangular weir may be necessary.

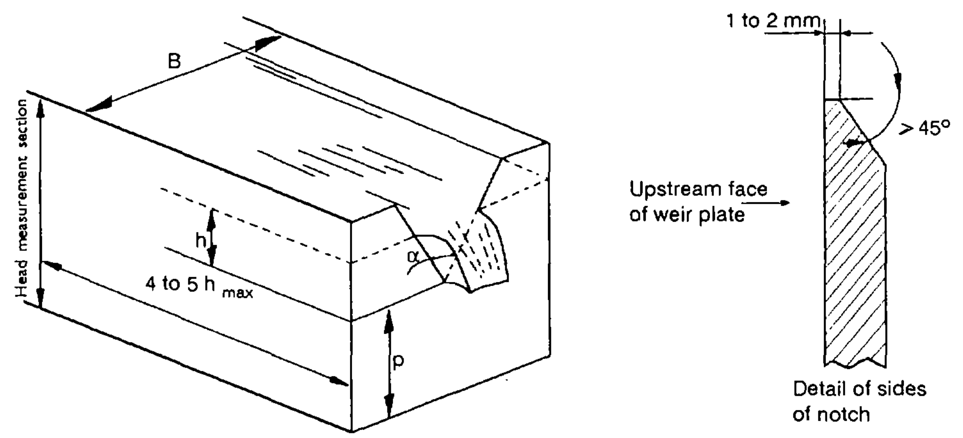
Where significant suspended solids are present, care should be taken to ensure that there is no accumulation of floating debris or settled solids behind the weir at the time of water level (head) measurement.

Triangular-Notch (V-notch) Weirs

The triangular weir consists of a symmetrical V-shaped notch in a vertical thin plate. A diagrammatic illustration is shown in Figure A.

The bisector of the notch should be vertical and equidistant from the two walls of the channel.

Figure A: Triangular-notch, thin-plate weir



The plane surfaces of the notch should form sharp edges at their intersection with the upstream face of the weir plate. The width of the notch surfaces, measured perpendicular to the face of the plate, should be 1-2 mm. The downstream edges of the notch should be chamfered if the weir plate is thicker than 2 mm, the maximum allowable width of the notch surface. The surface of the chamfer should make an angle of not less than 45° with the surface of the notch.

An appropriate formula, the Kindsvater-Shen formula, for all notch angles (α) between 20° and 100° degrees is:

$$Q = C_e \frac{8}{15}\sqrt{2g}\tan\frac{\alpha}{2}\, h_e^{5/2}$$

where Q = wastewater flow in cubic metres per second
C_e = coefficient of discharge (non-dimensional)
g = acceleration due to gravity, = 9.81 metres per second squared
α = the notch angle included between the sides of the notch, in degrees
h_e = the measured head over the weir, in metres
= h (measured head) + k_h (which compensates for the combined effects of viscosity and surface tension)

Also, p = the height of the weir crest above the upstream channel bed; and B = channel width at the weir section (ref. Figure A).

The factor k_h is small and can be ignored for all practical purposes with only minimal loss of accuracy; hence h_e can be assumed to equal h.

C_e is a function of the three variables - h/p, p/B and α. For most purposes, use of a standard value of 0.6 will give sufficient accuracy. For further information on the small variations of C_e under different weir conditions, reference may be made to the International Standard 'Water Flow Measurement in Open Channels using Weirs and Venturi Flumes', ISO 1438/1, 1980.

The V-notch weir formula can therefore be simplified to:

$$Q = 1.42 \tan \frac{\alpha}{2} h^{5/2}$$

For reasons related to measurement-error and lack of experimental data, limitations applicable to the use of this formula are:

- h/p limited to the range 0.1-2.0 for a 90° V-notch, and not greater than 3.5 for all other angles within the range 20°-100°;
- p/B limited to 0.1-1.0 for a 90° V-notch, and 0.1-1.5 for other values of α;
- h not less than 0.06 metres;
- p not less than 0.09 metres.

In the absence of continuous level recording equipment (which may be of a type which automatically records levels as flow for a given weir type and size), weir height readings may be taken using a calibrated dipstick positioned in the centre of the channel upstream of the weir, away from the immediate point of turbulence at the weir. The location of the dipstick will be satisfactory if it is at a distance equal to 4-5 times the maximum anticipated head (4-5 h_{max}) upstream from the weir.

With the bottom of the dipstick in contact with the base of the channel, the depth of immersion at any one point in time will equal h + p. Knowing p, h can then be calculated by difference and inserted into the weir formula to obtain the corresponding flow rate (Q).

Alternatively, it is recommended that a calibration curve be drawn up for any one weir size for a range of h values and corresponding Q values. This should be done before commencing flow measurement work so that Q values can be assessed quickly from the graph as soon as values of h are recorded.

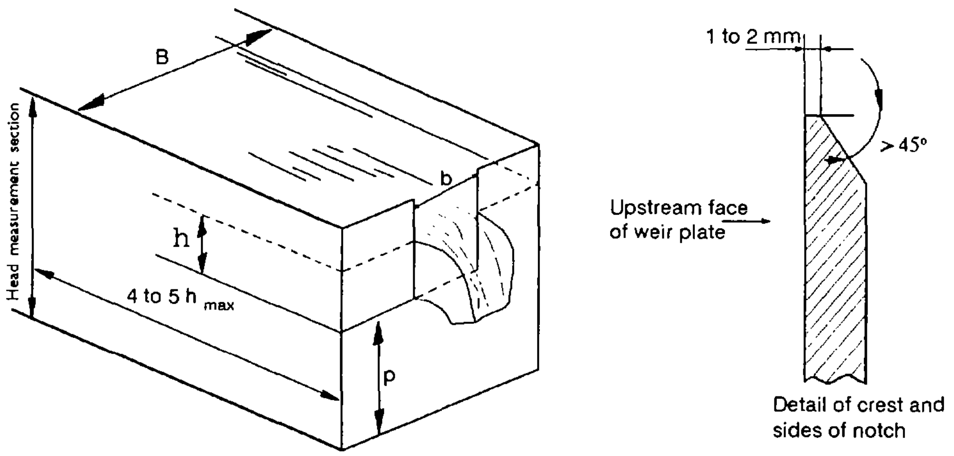
Level/flow rate measurements should be taken at least once per hour. More frequent measurements may be necessary depending on the pattern of flows experienced. The data can then be assessed to give an average daily flow (m^3/d) as well as an indication of minimum and maximum instantaneous discharge rates.

Rectangular Weirs

A rectangular thin-plate weir is a general classification in which the rectangular-notch weir is the basic form and the full-width weir is a limiting case.

A diagrammatic illustration is shown in Figure B with intermediate values of b/B and h/p. When b/B = 1, that is, when the width of the weir (b) is equal to the width of the channel at the weir section (B), the weir is a full-width weir type (also referred to as a 'suppressed' weir, because its nappe lacks side contractions).

Figure B: Rectangular-notch, thin-plate weir



A formula for rectangular weirs (the Kindsvater-Carter formula) is as follows:

$$Q = C_e \frac{2}{3}\sqrt{2g}\, b_e\, h_e^{3/2}$$

where Q = wastewater flow in cubic metres per second

C_e = coefficient of discharge (non-dimensional)

g = acceleration due to gravity, = 9.81 metres per second squared

b_e = the effective width in metres

= b (measured width) + k_b (which compensates for the combined effects of viscosity and surface tension)

h_e = the measured head over the weir, in metres

= h (measured head) + k_h (compensating factor similar to k_b)

Also, as for V-notch weirs, p = the height of the weir crest above the upstream channel bed; and B = channel width at the weir section (refer to Figure B).

The factors k_b and k_h are small and can be ignored for all practical purposes with only minimal loss of accuracy; hence b_e and h_e can be assumed to equal b and h respectively.

For rectangular weirs, C_e is a function of the two variables - h/p, p/B. As for V-notch weirs, use of a standard value of 0.6 will give sufficient accuracy in most cases.

The rectangular weir formula can therefore be simplified to:

$$Q = 1.77\, b\, h^{3/2}$$

For conservative practice, limitations applicable to the use of this formula are:

- h/p not greater than 2.5;
- h not less than 0.03 metres;
- b not less than 0.15 metres;
- p not less than 0.1 metres;
- either (B-b)/2 = 0 (weir full width of channel) or (B-b)/2 is not less than 0.1 metres (concentrated weir).

As in the case of V-notch weirs, the location of the head-measurement section will be satisfactory if it is at a distance equal to 4-5 times the maximum anticipated head (4-5 h_{max}) upstream from the weir.

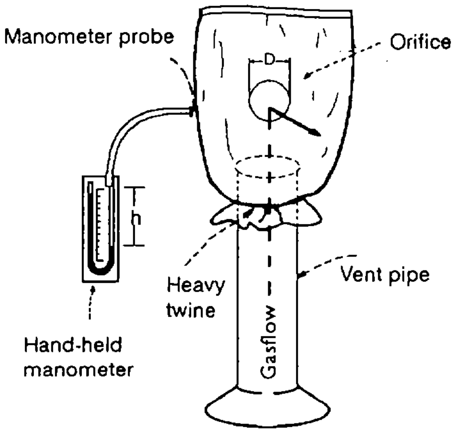
Gas Flow Measurements

In the course of gathering gas flow data for environmental control or a waste audit, flow measuring equipment is often lacking, or the velocity of the gaseous emission is too low for measurement. Even when the velocity is high enough for meter methods, the geometry of the system may make the measurement difficult or subject to error. Consequently, a method is needed for a quick and fairly accurate measurement of gas flow, that can be operated without the use of expensive or time-consuming installations.

In most cases the following method will work (or serve as a valid double-check) if only the gas can be made to flow through an accessible open-ended pipe or duct; it has been developed by the Chesapeake Corporation, Virginia, USA.

A plastic bag with a hole cut in it is placed over the end of the pipe or duct, causing a small resistance to the flow, depending on the size of the hole. Hence, a manometer reading of the pressure drop across the bag orifice accomplishes the purpose of an ordinary orifice. A diagram of the bag orifice is shown in Figure C.

Figure C: Measuring Gaseous Emissions Through a Vent Using a Bag Orifice



Since compressibility can be ignored for small pressure drops, the general orifice equation applies:

$$Q = K A\sqrt{2 g h}$$

where Q = gas flow
g = the acceleration due to gravity
A = the orifice area
h = the pressure drop
K = the discharge coefficient including the velocity-of-approach factor

Where the bag size is large relative to the orifice diameter, the velocity-of-approach factor can be taken as 1.0. Experiments with different bag thicknesses, flow rates and air densities have then shown that the orifice equation can be rewritten, independently of bag thickness.

The simplified formula is as follows:

$$Q = 0.00257\, D^2\sqrt{h/\rho}$$

where Q = gas flow in litres per second (to within ±4%)
D = the orifice diameter in millimetres
h = the pressure drop in millimetres
ρ = the gas density at the gas temperature in grammes per litre

In selecting a suitable orifice size, a pressure drop of 25-100 mm water gauge should be sought. Less than 25 mm is difficult to measure, and greater than 100 mm may make the bag slip off the pipe. If a rough estimate of the gas flow is known, the hole diameter (mm), necessary to produce a pressure drop of 63 mm, is approximately:

$$D = 7.65\sqrt{Q}$$

Several features of the design can minimise error. These are as follows.

- The position of the manometer probe should project slightly through the bag wall, so that the axes of the vent pipe, the bag orifice and the probe end are all perpendicular (ref. Figure C), and so that a true indication of static pressure can be obtained.

- The bag should be large enough to minimise the effects of approach velocity and to prevent flapping or tearing.

- The orifice diameter should be measured during operation, so as to obtain true operating dimensions; if stretching causes an elliptical orifice, the area should be based on the product of the major and minor axes.

- Thin-walled bags, high temperatures and high velocities should be avoided since fluting outward of the orifice edges will tend to occur; when pronounced, the effect would be to increase the discharge coefficient as the shape of the orifice approaches that of a nozzle.

Finally, when members of the waste audit team make a bag orifice measurement, it is important to ensure that adequate steps are taken to prevent burns or fumigation.

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APPENDIX 2: GLOSSARY

BOD_5: biochemical oxygen demand; a measure of the quantity of dissolved oxygen consumed by microorganisms as a result of breakdown of biodegradable organic constituents. The standard test is carried out at 20°C over a 5-day period.

By-Product: a secondary or incidental product of a manufacturing process.

Catalyst: a substance that increases the rate of a chemical reaction without itself undergoing any permanent change.

COD: chemical oxygen demand; a measure of the quantity of dissolved oxygen consumed during chemical oxidation of wastewater with potassium dichromate.

Counter-Current Rinsing: the introduction of water or a solvent in the opposite direction to the product flow.

Discharge Points: this term refers to the points of exit for wastewater leaving the site. A discharge point may also refer to the place where an incoming tanker discharges a load.

Drainage: refers to the effluent collection system on a site.

Emission: an emission usually refers to fugitive or waste discharges from a process. Emissions are traditionally associated with atmospheric discharges. All such discharges are termed waste within the context of this manual.

Energy Audit: a quantitative account of the energy inputs and outputs to and from a unit operation, a process, a plant or an industry.

Gaseous Emissions: gaseous emissions can be classified into several categories; pure gases or vapours, combinations of gases and solids, combinations of gases and liquids and combinations of gases, liquids and solids. The last three categories are considered to be gaseous emissions because the gas is the carrier for the solid or liquid phase.

Material Balance: a precise account of all the inputs and outputs of a process, based on the law of conservation of mass.

Monitoring Programme: a monitoring programme that describes a timetable for regular sampling and testing of equipment, pumps, products, wastes and general operations to ensure that any deviations from the norm are noticed and can be rectified before problems result.

Operating Costs: also known as variable or running costs; they refer to costs which vary directly with the rate of output, for example labour costs, raw material costs, fuel, power, etc.

Plant: in the context of this manual a plant refers to the factory site. A plant may comprise a number of processes, administration buildings, site waste treatment facilities, site storage facilities, etc.

Pollution: the term describes the presence of harmful, hazardous or detrimental constituents in an environment. A polluted environment describes a state that occurs when the assimilative capacity of the environment is exceeded, resulting in undesirable ecological changes.

Process: in the context of this manual a process is taken to include all operations involved in production. Therefore, a process may begin with receipt of raw materials, storage and handling through process technology to product handling and waste treatment.

Process Flow Diagram (PFD): an essential tool in developing an organised diagrammatic presentation of a process.

Process Inputs: defined as one half of the material balance equation. Inputs to a process may comprise raw materials, water, energy, etc.

Process Outputs: the second half of the material balance equation. Outputs from a process may include a product, a by-product, wastewater, gaseous, liquid and solid wastes, heat, etc.

Product: the useful material output from a process.

Purchasing Records: documentation of invoiced purchases.

Raw Material: a material on which a particular manufacturing process is carried out.

Recovery: waste minimisation can be achieved by recovering valuable material from a waste. For example, cleaning solvent can be recovered from waste oil. Recovery often involves advanced technology such as ultrafiltration or reverse osmosis, although simple settlement can separate oil and water solutions.

Recycle: this term represents an important aspect of waste minimisation. The recycling of wastes within a process often reduces the fresh material input requirement. For example, a solvent used for cleaning engine parts can often be used twice before its cleansing power is exhausted.

Reuse: this is an important consideration in waste minimisation. If a waste cannot be reduced can it be reused? Reuse represents a secondary line of action in a waste reduction plan.

Segregation: the term segregation refers to isolating hazardous and/or strong wastes from less polluting wastes. For example, uncontaminated surface drainage should be collected in a separate system from contaminated effluents from process areas. If the two wastes are not segregated the volume of wastewater requiring treatment is greater.

Services: in the context of this manual the term services is taken to mean supporting facilities such as a power supply.

Stockpile: refers to solid material such as coal or gravel stored outside on the ground. Stockpiling should comply with legislation to minimise pollution.

Stoichiometric Estimations: mass or concentration calculations based on the exact molecular relationship between constituent elements, taking into consideration atomic and molecular weights.

Unit Operation: a process will comprise a series of unit operations. A unit operation may be pulping or bark stripping in a pulp and paper mill, or distillation in a chemical manufacturing process. Unit operations may be intermittent such as tank washing and steam cleaning.

Waste: in the context of this manual waste is taken as a broad term to cover any non-product discharge from a process. Thus, it describes discharges in the gaseous, liquid and solid phases.

Waste Audit: a waste audit is a thorough account of the wastes from an industry, a plant, a process or a unit operation. A waste audit requires the derivation of a material balance for each scale of operation. The waste audit should result in the identification of wastes, their origin, quantity, composition and their potential for reduction.

Waste Reduction Plan: a waste reduction plan should include a series of scheduled actions to be undertaken with the overall aim of reducing the amount of waste generated.

Wastewater: the aqueous effluents from a process that pass to drain or to storage.

Wet Scrubber: pollution control equipment designed to treat off-gases. A wet scrubber will involve water or a chemical solution to strip certain gases from the gaseous phase before discharge to atmosphere. The wet component may be a once-through scrub or a recirculating solution (with a bleed to drain), the solution strength needing to be topped-up either continuously or periodically.

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'Money Down the Drain', video by Ontario Waste Management Corporation, Canada.

'Prepare for Tomorrow', video for the Prepare Project, NOTA, The Netherlands.

'Pollution Prevention - The Bottom Line', a video by Coastal Video Communications Corporation, USA.

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(e) Information Systems/Bulletins/Newsletters

'Cleaner Production', a biannual newsletter of the Cleaner Production Programme of UNEP/IEO.

International Cleaner Production Information Clearinghouse (ICPIC), an on-line, computer-based information service, UNEP/IEO (see this manual, Appendix 4).

NETT, a network for environmental technology transfer, Ave Louise 207, Box 10, Brussels, Belgium.

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APPENDIX 4: UNEP/IEO CLEANER PRODUCTION PROGRAMME

Recognising the need to prevent pollution and minimise waste, the UNEP Governing Council, in May 1989, took Decision 37 urging UNEP 'to continue its catalytic role to promote, with governments, industry, research organisations and other relevant institutions, the establishment of a network which will allow the transfer of environmental protection technology'.

To implement this decision, the UNEP Industry and Environment Office (IEO) convened a group of 23 senior level experts from various countries and international organisations for advice on the steps to be taken. Their recommendations led to the establishment of the UNEP/IEO Cleaner Production Programme. The Programme links existing sources of information on low and non-waste technologies and promotes cleaner production worldwide through four primary activities: the International Cleaner Production Clearinghouse (ICPIC), expert working groups, a newsletter, and training activities.

(a) Working Groups

Working Groups are composed of experts who seek to identify cleaner production methods in specific industries (leather-tanning, textile, solvent, metal-finishing and pulp and paper industries), and to identify other experts and some working publications. Groups also cover wider issues, such as data networking, education and policies promoting cleaner production.

(b) Cleaner Production Newsletter

The newsletter includes news and information on cleaner technologies and products, and steps taken by governments and organisations to promote cleaner production.

The newsletter is available in English, French and Spanish.

(c) International Cleaner Production Information Clearinghouse - ICPIC

This computer-based information exchange holds over 600 case studies and programme summaries, a directory of experts and an extensive bibliography. The system can be accessed by users in more than 100 countries.

(d) Training Activities

In order to support the initiation and development of national cleaner production programmes in different regions of the world UNEP/IEO organises workshops and seminars.

The International Cleaner Production Information Clearinghouse - ICPIC

ICPIC contains information on cleaner production methods, and on industries using such technologies. It also acts as a pointer to more detailed sources of information. ICPIC was established in cooperation with the US EPA and is based on their Pollution Prevention Information Exchange System PIES. Data are also contributed by users - either individuals or organisations - of the ICPIC system.

In addition to the main database, the ICPIC system incorporates an interactive message centre where users can leave information and questions for other network users. Also listed are bulletins concerning developments in the field of cleaner production, and subsidiary databases on individual subjects.

The main databases contain:

Message Centre
An on-line feature allowing communication with other network members.

Bulletins
Latest news and announcements in the international clean technology community.

Calendar of Events
Listing of upcoming national and international conferences, training seminars and workshops.

Case Studies
A database of technical and programme case studies highlighting industry and waste involved, economic incentives and cost recovery time.

Programme Summaries
Descriptions of national and international programmes on cleaner production, as well as programmes adopted by industries.

On-line Bibliography
A bibliography of hundreds of clean technology documents, with information for ordering.

Directory of Contacts
An automated version of UNEP's Cleaner Production Directory.

ACCESSING ICPIC

Twenty-four hour access is free of charge to individuals and organisations with an Apple, an IBM-compatible computer or a terminal equipped with a modem (2400 baud or less) and appropriate communication software. The system can be connected either through direct telephone lines, or through Telenet data-packet switching network.

Different ways to access the system:

- via direct dial, set your software to 8 data bits, 1 stop bit, no parity and telephone number to 33-1-40 58 88 78 - omitting country and city code as appropriate if calling from France;
- directly via SPRINTNET (Telenet) by telephoning local Telenet access node and enter access code 762 006 04000;
- if connecting indirectly via another packet switching network, the Telenet and ICPIC access code is 3110 762 006 0400. In the latter case, the software settings may be different and dictated by the network being used.

Contact UNEP/IEO or US-Sprint to find out your local Telenet service address of national-packet switching networks appropriate to access ICPIC. A list of packet-switching networks which allow you to connect ICPIC via Telenet is also available in the ICPIC User Guide available from IEO.

Further information from UNEP/IEO by faxing 33-1 40 58 88 74.

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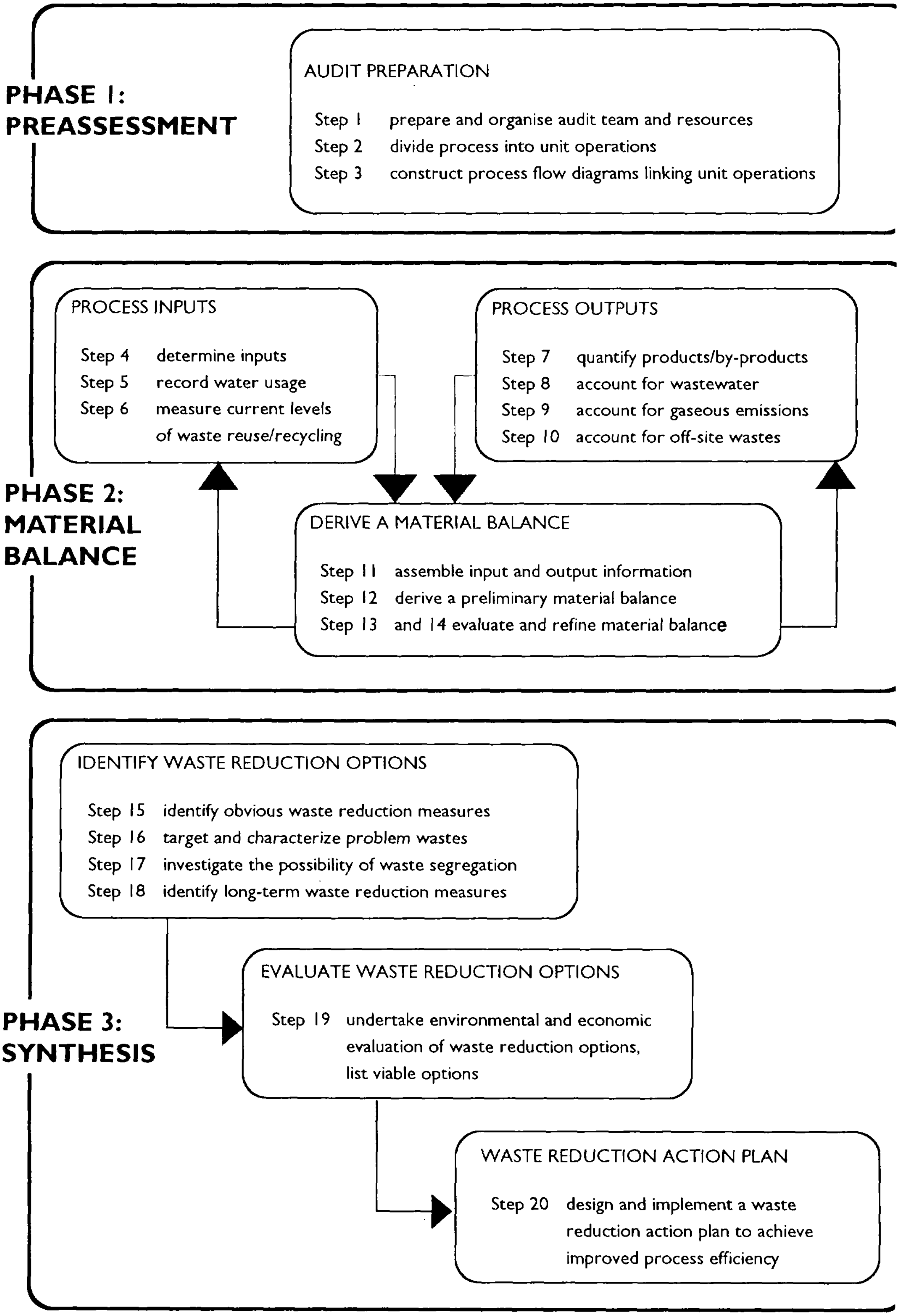
QUICK REFERENCE AUDIT GUIDE



PHASE 1: PREASSESSMENT

AUDIT PREPARATION

Step 1	prepare and organise audit team and resources
Step 2	divide process into unit operations
Step 3	construct process flow diagrams linking unit operations

PHASE 2: MATERIAL BALANCE

PROCESS INPUTS

Step 4	determine inputs
Step 5	record water usage
Step 6	measure current levels of waste reuse/recycling

PROCESS OUTPUTS

Step 7	quantify products/by-products
Step 8	account for wastewater
Step 9	account for gaseous emissions
Step 10	account for off-site wastes

DERIVE A MATERIAL BALANCE

Step 11	assemble input and output information
Step 12	derive a preliminary material balance
Step 13	and 14 evaluate and refine material balance

PHASE 3: SYNTHESIS

IDENTIFY WASTE REDUCTION OPTIONS

Step 15	identify obvious waste reduction measures
Step 16	target and characterize problem wastes
Step 17	investigate the possibility of waste segregation
Step 18	identify long-term waste reduction measures

EVALUATE WASTE REDUCTION OPTIONS

Step 19	undertake environmental and economic evaluation of waste reduction options, list viable options

WASTE REDUCTION ACTION PLAN

Step 20	design and implement a waste reduction action plan to achieve improved process efficiency

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UNEP INDUSTRY AND ENVIRONMENT OFFICE

About UNEP/IEO
The Industry and Environment Office (IEO) was established by UNEP in 1975 to bring industry and government together to promote environmentally sound industrial development. The IEO is located in Paris. Its goals are:

(1) to encourage the incorporation of environmental criteria in industrial development plans;
(2) to facilitate the implementation of procedures and principles for the protection of the environment;
(3) to promote the use of safe and 'clean' technologies;
(4) to stimulate the exchange of information and experience throughout the world.

IEO provides access to practical information and develops co-operative on-site action and information exchange backed by regular follow-up and assessment. To promote the transfer of information and the sharing of knowledge and experience, IEO has developed three complementary tools: technical reviews and guidelines, 'Industry and Environment' review; and a technical query-response service. In keeping with its emphasis on technical co-operation, IEO facilitates technology transfer and the implementation of practices to safeguard the environment through promoting awareness and interaction, training activities and diagnostic studies.

Some recent UNEP/IEO publications
Industry and Environment Review (quarterly), ISSN 0378-9993. Issues deal with topics such as: hazardous waste management, technological accidents, environmental auditing, industry specific problems, environmental news.

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UNIDO AND THE ENVIRONMENT

As the lead agency for industrial development in the United Nations system, UNIDO is closely involved in the growing international co-operation on industry-related environmental matters. In mid-1990 UNIDO consolidated its various environmental activities under the umbrella of the UNIDO Environment Programme. UNIDO is well placed to transfer new technologies and cleaner production processes to developing countries in such important sectors as leather, cement, textiles, food processing, metal working, iron and steel, and others. Its assistance takes such forms as technical projects, provision of equipment and/or advisory services, investment promotion schemes, human resource development through training and fellowships.

The immediate emphasis of the UNIDO Environment Programme is on: (1) incorporating environmental considerations into the activities of UNIDO; (2) enhancing the awareness of developing countries of the need to include environmental considerations in their industrial plants and policies; and (3) assisting developing countries to prevent and cure the effects of environmental degradation attributable to industry through practical technical assistance projects and other activities such as cleaner technologies and processes, environmental audits, environmental impact assessments, energy efficiency, studies and technical reports, and provision of training and information. Specific support can also be given in design, installation and operation of industrial pollution abatement facilities.

Inquiries about UNIDO's programmes can be channelled through UNDP offices in developing countries, or sent directly to UNIDO headquarters, P O Box 300, A-1400 Vienna, Austria.

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TRANSFORMING TECHNOLOGY:

AN AGENDA FOR ENVIRONMENTALLY SUSTAINABLE GROWTH IN THE 21ST CENTURY

George Heaton
Robert Repetto
Rodney Sobin

WORLD RESOURCES INSTITUTE

48p
diagrams
graphs

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FOREWORD

Countries around the globe have set two potentially conflicting goals for themselves: improving environmental quality, in part by reducing *current* levels of pollution and resource deterioration, and achieving large, sustained increases in economic activity. Indeed, by the middle of the next century, the world economy is projected to be five times larger than it is today. Quite possibly, political leaders will face no greater challenge in the decades ahead than reconciling these two goals. Doing so will demand continuing effort at the highest levels of government, including international cooperation on a scale seldom seen.

What will this reconciliation require in practical terms? If a doubling and redoubling of economic activity is accomplished with the technologies now dominant in energy production, transportation, manufacturing, agriculture, and other sectors, truly catastrophic impacts are likely on global climate, human health, and the productivity of natural systems. Seen this way, reconciling the economic and environmental goals societies have set for themselves will be possible only through a transformation in technology—a shift, perhaps unprecedented in scope and pace, to new technologies that dramatically reduce environmental impact per unit of prosperity.

Of course, it is not only technology that must change; values, lifestyles, and policies must change also. But, economic growth on an unprecedented scale will occur. For much of the world this growth is essential to meeting basic human needs and achieving acceptable levels of personal security and comfort. The bottom-line question remains: with what technologies will this growth occur? Only the population explosion rivals this question in fundamental importance to the planetary environment.

The good news, as this new World Resources Institute report makes clear, is that many emerging technologies offer exciting opportunities to achieve an ecological modernization of industry and agriculture. The bad news is that there is no guarantee that these technologies will be fully explored or exploited. Neither discernible trends in technological change nor current approaches to environmental protection will be sufficient to bring about the needed technological transformation.

Certainly, some of the mega-trends at work should help. As Manfredo Macioti has noted, "there is less reason to jeopardize our natural inheritance. . . when the future belongs to 'intelligent' rather than 'inert' technologies, to software rather than to hardware, and to 'functions' rather than to 'products.'" And current environmental laws in the United States and other countries have at least modestly reduced pollution levels in most settings in the face of significant economic expansion over the past two decades. But the persistence of long-recognized environmental problems and the emergence of new challenges, such as global warming, both underscore the need for new policies and new approaches.

Some implications of this view—for example, that pollution prevention is preferable to end-of-pipe approaches—have gained many supporters. Yet, the full implications of asking how "green" technology can be developed and deployed more effectively are just beginning to emerge.

Transforming Technology takes a major step forward by analyzing the types of policy change needed to realize modern technology's potential. As the authors indicate, environmental regulation needs to be overhauled to promote long-term innovation and pollution prevention; more effective economic incentives for investments in clean technologies are long overdue; current measures of industrial productivity need to be reconceptualized so they recognize environmental costs; and altogether more attention needs to be paid to how clean technologies can be transferred successfully from country to country.

Recommending ways to address these issues as well as such concerns as how to educate managers and engineers to think about the environment and how to build environmental objectives into technology development and use, George Heaton, Robert Repetto, and Rodney Sobin both break new ground and consolidate the insights of an increasingly important field. Implicit in their approach to economic and regulatory policy is a new way of thinking about technology and the environment.

The new approaches recommended by Heaton, Repetto, and Sobin are badly needed. Environmental factors should be seen as opportunities, since demands for ecological responsibility are creating markets for new processes, products, and services. Yet, despite the enormous possibilities, environmental issues are left out of most discussions of national competitiveness, trade, and technology policy.

To bridge these gaps, a new type of cooperation must be forged among the private sector, government, and environmental advocates. Together, they must work "upstream" to change the products, processes, policies, and pressures that give rise to pollution and environmental deterioration.

This report is the first publication of the World Resources Institute's new Program on Technology and the Environment. In this program, WRI hopes to focus attention on the means needed to achieve large-scale transformation of today's technologies in order to meet the environmental and economic needs of the 21st century.

The report draws on the results of a symposium convened in Annapolis, Maryland, by WRI in June 1990. Sixty-four experts in science, technology, and management from some eighteen countries provided a fertile source of information and ideas. WRI also commissioned twelve papers covering the connection between technology and the environment in various sectors and policy areas as background material. These papers, listed in an appendix, and a report on the symposium's suggestions for a publicly supported research agenda are available separately from WRI.

This conference—"Toward 2000: Environment, Technology and the New Century"—was organized in cooperation with the Organisation for Economic Cooperation and Development (OECD) and was supported by the U.S. National Science Foundation and the Hitachi Foundation, all of which have our appreciation.

James Gustave Speth
President
World Resources Institute

EXECUTIVE SUMMARY

Two decades of environmental regulation in the industrialized countries have yielded some results, but also demonstrate the limitations of current approaches. In the United States, "pollution control" through end-of-pipe treatment has been countered by the lack of non-point source controls and the steadily expanding scale of economic activity. The ambitious goals adopted twenty years ago have not been met. Meanwhile, developing countries have increasingly joined the pattern of degradation begun in the developed world. The volume of pollutants expands worldwide. New classes of global and regional threats—global warming, ozone layer destruction, acid rain, deforestation, mass extinctions, marine degradation, and others—have emerged. This growing assault on the earth demonstrates that we now risk irrevocably altering the planetary life support system with little grasp of the consequences.

In principle, demands on the earth's resources could be reduced by diminishing economic growth, limiting population increase, or increasing the resource efficiency of production. However, the third option is the most viable. Demographic momentum points toward a doubling of global population by the mid-21st century. Economic growth is needed to meet the aspirations of most of the world's people.

These realities leave technological transformation as the primary strategy for avoiding environmental degradation. Technological transformation means widespread, continuing development and adoption of ever less polluting and more resource-efficient products, processes, and services. Technological change has contributed most to the expansion of wealth and productivity. Properly channelled, it could hold the key to environmental sustainability as well.

Technologies to reduce environmental problems while raising economic productivity exist. Studies of major sectors of the economy—energy, agriculture, and manufacturing—demonstrate clearly that far-reaching environmental improvements could be made immediately. For example, many opportunities in industrial pollution prevention and improved energy efficiency are highly profitable today. A variety of new renewable energy technologies, already commercially available, are becoming more widely competitive with conventional fossil fuels.

Emerging revolutions in advanced materials and biotechnology, along with continuing spectacular advances in information technologies and miniaturization, can provide radically new products and processes that harmonize environmental and economic objectives. Investment in environmentally preferable technologies represents an exciting opportunity to enhance competitiveness.

Much more needs to be done to capitalize on this potential. Current best practice must be diffused more rapidly. Environmentally superior products and processes need to be brought to market more quickly. Research and development should be encouraged and channelled in environmentally sound directions.

Technical constraints are not the principal factor limiting technological transformation. The biggest barriers to change are rooted in the social, economic, political, and cultural milieus in which technologies are developed, diffused, and used. Many impediments to technological transformation are imbedded in the structure of public and corporate policy regimes.

Environmental regulation should be reformed to encourage technological change. Many environmental laws favor old technologies over new. Relying on "best available technology" standards tends to entrench existing control technologies at the expense of long-term innovation. Regulations have largely been uncoordinated across media (air, water, and land), have focused on "end-of-pipe" pollution controls instead of pollution prevention options, and have provided no incentives for doing better than standards dictate. Cumbersome administrative procedures also impede innovation.

Given this poor record, serious consideration should be given to changes that require regulatory agencies to promote the development and deployment of new technology. This would necessitate a variety of new policy tools. Foremost among them would be greatly expanded use of performance-based standards and economic instruments. Public disclosure requirements, like the Toxic Release Inventory required under the United States Superfund Amendment and Reauthorization Act Title III can also increase public demands and corporate incentives for environmental protection.

Economic incentives should be employed in tandem with regulation to encourage technological transformation. Pollution charges that reflect the full social and economic costs of production, consumption, and waste disposal would provide long-term incentives for investments in clean technologies. Emissions trading also deserves wider use.

Economic indicators conventionally underestimate the value of the environment. National income accounts, such as GNP, treat activities that erode the soil, contaminate air and water, and diminish forests and fisheries as contributions to income rather than as consumption of capital. Similarly, measures of industrial productivity and corporate accounts fail to consider the costs of *not* protecting the environment. Without economic indicators that fully reflect the value of the environment, environmentally perverse public policies and private practices are likely to continue.

Technology policies have thus far largely ignored environmental objectives. Government support of new technologies through R&D funding, procurement, research consortia, and other mechanisms have led to great strides in aerospace, computers, defense, and medicine. Technology policies could play a critical role in advancing environmentally sustainable technologies while promoting commercial competitiveness. But, large areas of environmentally important "generic" research (widely applicable research too removed from marketable products to be adequately supported by industry but too "applied" for most academic laboratories) remain undersupported. Efforts to translate the fruits of laboratory research into marketable technologies have also been inadequate.

Technology and other policies are particularly critical in the early stages of technological development when an advantage given to one of several competing approaches may "lock in" a technology for many years even if that technology is, in the longer run, an inferior option. To avoid this problem, long-term consequences of technologies must be assessed more thoroughly at an early stage.

Rapid dissemination of clean technologies from the industrial countries to the developing and formerly centrally planned countries where over 80 percent of humanity lives and where much of the globe's economic and population growth will occur is vital for technological transformation. This diffusion of innovation may require new initiatives to overcome barriers in both technology exporting and importing countries to the flow of information, capital, and trade. A particularly useful role—that of technology broker—could be played by private sector intermediaries: for example, matching partners, arranging financing, and negotiating and managing licensing agreements.

Private companies, the main producers and users of new technologies, are central to any hope for technological transformation. Environmentally affirmative **corporate leadership** is likely to be a stronger force for technological change than public policies. Some companies have realized that environmentally sound investments are often rewarded by cost reductions, improved quality, and product innovation, and they see environmental performance as key to future business success. But many others do not yet treat environmental stewardship as integral to good management practice.

A switch to corporate accounting systems that more accurately reflect both the costs of environmental protection and the cost of forgoing environmental protection could stimulate environmentally sound innovations. Better accounting would show that pollution prevention is often a more cost-effective approach than pollution control. The growing market for "green" products shows that environmental concerns can be profitably integrated into product life-cycle design.

In the long-term, **better educated managers and engineers** are key. Business students must learn to incorporate environmental issues in business planning and decision-making. Engineers must be trained to integrate environmental factors into the design process and not address them as an afterthought. Curricula that bring environmental concerns into the mainstream need to be developed for these future professionals.

For two decades, environmental policy has focused—with only modest success—on abating pollution and cleaning up local problems. Today, newly recognized global hazards pose a profound challenge to society. Rapid technological change stands as the key element in reconciling inevitable economic and population growth with a livable environment. Many resource-efficient technologies are available today and emerging technologies can dramatically transform the economy for environmental benefit. Because technological change is at bottom a social process, it can be accomplished only by redirecting economic, political, and cultural channels in ways that guide the stream of technological transformation.

I. THE CHALLENGE OF TECHNOLOGICAL TRANSFORMATION

I.1 Why Technological Change is Key

Despite two decades of intense concern and effort, global environmental deterioration continues on an unprecedented scale (Speth 1990). For the first time, the global systems that control climate and sustain the conditions for life are threatened.

From the beginning of history until 1900 A.D., the world economy grew to $600 billion; now, it grows this much every two years. By the mid-21st century, the world population will probably double to ten billion and the global economy, now $16 trillion, could be five times larger. If past practice remains our guide, such growth cannot occur without tremendous environmental destruction.

A thread of hope that this dilemma can be resolved connects technological progress and the environment (Speth 1989). Human impact on the natural environment depends fundamentally on an interaction among population, economic growth, and technology. A simple identity encapsulates the relationship:

$$\text{Pollution} = \frac{\text{Pollution}}{\text{GNP}} \times \frac{\text{GNP}}{\text{Population}} \times \text{Population.}$$

Here, pollution (environmental degradation generally) emerges as the product of population, income levels (the GNP per capita term), and the pollution intensity of production (the pollution/GNP term).

In principle, pollution can be controlled by lowering any (or all) of these three factors. In fact, however, heroic efforts will be required to stabilize global population at double today's level, and raising income and living standards is a near-universal quest. Indeed, economic growth is a basic goal for at least 80 percent of the world's population. These powerful forces give economic expansion enormous forward momentum.

In this field of forces, the pollution intensity of production looks to be the variable easiest to manipulate, which puts the burden of change largely on technology. In fact, broadly defined to include both changes within economic sectors and shifts among them, technological change is essential just to halt backsliding: even today's unacceptable levels of pollution will rise unless the percentage of annual growth in global economic output is matched by an annual *decline* in pollution intensity.

To an environmentalist, technology is a double-edged sword. Consider the automobile, for example. The automobile initially seemed a much less polluting means of transportation than the horse. Now, its severe pollution, energy, and land-use drawbacks are painfully obvious. At the same time, however, technological change offers potential remedies: catalytic converters, new engine types, alternative fuels, advanced materials to substitute for steel, and computer-controlled manufacturing, to mention only a few.

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> **Human impact on the natural environment depends fundamentally on an interaction among population, economic growth, and technology.**
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Over the last two decades—environmentalism's modern history—technology and the environment have not always been friends. Environmentalists were usually either wary of new technology, viewing it as a potential hazard, or highly optimistic that technological solutions could be forced from reluctant industry by regulation. For their part, members of the technical community were apt either to criticize environmental regulation for constraining their creativity or to view it as only a marginal concern in product and process design.

Unfortunately, policy-makers have regarded these two positions as irreconcilable, too often pitting environmental against economic goals. With environmental problems deepening and technology advancing rapidly in ways that could reduce pollution and waste, a new synthesis needs to be formed so that environmental concerns and economic competitiveness are addressed in tandem. Once this false dichotomy that has bedevilled the development of both policy and industrial technology has been sundered, technological innovation can be the key to improved environmental quality.

> **“Technological change is essential just to halt backsliding: even today’s unacceptable levels of pollution will rise unless the percentage of annual growth in global economic output is matched by an annual *decline* in pollution intensity.”**

1.2 What Is Technological Transformation?

Technology is fundamentally different from science—the search for knowledge—and, indeed, does not always rely on scientific discovery. Many revolutionary innovations preceded an understanding of the underlying science, and others—for example, mass production techniques—required scant scientific knowledge. Neither is technology the same as invention, which is a new technical idea.

Technological change consists of both innovation—the introduction of a new product, process, or system—and diffusion—the application of innovations in new contexts. Technological change proceeds mostly by modest increments—small improvements made by firms, workers, or consumers to increase efficiency and performance. Radical innovation is a major change from the technological status quo—the advent of the electronic digital computer, for example. Yet, even a revolution of this magnitude rests both on breakthroughs and on the sum of many small improvements over time.

Technological change is a complex, iterative, unpredictable, creative endeavor. It links social and economic needs with technical solutions. Research and development are often, but not always, necessary. Studies show repeatedly that a new technology's ability to fulfill a market need predicts success better than technical sophistication (Freeman 1982). In other words, change is usually demand-driven more than supply-driven.

In the early stages of technology development, several models may compete. One may become dominant if early gains in market share are reinforced by economies of scale and "learning curve" effects (Arthur 1990). Early market advantages created by superior corporate strategy or public policies can then lock society onto a particular technological trajectory—sometimes a technologically inferior trajectory. For example, the standard English-language typewriter keyboard (QWERTY), designed to suit the needs of early mechanical typewriters built a hundred years ago is now demonstrably inefficient but is so deeply imbedded in minds and machines as to be immutable (Hammond 1990). For this reason, the "right" design factors must be embedded in the early development of new technologies, and technological systems need to be evaluated for their environmental characteristics.

The needed fusion of economic and environmental objectives requires technologies that meet two criteria. First, they must be able to transform industry and transportation from materials-intensive, high-throughput processes to systems that use fuel and raw materials highly efficiently, rely on inputs with low environmental costs, generate little or no waste, recycle residuals, and release only benign effluents. The need, in short, is for technological systems that are environmentally "closed"—that is, detached as much as possible from natural systems.

Second, because the first criterion can't be fully met while human annual consumption of nature's land-based output approaches 40 percent and such non-renewable resources as fossil fuels are being rapidly depleted, new technology must help societies live strictly off nature's income rather than consuming nature's capital. An honest accounting of the costs of such "capital depletion" would show that few societies are doing anything of the sort today.

For any economic system—firm, industry, nation, or community of nations—environmental damage over time is in one sense a function of the consumption of inputs from environmentally unsustainable processes, the generation of pollution and post-consumption waste, and other factors. This damage won't stabilize and decline until pollution per unit of output and materials consumption per unit of output—factors that are at their core technological—decline rapidly enough to outweigh growth in economic output. "Technological transformation for environmental sustainability" is thus a process that reduces environmental damage per unit of output (or value-added) fast enough to outpace production increases (Speth 1990).

Bringing about this transformation will be neither certain, quick, nor easy. Many adverse trends in global environmental quality are evident. Nevertheless, the current moment offers unique potential, in part because of new technological developments in such fields as biotechnology, information systems, and advanced materials. These advances could create a new technical base for long-term environmentally sustainable development. Even now, emerging and on-the-shelf technologies offer tremendous gains. To name but a few, steelmaking processes halve energy use, photovoltaic and wind systems substitute for fossil fuels, bioengineered plants dramatically cut the need for pesticides, and computerized control of manufacturing systems reduce waste.

Other hopeful signs can be found in industry, government, and the universities. Many businesses' new environmental standards far exceed regulatory requirements while achieving sound economic results. Environmental investments attract capital quickly. Academic research is turning toward environmental issues, and government agencies are experimenting with new policies to encourage technological change.

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II. THE ENVIRONMENT AND TECHNOLOGY: A NEW CONTEXT

II.1 New Environmental Imperatives

Throughout the 20th century but especially in the post World War II period, environmental pollution increased dramatically. Globally, pollution is still increasing, and global environmental problems pose new challenges. Four long-term trends, described below, characterize this situation (Speth 1988a).

From Modest to Huge Quantities

Environmental problems are as old as humanity, but the 20th century has produced enormous quantities of pollution because of economic and population growth. Within the century, population has increased more than threefold and the world economy has expanded twentyfold.

Figure 1 traces global emissions of two major pollutants: sulfur oxides and nitrogen oxides. Figure 2 shows atmospheric concentrations of contributors to global warming and ozone depletion. All show enormous increases: sulfur oxides by about 446 percent and nitrogen oxides by about 900 percent over the years 1900 to 1980, to cite only two examples (Dignon and Hameed 1989 in WRI 1990, p. 4). Other environmental problems have multiplied correspondingly. The quantity of municipal solid waste in the United States has doubled in three decades. Trends like these cannot persist. The earth's assimilative capacity is finite. Continued pollution, even at today's levels, is unsustainable. Continuing the increase in emissions of recent history would be ecologically disastrous.

From Gross Insults to Microtoxicity

Before World War II, smoke, sewage, and soot were the main environmental concerns. These basic threats to public health are still acute in developing countries and in Eastern Europe. Since 1950, however, synthetic organic compounds and radioactive materials have posed a different kind of problem. Many such substances are highly toxic in minute quantities and highly persistent in biological systems or the atmosphere.

Such substances, though imbedded in modern life, pose extraordinary risks. Of 70,000 chemicals in commercial use, about half are classified by the U.S. Environmental Protection Agency (EPA) and the Organisation for Economic Cooperation and Development (OECD) as definitely or potentially harmful to human health (IIED and WRI 1987, p. 205). For perspective here, approximately 1,500 new chemicals are introduced into commerce in the United States each year (Conservation Foundation 1987, p. 136).

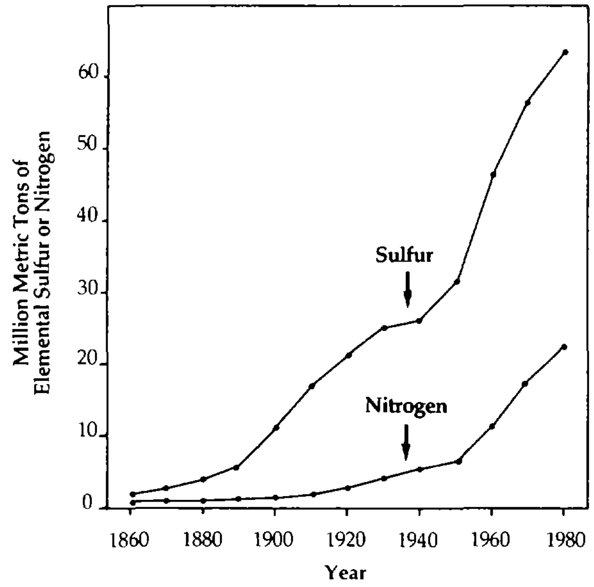
Improper design, use, and disposal of these substances has had large costs. In the United States, for example, 2,000 to 10,000 hazardous waste sites require clean-up, at a cost that could range from $20 billion to $100 billion (IIED and WRI 1987, p. 207). Every year perhaps a million cases of acute pesticide poisoning occur worldwide, plus some unknown larger number of lesser incidents (UNEP 1987, p. 96). High-level radioactive wastes, like the 21.4 billion curies of spent U.S. nuclear fuel, still have no permanent disposal sites (US CEQ 1990, p. 448). These experiences illustrate the challenges ahead in managing new technologies with environmental prudence.

> **"The notion that pollution is mainly a problem in highly developed economies is a myth."**

From Developed to Developing World

The notion that pollution is mainly a problem in highly developed economies is a myth. Many of the most dramatic and alarming examples of environmental degradation can be found in Eastern Europe and developing countries in Africa, Asia, and Latin America. Cities in these regions are usually more polluted with sulfur dioxide and particulates than most of the cities in OECD countries. Even more alarming, the situation seems to be getting worse. Available data for Asian countries suggest that sulfur dioxide pollution went up about 10 percent a year between 1973 and 1984. Pesticide use is also accelerating rapidly. Developing countries now consume 45

Figure 1. Global Emissions of Nitrogen and Sulfur Oxides from Fossil Fuel Combustion



Source: J. Dignon and S. Hameed, "Global Emissions of Nitrogen and Sulfur Oxides from 1860 to 1980," *The Journal of Air Pollution Control Assoc.*, (1989), Vol. 39, No. 2, p. 183

percent of all insecticides and 10 percent of fungicides and herbicides produced annually (UNEP 1987, p. 96).

Rapid economic development explains part of this proliferation of environmental hazards. Population growth is fastest in developing countries, and their economic output increased sixfold between 1965 and 1985. The consequences of pollution, however, may be disproportionately severe. Among large segments of those populations, exposure is high. In a ten-country sample of population blood-lead levels in industrial and developing countries, Mexico, India and Peru ranked as three of the top four. DDT in human milk was highest in China, India, and Mexico (UNEP and WHO 1987, pp. 18–22). And the worst industrial accident in history, the methyl isocyanate release of December, 1984, occurred in Bhopal, India (Ayres and Rohatgi 1987).

Many of the problems of environmental degradation in developing countries are well-understood and technically preventable. Again, the history is one of technologies and manufacturing systems applied with short-term goals foremost, to the detriment of long-term environmental realities. Widespread adoption of more appropriate technologies will be necessary to correct this imbalance, but the necessary resources are not yet in sight.

From Local to Long-Term Global Effects

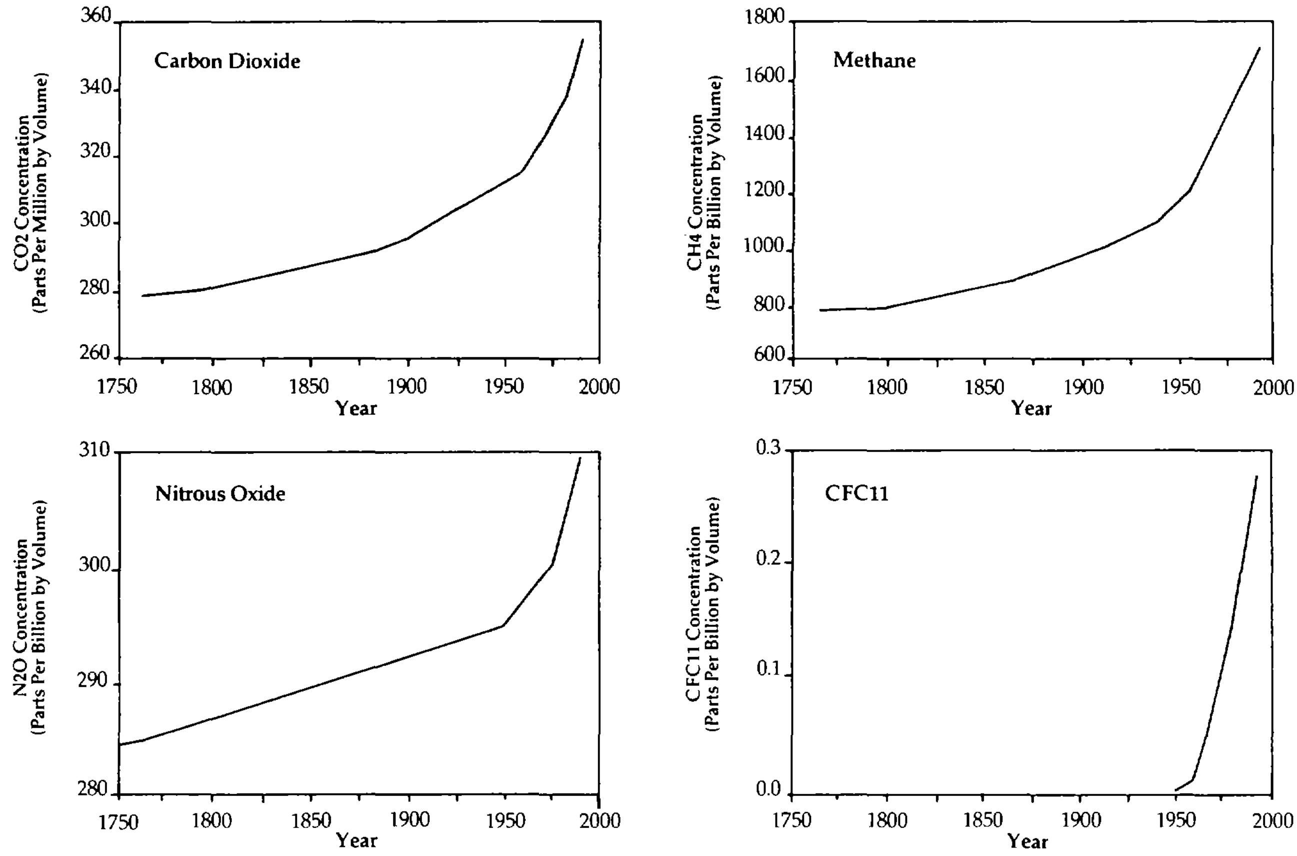
When the first generation of environmental laws was passed during the early 1970s, pollution was usually viewed as a local and acute problem. Today, this view is no longer tenable. Since the worldwide scale and intensity of pollution abated little, and scientific knowledge has grown, pollution has come to be recognized as a global and chronic phenomenon. This means not only that pollution can be found everywhere but also that its impacts are now large enough to alter the fundamental natural processes that support life.

Long-range transport of air pollutants is now recognized as the source of acid deposition that has emerged as a major problem in Europe and North America, as well as in parts of Asia and Latin America. While acidification of surface waters has long been a concern, pollution's threat to vegetation looms larger. Recently, air pollution has been implicated as a primary factor in forest decline. In Europe, ***Waldenschaeden*** ("forest damage") has struck over half of German trees (MacKenzie and El-Ashry 1989). Over a half million square miles of China are under assault by acid rain (Southerland 1990). In the United States, ozone damage to U.S. crops costs $1 billion to $5 billion yearly (MacKenzie and El-Ashry 1989).

The discovery of an ozone "hole" over Antarctica reinforced many scientists' fears and offered a major motivation for adopting the precedent-setting international accord in Montreal in 1987 to limit chlorofluorocarbon (CFC) use. Global warming from the accumulation of carbon dioxide, methane, CFCs, and other greenhouse gases presents another profound global challenge. Resulting changes in weather patterns and predicted sea level rise could wreak widespread environmental and social havoc, and cost all nations enormous sums. Although the industrial nations have been the greatest source of greenhouse gas emissions, developing nations are growing contributors to the problem, so global solutions are required.

To respond to these new dimensions of the age-old environmental challenge, the world economy's "industrial metabolism" must be tamed (Ayres 1989). Like an organism that eats its food, metabolizes it at some rate and excretes, an industrial system does environmental damage as it consumes inputs of natural resources and generates harmful residuals. Just as an organism dies if its rate of consumption exhausts its available resource base or if its wastes destroy its habitat, industrial

Figure 2. Global Greenhouse Gas Concentrations



Source: "Climate Change, the IPCC Scientific Assessment," World Meteorological Organisation and United Nations Environment Programme, Executive Summary, (1990), p. xvi

systems cannot indefinitely devour natural resources or exceed life-sustaining natural systems' regenerative capacity.

II.2 Extraordinary Technological Potential

Today, the climate for innovation seems uniquely rich, poised between technological revolutions in progress and others just emerging. If environmental goals are integrated into these innovations, the transition to a sustainable future will happen faster, cost less, and have longer-lasting results.

The current moment offers an unmatched technical potential for environmental improvement, a fluid climate for technological advance, which badly needs to be exploited. The reservoir of available but unused technology is large. Developments on the horizon could yield major benefits if they are deployed and managed with an environmentally sustainable future in mind.

If this vital transformation has a watchword, it is prevention. Until now, most environmental technologies have been designed as "end-of-pipe" controls. Stack gas scrubbers and automotive catalytic converters are prototypical of this approach. However, products, processes and systems can also be designed to prevent pollution. Pollution prevention, where feasible, is usually more effective and less expensive than are fix-it-later strategies.

More Efficient Technologies

Enormous improvements in the quality of the global environment could be made with existing technologies, often at no, or small, additional cost. In agriculture, for example, alternative practices that exploit natural cycles and interrelations while decreasing reliance on such off-farm inputs as synthetic fertilizers can drastically reduce environmental damage. Increasingly, these practices are also being recognized as economically competitive with conventional input-intensive farming systems (Benbrook 1990; Faeth et al. 1990).

The examples of currently available energy-saving technology are even more dramatic. For example, Dow Chemical's Louisiana Division's returns on investments in energy efficiency averaged 198 percent for 167 audited projects carried out over seven years (Ayres 1990). Much more fuel-efficient automobiles—doubling today's average gas mileage—are also at hand (Bleviss 1988). New low-emissivity windows can rival walls in their insulating capability (Bevington and Rosenfeld 1990).

> **“Enormous improvements in the quality of the global environment could be made with existing technologies, often at no, or small, additional cost.”**

Enormous waste reduction is within reach. The Office of Technology Assessment (OTA) estimates that about half of all environmentally harmful industrial wastes in the United States could be cut with available technology; with some R&D, another 25 percent could probably be eliminated (Hirschhorn 1990). Even with current technology great gains are possible. Industry can make use of more recycled paper, metal, glass, waste oil, and plastics than it now does, and higher recycling rates would reduce the need to process virgin materials and the burden on waste-disposal facilities.

Why is this rich, near-term potential not being realized? Many explanatory factors—lack of information, lack of capital, management failures, and short-sighted or obsolete public policies that impede environmental improvements—are detailed later in this report. But technology is not the limiting factor: technical solutions available right now could make dramatic environmental improvements at small or negative cost.

Revolutionary New Technologies

Revolutionary technological developments on the horizon could yield enormous environmental benefit, if developed appropriately. Biotechnology, still in its commercial infancy, could fuel a new and environmentally sounder "green revolution," freeing farming from heavy dependence on agrichemicals. Although widely recognized for their pharmaceutical potential, biological tools are also likely to profoundly affect a wide variety of industrial activities. Enzymes used as industrial catalysts, microbial recovery of metals (biohydrometallurgy,) waste degradation, and biomass fuels and feedstocks are but a few examples. These applications could lower the energy- and pollution-intensity of production while decreasing dependence on fossil fuels. Like other new technologies, biotechnology may not represent an unequivocal environmental gain. Fears that poorly designed or poorly understood genetically engineered organisms might become pests—a self-replicating environmental hazard—once released into the environment are reinforced by limits to our understanding of ecology.

Materials technology, equally dynamic, shows even more immediate application. Products based on specially engineered materials probably now comprise more than a third of U.S. GNP—over $1 trillion yearly (US OTA 1990). Because composite materials typically perform better than conventional materials per unit of weight, they require less raw material and produce less waste. Perhaps most important, materials design has become so highly sophisticated that engineers can now incorporate environmental criteria rather than deal with them as an afterthought. Here too, though, potential environmental drawbacks need consideration. Composites and other specially engineered materials are usually very difficult to recycle and may use more toxic substances.

The term "information technology"—encompassing developments as diverse as real-time monitoring of effluent streams, computer-controlled manufacturing, software development, and chemical and biological sensors—undoubtedly covers the broadest range of potentially important new technologies. All these technologies could have an enormous impact on pollution prevention and control. The application of computers to manufacturing systems not only greatly increases their efficiency and flexibility but also makes possible real-time monitoring of reaction conditions and effluent streams. When coupled with sensors that recognize changes in such conditions, automated processes can both prevent pollution and use input materials and energy more efficiently.

The challenge is not only to encourage these revolutionary developments for their potential but also to ensure that environmental factors are designed at the earliest possible stage.

The Promise of Dematerialization

Dematerialization describes a technological shift away from economies based on enormous and increasing consumption of raw materials (Herman et al. 1989). Some modern societies seem to be dematerializing, and dematerialization is certainly a consequence of many of today's most creative technological changes. Nevertheless, these trends are by no means universal, nor are they moving fast or consistently enough toward environmental improvement.

One measure of dematerialization is the consumption of energy, steel, cement, and other materials in relation to changes in GNP. For instance, U.S. steel consumption per unit of GNP has dropped 30 percent since 1974 (Williams et al. 1987); and while GNP has risen by about 50 percent in western industrial countries over the same period, energy consumption grew by only 14 percent (Colombo and Lanzavecchia 1990). Nationally, the data reveal significant divergences. Countries such as Sweden have reduced energy and materials consumption in comparison to growth rates enough to make environmental gains at little or no cost. Japan and Norway seem to have improved the environmental efficiencies of their economic structures, though fast growth has limited the net environmental benefit. Still other countries, notably in Eastern Europe, have experienced no or environmentally negative structural change (Jänicke et al. 1989).

Technological change and new information make dematerialization possible. The obvious trend in industrial countries is away from resource-intensive (high-volume) production toward knowledge-intensive (high-value) production. In the United States, for example, the pattern of investment has shifted dramatically: information-related technology now comprises around 40 percent of all new capital investment (US OTA 1988). Indeed, because information can often substitute for material inputs, information is the fundamental agent of dematerialization.

Miniaturization and hyperminiaturization (nanotechnology) also promise the performance of countless industrial functions with vastly less energy and material expenditures. Many developments that were recently inconceivable are already on-line: turbo-chargers for automobile engines, fiber optic cables one-fortieth the weight of copper cables, or a 25,000 rpm micropump implanted in a patient's heart (Colombo and Lanzavecchia 1990).

Globalization

Globalization means the removal of national barriers to information, investment, and trade. Despite debate about the extent of globalization and its desirability, science and technology have unquestionably become highly internationalized. In the 1960s, for example, two-thirds of the non-communist world's R&D was done in the United States; now, the United States share is probably less than half. Foreign holders of U.S. patents have doubled, from about 20 percent in 1970 to more than 40 percent today (US NSF 1989). International trade has grown enormously, from about 7 percent of GNP in the United States in 1960 to around 15 percent today (US NAE 1988, p. 17). The penetration of industrial markets by developing countries was one of the major economic phenomena of the 1970s. The growing speed with which technology can diffuse internationally means that environmental problems of global scope can call forth technological responses of equal scope.

> **"Miniaturization and hyperminiaturization promise the performance of countless industrial functions with vastly less energy and material."**

II.3 Competitiveness and Environmental Technology

Technology holds the key to commercial competitiveness in the developed economies. High-technology exports have long been the most favorable aspect of American trade balances; global markets for high-technology products are growing faster than markets for other products; and high-technology companies export, on average, three times more of their production than other manufacturers do (US NSF 1989).

Whether environmental investment undermines competitiveness is more controversial. Some studies suggest that pollution control expenditures lower productivity growth (Jorgenson and Wilcoxen 1989; Barbera and McConnell 1990). Recent work argues that such investments contribute to productivity growth if productivity is measured appropriately to include reductions in environmental damage costs (Repetto 1990). In economic policy, what is measured often assumes paramount importance; what is unmeasured is ignored. Measurements of GNP and productivity, the foundation on which national and international economic policies are built, are grossly inadequate from an environmental standpoint. GNP statistics ignore resource depletion, valuing activities like polluting aquifers or depleting topsoil as generating income rather than as depleting assets. Conventional productivity measures encompass only marketed outputs and inputs, ignoring the costs of harmful outputs like pollution.

> **"In the electric power industry, the cost of emissions as unpriced outputs in the 1980s was about as large as the cost of labor to the industry."**

Economists need to develop measures that put the benefits and the costs of environmental protection on an equal footing. Initial analysis conducted at WRI suggests that this is a difficult, but feasible, task (Repetto 1990). A study of the electric power industry, develops the concept of environmental productivity and demonstrates that the cost of emissions as unpriced outputs in the 1980s was about as large as the cost of labor to the industry. Technologies that reduced environmental damages over the decade thus contributed substantially to economic productivity, and conventional productivity measurements significantly understate the productivity improvements that occurred.

Approaching the question from the narrower point-of-view of stockholders, however, many investments in environmental technology make good business sense. Better process control, for example, often yields both substantial cost savings and environmental benefits. Some companies, of course, have long realized this: environmental programs in Dow Chemical, 3M, and DuPont are frequently cited as examples (Ehrenfeld 1990). Nevertheless, many analyses of manufacturing practice confirm that widespread ignorance of the economic benefits of improved process control greatly inhibits waste reduction (Hirschhorn 1990).

A new motivation for investments in environmental technology appears to be arising in the development of "green consumer" markets. European companies have mounted particularly aggressive product development and marketing strategies, playing to a large consumer market receptive to environmentally preferable products (Cairncross 1990).

The strength of consumer environmental consciousness and the expected implementation of stronger regulations during the 1990s has made Europe a particularly promising market for U.S. environmental technology and services. Some environmental services firms reported 60 percent revenue growth in 1989 (Sternberg 1990). Automobile and industrial catalyst technology illustrates a similar trend. While the U.S. market grows slowly, new European legislation holds the promise of 30-percent yearly growth, to a $500-million market in 1993 (Chynoweth et al. 1990).

Growth in hazardous waste management and treatment markets has been widely noted, and recent projections indicate a $30-billion yearly total by the mid-1990s (Heller 1990a; Heller 1990b). The obvious opportunity has prompted many new corporate ventures, such as DuPont's recently announced new environmental services business unit, projected to grow to $1 billion yearly within 10 years. The size of investments in pollution prevention and control is unprecedented: Bayer, from West Germany, reports a level equal to 20 percent of its manufacturing costs, and Chevron predicts increases of 10 percent a year, which will make anti-pollution activities its principal area of corporate growth (Cairncross 1990).

Some companies recognize environmental investments as a profitable opportunity, but this perception is not yet nearly widespread enough. The Conference Board of Canada has put the problem well, characterizing "the task of building an environment industry [as] the great enterprise in the 1990s and beyond." (Conference Board of Canada 1990).

III. SCENARIOS OF TRANSFORMATION: SECTOR STUDIES

In the coming decade a thorough transformation of technology can begin. This technological transformation—fueled by key developments in energy, agriculture, and industrial production—can move society away from the material-intensive, high-throughput economy of the past toward a growing economy of great material and energy efficiency. Emerging and existing technologies enable us to envision an economy that moves toward the goal of living off nature's income instead of its capital.

III.1 Energy

Energy moves the entire economy but poses some of the gravest environmental issues. Exciting technologies—available now or in the next decade or two—may revolutionize the way we produce electricity and fuels, transport ourselves and our goods, and control the indoor environment. Even with today's technology, the United States could meet 30 percent of its energy demand with renewable resources at competitive prices (US DOE 1990), but instead meets only 9 percent from these sources. Existing and emerging technologies offer great environmental potential and highly profitable possibilities to firms with vision and foresight.

Electric Power Production and Energy Storage

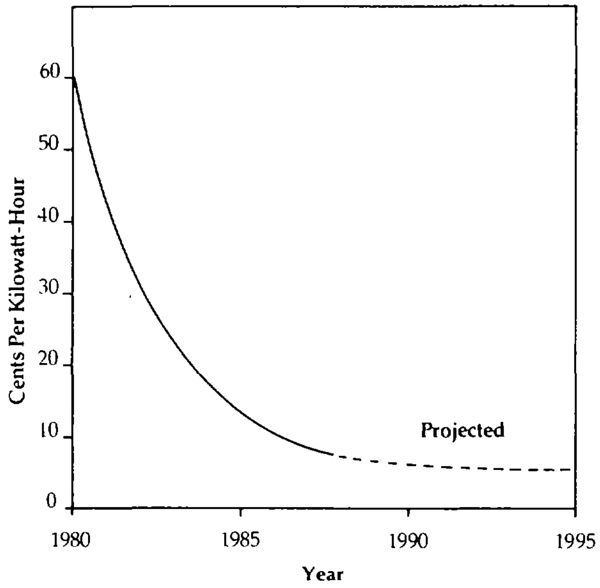
The seeds of post-fossil fuel power generation are germinating in the laboratories of scientists and engineers and in the plans of entrepreneurs. A variety of renewable energy technologies and technologies applicable to both renewable and fossil fuels are just becoming competitive. Others are here today.

Several technologies, including cogeneration of electricity and heat by combined-cycle gas turbines and fuel cells, are applicable to the exploitation of both fossil and renewable fuels. A combined-cycle power plant, which links a gas turbine with a steam generator and turbine, can raise thermodynamic efficiencies in electricity generation from about 35 percent in new central steam plants to nearly 50 percent (Burnett and Ban 1989). These efficiencies can be increased up to 80 percent when waste heat is recovered for industrial, space, and water heating. Furthermore, these turbines can be installed quickly and at lower cost than central steam power stations, making the technology attractive for utility planning in both developed and developing countries.

Astounding progress has been made in the past two decades in commercializing renewable energy technologies. Since 1973 the price of photovoltaic (PV) electricity production has decreased from $15 per kilowatt-hour (kWh) to $0.30. New manufacturing plants taking advantage of economies of scale are expected to bring this cost down to $0.15 per kWh by the mid-1990s (Hubbard 1989). The newest solar thermal power stations operated by Luz International in California generate electricity at $0.08 per kWh down from $0.24 in 1984. They anticipate being able to generate power at $0.05 per kWh by 1994 (WRI 1990, p. 158). Wind power has grown from near zero in the early 1970s to 1660 megawatts (MW) of electric power capacity worldwide (85 percent in California and much of the remainder in Denmark). Over this period, generation costs at favorable wind sites have decreased to between $0.05 and $0.09 per kWh (AWEA 1990). Figures 3 and 4 illustrate the cost trends for solar thermal and wind-derived electricity. As shown in Figure 5, costs for a number of renewable electricity generation systems compare well with the $0.05 to $0.09 per kWh costs for new coal- and oil-fired central power plants and the $0.10 per kWh cost of nuclear fission, especially since sunlight and wind neither release pollutants nor accumulate fissile products, and they can't be embargoed.

Continued cost reductions in renewable energy will require not only more research but also increased production so that economies of scale and manufacturing efficiencies can be achieved. Wind power's improved performance has largely come about from experience gained in siting, maintenance, manufacturing, and organization though the development of lighter composite turbine blades and microprocessor controls has also contributed (Weinberg and Williams 1990). If conversion efficiencies achieved in the laboratory for photovoltaic cells through the use of layered cells that absorb different wavelengths of light, new materials, and better assembly techniques can be matched in

Figure 3. Cost Trends: Solar Thermal Electricity



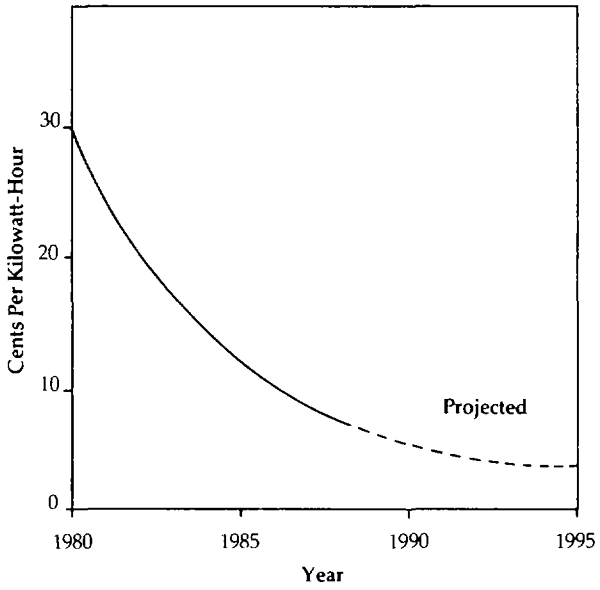
Source: United States Department of Energy, (1990)

mass production, we may also see large-scale use by utilities of the technology in the latter part of the 1990s (Carlson 1989; Hubbard 1989). In the United States, provisions of the Public Utilities Regulatory Policies Act of 1978 that denied power producers certain regulatory benefits once their facilities exceed 80 megawatts have been a major impediment to expansion of Luz International's solar thermal system, inhibiting achievement of economies of scale (Sklar 1990). Such economies that come with actual production and deployment of the technology are at least as important as laboratory research and development in making new technologies competitive.

Fuels and Energy Storage

Storing solar and wind power is an interesting challenge. Advanced batteries, compressed air, and stored hydroelectric potential (that is, pumping water uphill into a reservoir) may all come into play, but an especially appealing option is production of hydrogen, a fuel that releases only water vapor and minute amounts of nitrogen oxides when burned. Hydrogen derived from the electrolysis of water offers a clean and efficient means of storing solar energy for later use as a fuel for vehicles, industrial processes, residential use, or electricity production. Technology trends suggest that,

Figure 4. Cost Trends: Wind-Derived Electricity (at Sites with Greater than Thirteen Mile Per Hour Wind)



Source: United States Department of Energy, (1990)

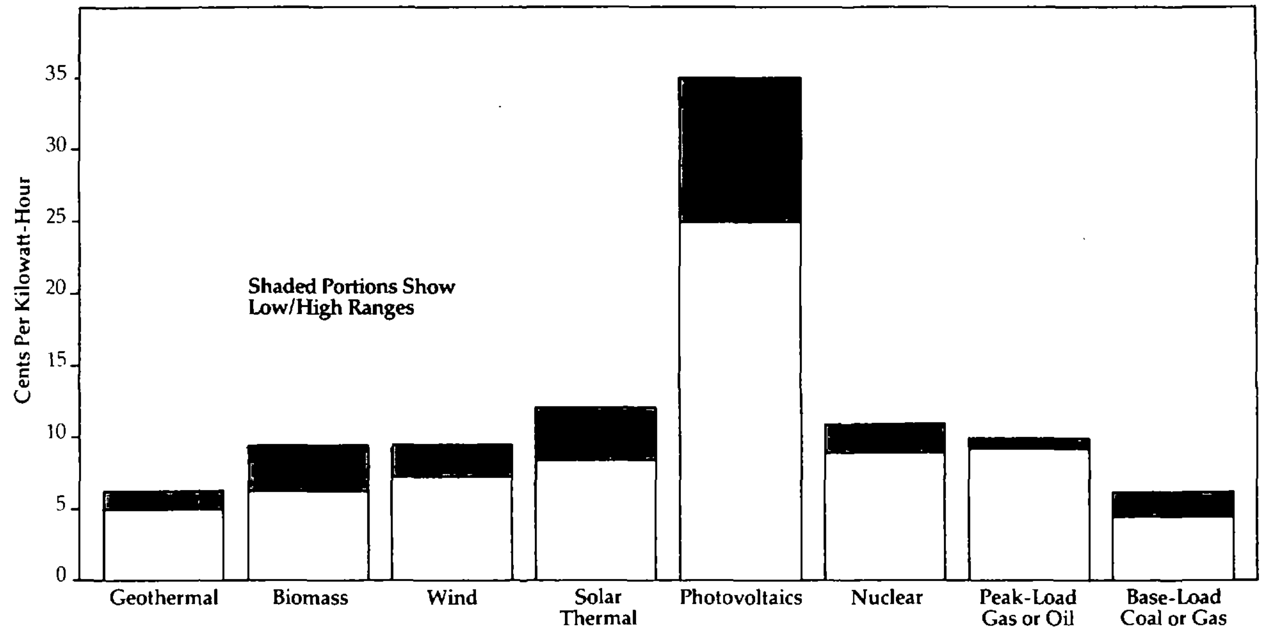
with appropriate public policies, solar and hydrogen technologies could soon begin fueling a transition to a post-hydrocarbon economy (Ogden and Williams 1989).

As for biomass, another storehouse of solar energy, technological advances promise improved production of fuels from this source. Genetic engineering techniques and a growing understanding of enzyme structures may greatly improve the efficiency of conversion. Of particular promise is the industrial-scale use of enzymes to degrade cellulose fibers and woody tissues. This process allows wastes from agriculture, forestry, and food processing, as well as urban wastes and biomass energy crops, to be converted into convenient (and renewable) liquid and gaseous fuels and into feedstocks for the chemical industry.

Transportation

Traffic jams under smoggy skies and the repeated crises in the Middle East reflect our dependence on uncertain oil supplies and the large environmental costs associated with the automobile. Transportation, which accounts for 27 percent of U.S. energy demand and 63 percent of U.S. oil use, need not entail such a high cost to the environment,

Figure 5. Electricity Costs for New Generating Capacity



Source: United States Department of Energy, (1990)

health, and economic security (US DOE 1989; MacKenzie 1989). Prototype cars from Volvo, Toyota, Renault, General Motors, and other firms achieve fuel economies of 66 to nearly 100 miles per gallon (mpg) of gasoline or diesel fuel. Yet, the U.S. passenger car fleet averages 19 mpg and new cars average 28 mpg (Bleviss 1988; US DOE 1989). Some of these prototypes are roomy, safe, and speedy as well as economical in fuel use. Multivalve engines, electronic fuel injection, lightweight materials, improved tires, and aerodynamic styling are already common on the road. Current prototypes are proving the viability of continuously variable transmissions, energy-storage flywheels, improved electronic controls, advanced materials, and a new generation of the two-stroke engine. These new motor vehicle technologies greatly improve the energy economy of gasoline and diesel engines and can be transferred to the next generation of renewably fueled vehicles.

New nonfossil vehicle fuels are inevitable. The Daimler-Benz prototype hydrogen car and hydrogen buses built by Billings Energy Corporation for Provo, Utah, offer a glimpse into transportation's future. They are clean, emitting only water vapor and traces of nitrogen oxides when they run. Prototype electric cars are also tantalizing: they can run for 120 miles at 55 miles per hour on a single charge and can be recharged at night when electricity demands are low. General Motors has plans to manufacture an electric passenger car soon (Judge 1990). Both hydrogen and electric vehicles need better means of storing energy. Batteries take hours to recharge, and stored hydrogen is either bulky (cylinders or metal hydrides) or energy-intensive (liquid hydrogen). As with progress in solar and wind power, advances will come from innovations on the factory floor as well as from discoveries at the laboratory bench.

The Indoor Environment

Nearly two-fifths of U.S. energy use occurs at home or in the commercial sector and about two-thirds of electricity demand is from buildings (US DOE 1989; Kelly 1990). Heating, cooling, ventilation, lighting, cooking, and the various electrical equipment found in the modern home and office. provide many opportunities for energy efficiency gains. Much of the technology exists today. Already, superinsulated homes in frigid Scandinavia and Minnesota use only a tenth to a third of the energy required by a typical American home (Gibbons et al. 1989). One home builder in chilly

Chicago, the Bigelow Group, guarantees that its town houses and single-family homes will not cost more than $100 and $200, respectively, to heat annually (Bevington and Rosenfeld 1990). New buildings can be built cost-effectively to use 40 to 50 percent less energy than is typical for new American buildings (Kelly 1990).

Similar energy savings (50 percent to severalfold) are achieved by the best commercial and prototype refrigerators, furnaces, air conditioners, and lighting fixtures. The compact fluorescent light bulb—a new, efficient, cost-effective yet still underutilized technology—uses 25 percent of the power required by an equivalent incandescent light bulb and generally pays for itself in a year or two. Over its lifetime, a single 18-watt compact fluorescent bulb replacing 75-watt incandescent lighting can prevent a ton of carbon dioxide emissions from a coal-fired generating station (Lovins 1989).

> **“To increase production to feed a population doubling to 10 billion by the mid-21st century while protecting the resource base—soil, water, and genetic diversity—upon which that production depends, agriculture must combine ‘cutting edge’ high technology with the tried-and-true methods of the past.”**

Technologies emerging in the marketplace, such as advanced high-efficiency windows, will further improve building energy efficiency. Each year, windows cost the United States as much energy as it gains from a year's Alaskan North Slope oil production (Bevington and Rosenfeld 1990). Heat-reflecting transparent coatings and layers of insulating vacuum or special gases enable these new windows to rival well-insulated walls in their heat-blocking ability (Bevington and Rosenfeld 1990; Granqvist 1989). These coatings also keep rooms from overheating on sunny days, saving on air-conditioning expense. The next generation of windows will incorporate "active" or "smart" electrochromic coatings that will automatically control light reflectance in response to the intensity of outside sunlight.

Smart windows may be one component of the evolving technology of "smart buildings." Like a body maintaining homeostasis, smart buildings automatically adjust heating, cooling, ventilation, and even lighting to maintain a comfortable interior environment. Far more sophisticated and efficient than standard thermostatic controls, these systems respond to changing temperature by optimally controlling ventilation by computer. For example, excess heat from office equipment can be redistributed to cooler parts of the building where it is needed, thus maintaining comfort and saving energy. Smart building systems can also incorporate "occupancy sensors" that turn off lights in empty rooms.

Many other technologies can improve energy efficiency in the residential and commercial sectors, ranging from simple low-flow shower heads, to ground-source heat pumps, to large commercial water chillers that run at night and save the cooling power for the peak hours of the day. Numerous opportunities such as these remain to be grasped.

III.2 Agriculture

The challenges for agriculture in the coming decades will be to increase production to feed a population doubling to 10 billion by the mid-21st century while protecting the resource base—soil, water, and genetic diversity—upon which that production depends. To meet these challenges, agriculture must combine "cutting edge" high technology with the tried-and-true methods of the past. Both spliced genes and recycled manure have a place in tomorrow's highly productive and environmentally friendly farming systems. Both biotechnology and "alternative" agriculture have the potential to transform agriculture in the new century.

Biotechnology

In the last 20 years, scientists have made extraordinary progress in deciphering the molecular mechanisms of life, developing a powerful set of technologies in the process that can manipulate living organisms with unprecedented scope and precision. Biotechnology is only in its infancy, but its potential applications in agriculture, medicine, and industry are revolutionary.

Biotechnology permits much more rapid and precise transfer of genetic traits into agriculturally useful organisms than do conventional breeding methods. Also, in contrast to traditional breeders, biotechnologists can transfer genes from virtually any living species and can even custom modify genes in the laboratory. Numerous livestock and crop species, including two major grain crops, corn and rice, have already had "foreign" genes inserted into their chromosomes (Moffat 1990; Schneiderman and Carpenter 1990).

Biotechnology's environmental implications are vast. Proponents predict that biotechnology will liberate farmers from pesticides and synthetic fertilizers while increasing the quality and quantity of their production. Critics fear that genetic engineers will inadvertently create pests and pathogens from otherwise benign organisms and unleash ecological havoc by releasing them into the environment. Critics further contend that corporations will exploit biotechnology to reinforce their sales of pesticides and other agrichemicals and will further narrow agriculture's genetic base. Clearly, however, biotechnology will grow in importance; and, if used wisely, can make agriculture more sustainable.

For example, the bacterium *Bacillus thuringiensis* (B.t.) produces a protein that is toxic to some insect orders but has no ill effect on other animals. B.t. toxin has been used as a safe biological pesticide for many years but suffers from a short field life. Undergoing field trials are crop plants that have been "engineered" to make the B.t. toxin in their tissues. Implanted in corn, B.t. toxin could, without any insecticides, control the European corn borer, which now causes $500 million of damage annually in the United States (Twombly 1990). Also, because B.t. toxin would affect only insects that ate from the protected plant, beneficial nontarget insect species would not be harmed. Biotechnology has also made inroads against plant fungal and viral diseases and may provide protection while lessening the need for fungicides (many of them suspected carcinogens) or for insecticides to control insects that spread certain crop viruses (Schneiderman and Carpenter 1990).

Greatly improved understanding of the mechanisms of plant physiology and the interactions among plants, microbes, and the soil are opening up other frontiers. Scientists now understand better how plants respond to such stresses as heat, drought, freezing, poor soil, and disease. Armed with this understanding and the tool-box of biotechnology, they can make crop and forestry species more resistant to these stresses than conventional plant breeders can.

Further in the future, biotechnologists may be able to manipulate very complex genetic characteristics, such as nitrogen fixation and photosynthesis. Synthetic fertilizers, which are polluting and energy-intensive agricultural inputs, might become unnecessary if nitrogen fixation can be transferred from leguminous crops (for instance, soybeans, peas, beans, and alfalfa) to grains like wheat and corn. The genetic engineering of nitrogen fixation would involve the coordinated manipulation of numerous genes from both the crop plant and certain bacteria *(Rhizobia)* that are essential to the process.

Genetic modifications to improve the photosynthetic efficiency of crops would allow more solar energy to be captured in the form of biomass. This would increase the production of food per area of land and increase the availability of biomass as an energy resource and chemical feedstock—helping to create renewable bases for energy production and industry.

Biotechnology is not without environmental risks. Efforts by numerous firms and public laboratories to make crop plants resistant to synthetic herbicides have been criticized because this could lead to increased use of herbicides that damage water resources and ecological cycles. The fear that releasing genetically modified organisms might result in unintended disaster is fed by the realization that little is known of the interactions between farms and natural ecosystems. Advances in the ecological sciences are needed to keep up with progress in biotechnology.

Alternative Agriculture

"Alternative" agriculture is another way of releasing food and fiber production from its heavy reliance on synthetic pesticides, fertilizers, and feed additives. Alternative techniques are demonstrating that high yields can be maintained without damage to soil, water, and ecological processes.

Unlike biotechnology's laboratory-derived reductionist approach, alternative agriculture is based on the understanding of natural nutrient cycles and ecological relationships. Alternative agriculture views the farm as a holistic system in which production processes interact synergistically. For example, this season's corn benefits from the soil nitrogen left by last season's soybeans while breaking up the pest and disease complexes that would otherwise plague next season's soybeans. Today's alfalfa improves the soil while providing feed for livestock, which in turn enriches the soil with its manure. The variety of production provides an ecological and economic resilience that insures farmers against supply and market collapses, major risks for intensive monocultures.

Alternative agriculture reduces the need for off-farm inputs, such as chemical fertilizers, pesticides, and feed additives that pose health and environmental risks. The methods decrease soil erosion and can improve soil quality. The best alternative practices can reduce production costs and sometimes improve yields over conventional techniques. Many farmers who have embraced these methods have profitable and productive operations that are less financially dependent on government subsidy programs (US NRC 1989).

Is alternative agriculture an approach of the past or of the future? The answer is both. While embracing some age-old practices like crop rotations, the methods of alternative agriculture are neither passive nor unsophisticated—nor are they incompatible with biotechnological advances. Alternative agriculture is knowledge- and information-intensive. For example, integrated pest management (IPM)—one important part of alternative agriculture—employs a wide ensemble of pest-control methods, including: growing pest-resistant cultivars; introducing or augmenting populations of natural enemies; using pest diseases, insect hormones, and pheromones (sex attractants); practicing crop rotations; and using various tillage techniques, in addition to judicious application of conventional pesticides. IPM requires frequent monitoring or "scouting" of pest levels, a good understanding of pest species behavior under various conditions, and well-timed performance of farm operations (planting, tilling, harvesting, and specific pest control measures). Alternative agricultural approaches to disease control, soil management, and livestock operations likewise emphasize precisely measured resource management. In contrast, in conventional farming, chemical inputs are typically applied at levels beyond what is economically profitable or ecologically desirable (Benbrook 1990).

Other Agricultural Technologies

Sustainable agriculture can include other technologies for meting out inputs highly efficiently. For example, drip irrigation is far more water efficient than conventional irrigation methods. If linked to soil moisture sensors, a drip-irrigation system can provide water exactly where and when needed. Fertilizers, if not obviated by alternative or biotechnological techniques, could also be applied efficiently through a drip irrigation apparatus. Technologies for timely and precise information on soil fertility, pest levels, and disease occurrences could allow farmers to apply inputs optimally with low environmental costs. Imagine the environmental benefits that could result if farmers could program their farm machinery to apply fertilizer or pest control agents only where and when required instead of dousing fields regularly on generalized advice from chemical vendors or extension agents.

A Synergistic Package

If agriculture is to meet ever-growing demands at diminished environmental costs, it will need technological innovation from many sources. Biotechnology and alternative agriculture are not separate and incompatible options. But many who advocate one are relatively ill-informed and skeptical of the other, sometimes even antagonistic. Clearly, future agricultural technologies must include a rich diversity of approaches. Farmers of the next decade may grow genetically engineered disease-resistant soybeans on one conservation-tilled field while monitoring real-time soil moisture data from a nearby insect-resistant cornfield and analyzing feed requirements for their cattle by computer.

III.3 Industrial Production

The ideal industrial system would transform energy and materials into goods at very high efficiencies—efficiencies approaching the limits imposed by the laws of thermodynamics. As much material and energy as possible would be recovered from process wastes and from post-consumer refuse. Such a system would also avoid such hazardous substances as chlorinated hydrocarbons and toxic heavy metals. Although this is an ideal, proven technical and managerial approaches can already deliver big gains in the efficiency of industrial production.

Pollution Prevention

As a manufacturing goal, "zero discharge" can be thought of as an environmental analog to the quality goal of "zero defects"—a goal that implies continuous improvement. Already, some firms have embarked on ambitious pollution prevention programs to approach these targets for at least some categories of pollutants.

One chemical manufacturer, Monsanto, established in 1988 a goal to reduce toxic air emissions by 90 percent by 1993 and has stated that its goal for itself, its contractors, suppliers, and shippers should be "zero spills. Zero releases. Zero incidents. And zero excuses." (Hirschhorn 1990). General Dynamics reduced hazardous waste production by 72 percent in 1984-88 and has a 1991 goal of zero hazardous waste generation. 3M cut waste by 50 percent over the past 15 years and plans to cut out another 50 percent by the year 2000 (Hirschhorn 1990). Since 1960, Dow Chemical has reduced its production of hazardous wastes from 1 kg per kg of saleable product to 1 kg per 1,000 kg of saleable product (Ehrenfeld 1990). Over 80 years, the Bayer AG Leverkusen sulfuric acid plant reduced sulfur dioxide emissions by 98 percent per ton of sulfuric acid produced (Hirschhorn 1990). Chevron and Polaroid are among the other firms that have adopted ambitious pollution prevention programs.

Preventing pollution often raises a firm's profits, not costs. Hirschhorn (1990) and Huisingh (1989) report many industrial pollution prevention projects with pay-back periods ranging from a month to three years. Table 1 provides some examples. These returns, in the form of diminished disposal fees and saved energy and materials, do not even include the benefits of decreased exposure to liability from hazardous waste disposal or improved reputation among increasingly "green" consumers.

The range of pollution prevention options are myriad and the feasibility of applying them depends on the particulars of each industry and each facility. Sometimes it is as simple as placing a lid on a vat of solvent. In other cases, significant changes in product or process—for instance, eliminating the use of heavy metals or replacing organic solvents with aqueous or mechanical processes—are required.

In any event, the limiting reagent of pollution prevention is generally not as much the "hardware" of technology as the "software" of corporate management. Experts in pollution prevention are more likely to identify corporate leaders' attitudes, organizational structures, and perceived internal incentives as the primary determinants of pollution prevention success than any set of machines, devices, or technical capabilities (Ehrenfeld 1990; Hirschhorn 1990).

Computer Monitoring and Control

As computer-aided design, computer-aided manufacturing, robotics, and other manifestations of the microelectronic revolution continue to enter the factory, we can expect simultaneous improvements in industrial productivity, product quality, and environmental performance. Sophisticated computers can make the production process highly efficient. When linked with advanced sensors that monitor in real-time the conditions inside a reactor vessel, a column, or a waste stream, and with actuators (pumps, motors, valves, power supplies, and

Table 1. Examples of Successful Pollution Prevention

Industry	Method	% Reduction of wastes	Payback
Pharmaceutical production	Water-based solvent replaced organic solvent	100%	< 1 year
Equipment manufacture	Ultrafiltration	100% of solvent and oil, 98% of paint	2 years
Farm equipment manufacture	Proprietary process	80% of sludge	2.5 yrs.
Automotive manufacture	Pneumatic cleaning process replaced caustic process	100% of sludge	2 years
Microelectronics	Vibratory cleaning replaced caustic process	100% of sludge	3 years
Organic chemical production	Adsorption, scrap condenser, conservation vent, floating roof	95% of cumene	1 month
Photographic film processing	Electrolytic recovery ion exchange	85% of developer, 95% of fixer, Ag and solvent	< 1 year

Source: Huisingh, 1988.

other equipment), they can precisely control the flow of material or energy inputs.

For example, distillation columns governed by "feed-forward" software that incorporates mass- and heat-transfer equations can save up to 15 percent of the steam required in a manual facility while increasing rates of production. A plant of this kind can also be built at lower cost per unit of production capacity than a plant with less sophisticated controls. One paper mill that employs automation to control chemical and energy inputs optimally has reduced its energy requirements by almost a fifth while improving product uniformity by almost a third (Ross and Steinmeyer 1990). In these and other cases, computer-directed optimization saves energy and materials by applying only the required amount of an input and only when needed. The quality and uniformity of the product is also improved, so discards and rejects are fewer.

Continuing computerization of industrial production and increased employment of robots will improve productivity and, in the process, decrease waste and pollution. Computer hardware and software are becoming ever more sophisticated and accessible. Monitoring and sensing technologies are also growing in capability. For example, in the pharmaceutical industry certain fermentation and organic synthesis reactions can be analyzed precisely in seconds or minutes using computerized Fourier transform infrared spectrographic (FT–IR) methods in lieu of labor-intensive, hour-long chromatographic analysis (Schneider 1990). Computerized gas chromatography-mass spectrometry (GC–MS) equipment allows the chemical industry and other industries to monitor their processes and effluents precisely and rapidly. In each case productivity and product-quality improvements can go hand-in-hand with environmental performance improvements.

Incremental and Radical Process Changes

Many environmental efficiency improvements in industry are the result of continual incremental advances. For example, computer controls, like those just discussed, and a series of mechanical innovations have led to a greater than 30-percent improvement in energy efficiency for electric-arc steelmaking furnaces (Ross and Steinmeyer 1990). Annual energy efficiency gains in ethylene production have averaged 3 percent over the last three decades resulting in a net 60 percent decline in energy requirements for production (Ross and Steinmeyer 1990). While these incremental innovations can offer significant gains over time, occasionally more radical process changes can offer very large environmental and commercial advantages.

Again using steel as an example, "direct steelmaking," being pursued by at least seven nations, could turn steelmaking from a three-step operation to a one-step process. The elimination of coking ovens (which can cost $250 million each) would streamline production costs while eliminating an important source of hazardous air emissions (*Scientific American* 1990).

The copper mining industry, which has used the same basic methods of ore smelting for six millennia, is also ripe for technological change. During the 1980s, unknown to most people, the action of the bacterium *Thiobacillus ferrodoxins* has grown to account for 30 percent of U.S. copper production and is credited with saving the U.S. domestic copper industry (Debus 1990). "Biohydrometallurgy" applicable to gold and other minerals, too, could eliminate some of the air pollutants—such as sulfur dioxide and heavy metals—associated with conventional smelting. Despite the promise of biological mining techniques, including possible *in situ* mineral recovery, the industry has invested very little in R&D (2 percent of sales in the United States) and almost nothing in biological techniques. Mining engineers are rarely trained in biological sciences, and biotechnological efforts in this area have been minute. Research in this field could pay big dividends.

Progress in chemical catalysis may greatly improve the efficiency and environmental performance of industrial chemistry. New biological and inorganic catalysts might improve product yields, cut down on by-products, enable less energy-intensive reaction conditions (lowered temperatures and pressures,) encourage use of alternative feedstocks, and lead to large-scale production of previously non-industrial compounds. Genetic engineering and scientists' growing understanding of the biophysical mechanisms of enzyme activity are leading to "protein engineering"—the custom design of protein molecules (Hahn et al. 1990)—which, in turn, could lead to the development of new classes of industrial catalysts. Such progress, in the laboratory and in industrial application, may go a long way toward decreasing the energy intensity, waste production, and fossil fuel reliance of the chemical industry.

New Processes for New Products

New processes also lead to new products. Chemical vapor deposition (CVD), a technique to layer thin coatings of materials on surfaces, is an emerging manufacturing technology with potentially large environmental and commercial benefits. CVD is used to make thin-layer photovoltaic cells and to apply special coatings to windows—two environmentally significant technologies discussed above. The technique has also recently been used to place thin diamond coatings onto surfaces, which can greatly increase the durability of industrial cutting and grinding tools, can increase the heat tolerance and speed of integrated circuits, and may beget a new class of semiconductor devices (Amato 1990). CVD, if applied at the industrial scale, might greatly decrease the cost of solar power, improve the energy efficiency of homes and offices, and increase the speed of computation.

No doubt, many other new and emerging technologies for manipulating matter with great precision—for example, scanning tunneling electron microscopy or x-ray lithography—will reinforce the "dematerialization" trend and may enable the economy to do much more with much less.

Recycling

Another environmental challenge for industrial society is waste management. Sustainable natural systems reuse essentially all materials, but human economies release materials into the environment at profligate rates—rates that far outstrip nature's assimilative powers. In most industrial nations, low rates of recycling increase the environmental impacts of both the disposal and production of goods. Furthermore, processing virgin materials is generally far more energy-intensive and polluting than recycling. The most energy-intensive step in processing is typically the conversion of raw materials (for example, ores, logs, crude oil) into basic commodities (aluminum, paper, gasoline, for instance). In the United States, recovery rates for discarded glass, steel, and paper are estimated to be 15 percent, 21 percent, and 30 percent, respectively (US OTA 1989). Aluminum is recycled at relatively higher rates (about 45 percent) but only 2 percent of plastics are recycled despite similar energy savings for recycling each of these materials.

Currently, most products are designed with little consideration of their ultimate disposability or recyclability. Changes in product design to permit easy sorting and disassembly would improve recycling's economic and technical feasibility. For example, BMW will label and design plastic automobile components for ease of disassembly and recycling, but other automobile manufacturers have not yet considered recyclability in their design of polymeric components. BMW's approach would increase recovery of plastics and steel from automobile hulks. But, mixing materials inextricably, as in current automotive designs, may put auto shredders out of business and exacerbate the waste of materials (Clark and Field 1990). To encourage better product design, the European Community and several member states are considering moving toward legislation that will increase manufacturers' responsibility for environmentally safe disposal of their products.

The technology for recycling is already available. For steel, electric-arc furnace operations, which can use 100-percent scrap inputs in contrast to the 30-percent maximum for basic oxygen furnaces, have improved the demand for scrap steel. For the recovery of many metals (for instance, aluminum, lead, steel, platinum-group), glass, many grades of paper, and some plastics, the technology of recycling is not the limiting factor. Collection and sorting, manual operations, except for magnetic separation of iron and steel, pose the main technological problems.

As this review shows, achieving the environmental and economic benefits of high recycling rates will take the combined efforts of policymakers and engineers. They must design and deploy both technologies and social incentives to induce producers and consumers alike to participate.

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IV. IMPEDIMENTS TO TRANSFORMATION

The foregoing discussion of technological possibilities in energy, agriculture, and industrial production presents an unequivocal picture of extraordinary untapped potential. Many factors account for this: public policies; management practices; economic, legal, and institutional structures; inadequate information; insufficient R&D; and others. All must be changed if we are to move toward environmentally sustainable economic growth.

In each sector, many environmentally preferable technologies already "out there" are not widely used—even though "rational" economic analyses might suggest that they should be. For example, a number of industrial firms have established energy-efficiency and pollution-prevention projects that quickly yielded annual financial rates of return in excess of 100 percent, implying that such technological opportunities were previously available but unrealized. Energy efficiency in the home, another example, is also underexploited according to present-value analyses of appliance, lighting, and heating options. Thus, great improvements in environmental efficiency—in energy use, in materials use, in air and water pollutant releases—are within easy reach today without apparent sacrifices in economic well-being.

Emerging technologies—advanced materials, biotechnology, and electronics, among others—are poised to deliver radically improved environmental performance in each sector. Rapid decreases in the cost of photovoltaic arrays offer one hopeful sign of what tomorrow's technological reality may be. Crops that do not need pesticides provide another.

In each sector, diverse promising approaches to technological transformation deserve support. For example, biotechnology and alternative agriculture are not mutually exclusive. They can be applied together synergistically. No single energy technology should be chosen as *the* answer to our problems lest a failure of that technology become a disaster. Diversity of approaches brings resilience and improves the chances of finding better technologies and strategies.

The limiting factors for technological transformation are not primarily technological but are instead part of the social, economic, political, and cultural milieus in which technologies are developed, diffused, and used. Market incentives, the structure of regulations, the content and quality of research and education, and social values and preferences all determine technological trajectories.

Perhaps the most fundamental impediment to environment-saving technological advance is the ubiquitous public goods/externalities problem. Prices of goods and services rarely reflect the social costs of environmental services. This pervasive market failure overshadows all other obstacles in energy, agriculture, and manufacturing. For example, the price of a gallon of gasoline does not fully reflect the costs to public health, agriculture and forestry, and ecological integrity that are associated with the production, distribution, and use of the fuel. Because users cannot capture the economic benefits of environmentally preferable technologies, their use is inhibited. Neither firm nor individual has much incentive to spend money and effort to benefit others unless compelled by social forces such as government policies, legal action, or public pressure. The incorporation or "internalization" of external costs would change the relative returns of various technological options, generally in favor of environmentally preferable technologies.

> **"A number of industrial firms have established energy-efficiency and pollution-prevention projects that quickly yielded annual financial rates of return in excess of 100 percent. Apparently, such technological opportunities were previously available but unrealized."**

Perverse incentives created by governments are another major impediment to technological transformation. They can make environmental improvements less attractive to the makers and users

> **“Prices of goods and services rarely reflect the social costs of environmental services. This pervasive market failure overshadows all other obstacles in energy, agriculture, and manufacturing.”**

of technology. Some of these technological disincentives are regulatory while others are fiscal—taxes and subsidies. For example, billions of dollars of agricultural subsidies in many industrial countries promote the overapplication of pesticides, synthetic fertilizers, and other agrichemicals while inhibiting crop rotations and other sound environmental practices. Electric utilities in most U.S. states are regulated with a bias that favors generating electricity over more economically and environmentally sound investments in improved energy efficiency. Industries face product-approval mechanisms and permitting requirements that can reinforce the technological status quo and inhibit the entry of environmentally superior products and processes into the market. Likewise, technology-based environmental standards that prescribe design constraints rather than performance requirements can inhibit innovation.

Although many firms have moved vigorously to improve energy-efficiency and pollution-prevention efforts, most industrial managers overlook profitable opportunities to better their environmental performance. In agriculture, many farmers overapply fertilizers and pesticides on advice from vendors, extension agents, and neighbors rather than using these inputs only when justified by on-farm soil conditions and observed pest levels. Understanding of alternative agriculture techniques, though increasing, remains low. Consumers in many nations seem willing to reflect their environmental concerns in their choices and uses of consumer products, but they, too, generally remain poorly informed about environmental risks and trade-offs. Environmental improvements in technology will come slowly without better information.

The high cost of capital in the United States has demonstrably inhibited the development and application of new technologies (Landau and Hatsopolous 1986). Although improved process control and other waste-reducing measures may look better when investible capital is scarce, environmental technology imbedded in new products and processes is a long-term investment. High capital costs inhibit investing in R&D and replacing old inefficient capital stock. Heavily indebted farmers may also try to maximize their current receipts at the expense of soil, water, and air quality.

Institutional and legal impediments to environmental improvement typically are rooted in problems of incomplete incentives. For example, landlords have little incentive to make buildings and appliances energy efficient if tenants pay utility bills, and tenants may have little incentive to make long-term investments in the building. In manufacturing, because firms are not responsible for disposing of their products after purchasers discard them, they have almost no incentive to design goods for ease of recyclability or for benign disposal. In most communities, rubbish and waste disposal is financed out of general tax revenues, so consumers are not faced directly with disposal costs either.

Finally, change is psychologically and politically difficult. Current technological systems include more than just the physical capital of machines, buildings, and infrastructure. Large amounts of human capital are also invested. Engineers, managers, farmers, employees, regulators, and the general public are accustomed to familiar systems that do not fully integrate environmental factors into decision-making or routine operations. New technologies and institutions threaten and annoy the constituencies forced to change behavior. Workers may lose jobs. Consumers may be inconvenienced. Yet, companies that fail to adapt fail to survive, and professionals may lose stature to colleagues who adapt to the new.

The impediments to technological change are given greater urgency by today's global ecological threats and economic imperatives. Across sectors we find strikingly similar impediments, but also the possibility of common solutions.

V. INADEQUATE POLICIES

Government actions and corporate management decisions—public and private policy—profoundly influence the direction of technological change. In most circumstances, policy decisions have ignored environmental consequences. In many others, environmental protection measures have not adequately encouraged the development or deployment of new technology. Often, resistance to policy change has entrenched existing technologies against environmentally and economically superior alternatives. Against this backdrop, six critical policy areas that influence technology development—regulation, economic incentives, technology policy, management, international policy, and education—deserve particular attention.

V.1 Environmental Regulation

Since the United States inaugurated modern environmental regulation some two decades ago, its primary focus has been to protect the public against rampant environmental hazards. Environmental laws on air, water, waste disposal, and other areas instructed regulatory agencies to abate pollution quickly and forcefully. Regulatory controls based on technical standards enabled the government, relatively rapidly, to demand needed modifications in products and processes that spawned environmental hazards.

Today, however, "second generation" environmental problems require more complicated solutions. If promoting rapid continuous technological transformation is today's mission, then requiring all pollution sources to install abatement equipment is not enough. The development and deployment of technologies economically and environmentally superior to those in current use must be stimulated through a wide range of mechanisms. It is in this respect that current regulatory policy appears least adequate. Lessons from U.S. and other industrial nations' regulatory experience should also be valuable to the developing and Eastern European nations, where environmental regulation is less mature.

Regulatory policy design often exhibits systematic biases against new technology and in favor of the status quo (Heaton 1990). In product regulatory regimes—pharmaceuticals, pesticides, toxic chemicals—risks from new products are scrutinized severely, but products long on the market, often more risky and less efficient, are "grandfathered" into a tolerated status. Post-market surveillance of old technology is weak. This bias puts a burden on innovation.

Many environmental laws also distinguish between new and old pollution sources. Typically, stronger controls are required of new sources, based on the sound premise that new plants can control pollution more effectively and cheaply than old ones. Unfortunately, this approach also creates a disincentive to modernize plants and equipment and prolongs the life of old sources. If technological innovation is to be encouraged, the distinction between new and old sources must be modified. The ideal incentive structure would equalize the marginal costs of abating pollution among new and old sources. Economic instruments such as tradeable emissions permits lead in this direction and should be applied much more widely than they are now.

Basing regulations squarely on firms' performance is also important. In air pollution, water pollution, and other areas, legislative mandates encourage regulators to base standards on best available technology (BAT). Although this approach diffuses known, effective pollution control techniques rapidly—thus creating a broader market for them—it also narrows the range of technological options. Sticking with conventional technologies on which standards are based is less risky for regulators, regulated sources, and engineering consultants than adopting less familiar technologies. This creates a high hurdle for entrepreneurs trying to develop and market new technologies. Theoretically, standards based on BAT can legally be met by other techniques with equivalent performance characteristics, and BAT requirements are continually updated as improved technology creates a market for technological innovation. In practice, however, the risks involved in substituting another technology weigh heavily in favor of the technology on which the standard is based. Moreover, the difficulty encountered and time consumed in promulgating new standards almost guarantee that today's best available technology will remain standard far into the future, thus creating a disincentive to fundamental, longer-term change.

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Technological advances in effluent monitoring and information processing open new possibilities for basing regulations on the environmental performance of each pollution source.

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Technological advances in effluent monitoring and information processing open new possibilities for basing regulations on the environmental performance of each pollution source. More reliable and less costly ways of monitoring source performance already permit much broader use of emissions trading, effluent charges, and other performance-based policies. For example, the new Clean Air Act Amendments in the United States will allow electric utilities to trade sulfur-abatement credits among themselves, with compliance monitored by in-stack, on-line emissions monitors. The greater efficiency this flexibility will allow will justify the added monitoring costs many times over as utilities choose among the use of low-sulfur coal, scrubbers, clean-coal technologies, and emissions trading to meet their performance requirements at minimum cost. The same flexibility could now be achieved in other regulatory settings as well.

Administrative procedures in regulatory agencies often inhibit the introduction of innovative new technology. The U.S. EPA advisory committee on Technology Innovation and Economics, charged with advising the agency on administrative ways to ease the introduction of new technologies, found that permitting procedures pose significant barriers to untried technology (TIE 1990). Drawn out, expensive, inconsistent, and inflexible permit procedures are great burdens on innovators, particularly small, creative, entrepreneurial firms whose capital is very limited. These procedures may impose inappropriate requirements on technologies that do not conform to pre-existing administrative categories. Permits that prescribe design constraints leave little room for innovation and generally provide no incentives for firms to exceed legal requirements. Although most U.S. statutes include variance or waiver provisions for innovative technologies, such provisions remain far underutilized. EPA is currently exploring ways to make them more effective.

Several characteristics of the standard-setting process favor technologically conservative results. The overwhelming workload leaves no room for experimentation. If point-source standard-setting remains the norm while the number of pollutants and point sources proliferate and government resources stagnate, then policy-makers will have little choice but to focus on the best available technology as the only way to get anything done. The information demands on regulators, who must tailor control requirements to disparate industrial conditions and defend them as reasonable and fair under administrative law, necessitate simple, standardized prescriptions.

The burden of information also forces regulators to rely heavily on the regulated industry for information about technical options. In fact, firms outside the regulated industry perceiving regulation as a chance to invade and gain market share might often prove a much more fertile source of innovation, were regulatory approaches structured to widen market opportunities for them. Especially in technologically rigid or mature industries, the most innovative or disruptive responses to regulation are not likely to be developed by the firms on which the onus of compliance falls but by small firms, potential new entrants, suppliers, and firms from abroad.

Regulatory agencies are generally not organized to promote wide-ranging technological change. The EPA, for example, is organized to administer uncoordinated environmental statutes dealing with particular problem areas. Its attention thus focuses on air pollution, water pollution, and hazardous wastes—not on major industries or economic sectors. Without major efforts at coordination, regulatory activities shift residuals from one medium to another. If, however, the focus of technological transformation is on major economic activities such as transportation, energy production, manufacturing, and agriculture, new organizational approaches may be necessary.

If environmental regulation is to promote technological transformation consistently and systematically, then its focus, not its purpose, must change. Technological change must be moved to center stage and seen as a potential solution to environmental problems, rather than their source (Speth 1988b).

The first step is to reorient the regulatory process with an affirmative mandate to promote technological innovation. This will take new tools, and the agencies must be firmly encouraged to use them. These tools include increased support for cooperative R&D, demonstration and testing projects, strengthened waiver procedures for new technologies, and, especially, a greatly expanded use of performance-based standards and economic instruments.

Policy analysis in regulatory agencies also needs to be refocused. At present, scenarios of possible technological change play only a marginal role in the economic impact and risk analyses required in standard-setting. Ideally, what is needed is industry-specific microanalysis of potential for technological change over different time frames, encompassing both economic and environmental performance and looking particularly to generators of new technology outside the mainstream.

Regulatory scrutiny, too, should be refocused away from its current preoccupation with controlling new technologies and toward increased scrutiny of existing products and processes with the goal of effective risk reduction. This could be accomplished through many means, including periodic review of existing products, increased use of emissions trading and economic incentives, similar standards for new and old sources of pollution, and increased use of disclosure and liability rules for existing sources of environmental risk. The essential goal, however, should be to create, through regulation, an incentive to replace the inferior technologies of the past with today's environmentally superior products and processes.

V.2 Economic Incentives

Economic incentives and regulation are different instruments for achieving policy goals. Regulations command specific results; economic incentives work through markets or prices to signal appropriate behavior. Each has advantages in certain circumstances. Economic incentives are more efficient when noncoercive signals to a large population of firms and households let them choose in their own self-interest, based on their own superior information about the social costs and benefits of their available options.

A vast variety of public policies affect producers' and consumers' economic incentives. Few have been devised and implemented expressly to improve environmental quality. In fact, in industrial and developing countries alike, most government policies affecting economic incentives ignore environmental consequences, and many inadvertently exacerbate environmental damage. Changing economic incentives in several sectors would benefit the economy and the environment: in agriculture, in energy production and use, and, as supplements to environmental regulations, in industry.

In the agricultural sectors of virtually all highly developed countries, governments have subsidized farming to such an extent that potential supply far exceeds domestic and export demands. Agricultural price supports and accompanying supply regulations have encouraged high-input agricultural techniques that generate serious nonpoint source pollution problems and have discouraged ecologically balanced systems of sustainable agriculture. The U.S. subsidy program, for example, encourages farmers to maintain intensively farmed monocultures, despite economic inefficiencies, environmental damage, and the availability of economically and ecologically superior alternatives (Faeth et al. 1990).

Americans' profligate use of energy, compared to any other country's consumption patterns, is largely the result of public policy: the decision to keep the price of petroleum products much lower than in other industrial countries. Many other public policies and institutional arrangements also work against energy efficiency and the development of environmentally superior alternative energy sources. On the positive side, recent changes in the structure of electric utility rate regulation in several U.S. states have made it equally advantageous for utilities to generate electricity, buy it from cogenerators and other independent suppliers, or conserve it by supporting demand-side management programs. Such reforms provide tremendous new opportunities for entrepreneurs and innovators in the energy industry.

Using economic incentives to supplement environmental regulations is not a new idea, but it has rarely been done effectively. Charges on pollution or resource use, marketable permit systems, deposit-refund systems, and removal of barriers to market activity (such as exchanges of water or emissions rights) are all ways of making environmental controls more efficient. A large literature assesses the virtues and drawbacks of these approaches as compared with conventional regulation (Stavins 1990). It shows that neither approach is a panacea or universally applicable. For example, some substances are so toxic that they must be banned or strictly controlled. Moreover, the laws, institutions, and systems for environmental protection have already been put in place in most countries, constraining choices among future policy options. Nonetheless, marketable permits and other incentive policies can be fit into many parts of the existing framework to provide greater flexibility and efficiency.

Today, in addition, environmental policy must attack a new generation of diffuse problems for which regulatory solutions would be difficult, while recognizing that some environmental problems have eluded conventional regulatory controls.

"Environmental policy must attack a new generation of diffuse problems for which regulatory solutions would be difficult, while recognizing that some environmental problems have eluded conventional regulatory controls."

In particular, diffuse nonpoint pollutants (for example, agricultural runoff), pollution created by numerous small generators (household refuse, for instance), and environmental problems caused by congestion cannot be well managed with permits, effluent/emission standards, or compliance monitoring and enforcement. Incentive-based policies that confront individual generators with the costs of their actions would be more effective and efficient.

Newly emerging technologies support a shift toward incentive-based policies such as industrial effluent charges, highway congestion charges, and municipal refuse disposal fees linked to the volume and composition of wastes. In particular, the development of real-time effluent and emission monitoring technologies enable accurate assessment and precise imposition of pollution charges and enforcement of emission trading. These monitoring technologies can also improve drastically the accuracy and reliability of environmental disclosure schemes, such as the U.S. Toxic Release Inventory (SARA Title III). "Electronic license plates," already in use in several cities to monitor traffic, make highway congestion charges technically feasible. Simple laptop computers in trash-collection trucks allow collection personnel to record each household's weekly disposal of mixed and separated trash, facilitating computerized monthly billing. Technological capabilities have already far outrun environmental management systems.

The implications are far-reaching. For one, we can begin to shift the tax base away from socially desirable activities—saving, risk-taking, and work—toward socially harmful activities—pollution and congestion. As we do so, the economic burden of the tax system will fall dramatically. For example, shifting a dollar from the income tax to an environmental tax will boost labor force participation and savings, an economic gain, while reducing pollution damage, another economic gain.

Economic incentives are also an attractive policy mechanism for encouraging technological transformation. The logic is simple: under a pollution tax or marketable permit system, reducing pollution has a real dollar value to a firm. Because trade-offs for investments in pollution prevention, recycling, and pollution control are easily assessed across the board, firms are more likely to make such investments. If all environmental control options are on an equal footing, the demand for improved technology should increase and prompt more R&D and investment.

Developing nations and the formerly centrally planned economies, where environmental institutions have been relatively immature and regulations have been weak, are promising places for implementing "green" taxes and other economic incentives. They might make more cost-effective environmental and economic progress than they otherwise would if they heed the regulatory lessons learned in industrial countries.

V.3 Technology Policy

An enormous range of public programs and policies affect technological innovation. Technology policy—a subset—can be defined more manageably as government actions *intended* to promote the development and diffusion of new technology. Even here, the range of mechanisms is vast: R&D tax credits to encourage industrial research, technology transfer programs that move inventions out of federal labs into private hands, government-supported research consortia that bring firms and universities together, and strengthened intellectual property rights to encourage investments in new technology.

In fact if not in principle, the U.S. government is deeply committed to technology policy and has been since World War II. Federal technology policy can point to some outstanding successes. The first generation of computers arose from far-sighted military support for a revolutionary technology (Flamm 1988). Today, federal support for biological sciences is paying off in the biotechnology industry.

Federal technology policies transfer massive resources from public to private sectors: public monies underwrite close to half but public institutions perform only around 11 percent of total R&D (US NSF 1989). This support is by no means distributed evenly. Defense, health, space, general science, and energy received 93 percent of the total in 1990, a distribution consistent with historical patterns. Within this enormous federal commitment to technology, environmental needs are almost invisible.

Another measure of federal technology policy toward the environment is shown in research outlays for the environmental sciences. The following points stand out: federal support fell in real terms during the 1980s, despite increases in support to other fields and has shifted significantly away from applied research toward basic research. *(See Table 2.)*

Table 2. Federal Environmental Sciences Research Obligations

	1980	1983	1986	1989
	—Million $—			
Current $ Total	1291	1251	1482	1691
1982 $ Total	1488	1201	1293	1337
Basic (1982 $)	616	557	654	748
Applied (1982 $)	872	644	639	589
% All Federal R&D	11.7	8.8	9.0	8.6

Note: Derived from US NSF, *Science and Engineering Indicators 1989,* Tables 4–11, 4–12.

Support for research in the environmental sciences, including work on ecological and health effects of pollution, is distinctly different from support for environmental technology. Although figures on direct federal support in this area are unavailable, the amount is undoubtedly minuscule. Indeed, the movement away from applied research support indicates that what little funding there had been for fields related to technology development was eroded during the 1980s. Not surprisingly, EPA research budgets have suffered similarly, contracting 25 percent in real terms during the 1980s.

As seen in Table 3, EPA's share of total federal R&D is only half what it was in 1980. Consistent with the general trend, EPA has shifted toward basic research and has dramatically decreased its support for applied research and development, the areas closest to commercial technology.

A federal technology policy toward the environment could play a vital role in promoting technological transformation. This policy avenue should be developed not only in technical mission agencies like the NSF or the National Institute of Standards and Technology (NIST) but also in regulatory agencies like the EPA.

In many respects, the realization that we need a federal technology policy toward the environment is analogous to the reawakening of interest in an industrial technology policy to enhance U.S. competitiveness. Technology is the key to both vital challenges. Both policies cut across many technical areas and both would support generic technology not adequately developed in private firms. Ironically, the movement away from applied research in environmental areas that could be relevant to industry comes at a time when applied research relevant to industrial competitiveness is enjoying increased support. Federal funding of Sematech (a public-private semiconductor research consortium), the NSF network of engineering research centers, and the Commerce Department's Advanced Technology Program (Heaton 1989) all bespeak a new government commitment to a civilian technology policy—but one that has not included the environmental performance of new technologies. In such key industries as transportation, energy, construction, and chemicals, the environmental and economic dimensions of innovation must be pursued together.

A federal technology policy for technological transformation should not concentrate on technologies of immediate commercial significance. Making money from new technologies should be left to private firms. What government can do effectively, however, is to support the generic technical areas on which commercial technology will subsequently be based. Private firms are unlikely to support work here because only rarely can they profit from the results.

Generic or base technologies have a wide range of potential applications but do not themselves involve marketable products. In virtually every area of civilian technology, these base technical capabilities could be vastly improved. The result would be major benefits in pollution prevention and control. A few examples in the energy sector illustrate the point. Photovoltaic energy conversion is potentially a key technology. Further

Table 3. EPA R&D Obligations

	1980	1983	1986	1989
		—Million $—		
Total Current $	345	241	317	374
% Federal R&D	1.3	1.0	0.7	0.6
Total 1982 $	407	231	277	296
Basic, 1982 $	16	21	34	24
Applied, 1982 $	273	146	156	206
Development, 1982 $	118	63	87	66

Note: Derived from US NSF *Science and Engineering Indicators 1989,* Tables 4–6.

advances in materials engineering applied toward increasing photovoltaic conversion efficiencies could profoundly improve future energy prospects, with important environmental and commercial consequences. As discussed earlier, advances in energy-storage technologies are also critical. Many fundamental physical and chemical properties of combustion itself remain poorly understood. Further knowledge could lead to increases in energy efficiency and decreases in the release of hazardous emissions. On a larger scale, experiments on the technical and social characteristics of alternative infrastructures—for example, solar hydrogen-fueled towns or cities without cars—have not been attempted.

> **“The realization that we need a federal technology policy toward the environment is analogous to the reawakening of interest in an industrial technology policy to enhance U.S. competitiveness. Technology is the key to both vital challenges.”**

In manufacturing, similar opportunities abound. Improving our ability to apply extremely thin coatings on surfaces through, for instance, chemical vapor deposition, is likely to have widespread significance. Industrial competitiveness in electronics, optics, tools, motors, and engines as well as solar energy, may be profoundly influenced by today's national and corporate research. More work on materials-separations technologies that can be used to improve the efficiency and cost-effectiveness of recycling low-valued wastes into high-valued goods is badly needed while further research on microbial metabolism of minerals can influence the environmental and economic performance in mining and minerals.

Agriculture is rife with generic technologies that are rarely supported by private R&D and only modestly funded by public institutions. Cases in point are biological control of insect pests and low-input soil-management techniques. More generally, applied ecological research remains underdeveloped compared to other farm- and forest-management technologies.

Through many policy mechanisms besides direct research funding, generic technologies can be advanced (Ross and Socolow 1990). Most of them have been used elsewhere. For example, targeted centers of excellence could bring technical expertise to bear on commercially significant problems, as several successful state technology-development programs do today (Osborne 1990). Technology-transfer programs from federal laboratories, cooperating with and giving private firms ownership of technology, have begun in a wide variety of areas but are still embryonic in environmental technology. Demonstration and testing programs, the basis of the agricultural extension service and many other initiatives in the United States and abroad, could also be used effectively for environmental technology. One of the most powerful mechanisms is government procurement, provided that it is fully utilized. Procurement, particularly through the Defense Department, has been one of the main means of creating markets for new technology (Nelson 1984). Except for limited purchases of recycled goods and energy-efficient lighting, and some specialized solar power applications, government procurement remains almost untried in environmental fields.

More Information and Analysis

Measurement, technology assessment, and analysis also constitute an important, but neglected, aspect of an environmental technology policy. New indicators of environmental performance need to be developed both for the economy as a whole and for industrial and consumer products and processes. The statistical base on which much of economic policy rests—GNP and productivity accounting—is seriously flawed from an environmental standpoint and needs to be reformulated. Inside firms, widespread acceptance of environmental accounting would bring environmental costs higher on the agenda when corporate decisions are made.

Consumers remain poorly informed about the environmental characteristics of products in common use. New environmental performance criteria and application data, along with appropriate means of disseminating this information, are urgently needed.

Because environmental policy has concentrated on managing existing hazards, little attention has been devoted to envisioning or evaluating the technological future. Far too little analysis has been done of the positive and negative potential of emerging technologies: biotechnology, advanced materials, information technology, and others.

The ability of environmental policy to move toward technological transformation is also limited by a paucity of innovative, well articulated policy proposals. The basic design of regulatory standards and analysis (such as the environmental impact statement) have remained intact for some twenty years, but environmental problems have changed. Policy experimentation is needed, particularly proposals addressed to the new global contexts. Policy analysis of this nature should be supported in universities, research institutes, private companies, and government.

Existing public institutions could spearhead a government technology policy directed toward the environment. In the United States, the National Science Foundation (NSF), Environmental Protection Agency (EPA), the National Institute of Standards and Technology (NIST), the Departments of Energy, Transportation and Defense, and many of the national laboratories could be given the new mandate—and new means—to support the development of environmental technology.

An institutional alternative would be to designate a lead agency—or create a new lead institution for environmental technology. Japan among other countries, has chosen the latter course. The Ministry of International Trade and Industry (MITI) has recently established a Research Institute for Innovative Technology for the Earth (RITE) focused on research leading to commercially viable future technology. A similar concept for the United States is contained in a 1990 proposal by Senator Albert Gore, Jr., for a Strategic Environmental Research Program (Gore 1990). Arrangements of this type deserve serious consideration.

V.4 International Policy

Globalization, long recognized in finance, manufacturing, and science, has only recently developed in environmental policy. Global warming, species extinction, and ozone depletion—problems that cut across national boundaries and force the world community to recognize its common future and to search for transnational solutions—contribute to this new awareness (WCED 1987).

> **“Environmental pollution has expanded from a localized domestic policy concern into a matter for international diplomacy, challenging the fundamental premise of national sovereignty.”**

Environmental pollution has expanded from a localized domestic policy concern into a matter for international diplomacy, challenging the fundamental premise of national sovereignty (Mathews 1989). But, as environmental problems have become global, so too has the potential for technical solutions. The developed countries in North America, Europe, and East Asia share an essential technical parity across most fields. Science and technology have become profoundly international. Research is often conducted cooperatively across borders, and knowledge is rapidly transmitted worldwide. All national sources of technology can participate in new cooperative arrangements, and advances can be diffused more rapidly.

Nations are beginning to cooperate to resolve international environmental problems. The 1987

Montreal Protocol on Substances that Deplete the Ozone Layer provides a useful precedent because many nations have agreed to act together to address a global environmental hazard and because it establishes a procedure whereby a limited number of signatories can convene expert groups to respond to new scientific knowledge. Signatories are also creating an institutional mechanism in the World Bank, United Nations Environment Programme, and the United Nations Development Programme to transfer financial and technical resources from advanced countries to help less developed countries implement the accord.

Unfortunately, such initiatives fall far short of the need. The most difficult problems lie in the developing world and in the formerly centrally planned economies. They range from vast increases in carbon dioxide emissions in China to deforestation in the Amazon and to toxic effluents in Eastern Europe. Developing countries show some of the world's highest economic and population growth rates, and their environmental problems expand at an even more alarming pace.

Theoretically, technology now on the shelf could solve these problems. The resources devoted to the efforts, however, are minuscule in comparison to the need. A massive effort to transfer technology from developed to developing countries could contribute more than any other action to environmental sustainability.

Judged by available resources, technical expertise, and experience, multinational companies are best able to develop and transfer technologies to combat global environmental degradation. Governments and international institutions are essential as well: disseminating nonproprietary technologies, especially the "software" of environmental management; dispensing aid; measuring effectiveness and monitoring compliance with agreements.

The principal elements of a successful technology-transfer program must therefore include at least five components (Smart 1990). First, industrial countries must reduce the impact of their own activities on the environment. Second, substantial financial resources must be raised in developed countries and transferred to developing countries by international institutions. Third, barriers to the flow of technology, capital, and trade must be reduced or eliminated. Fourth, industrial nations and developing countries must formally agree on financial support and the conditions of technology transfer. Last, developing countries must invest in technology acquisition, cultivating necessary local skills and promoting appropriate local policies and institutions.

New forms of intermediation may be useful in promoting transfers of environmentally beneficial technologies to developing countries and Eastern Europe. Matching technologies and potential applications, brokering partnerships, facilitating negotiations, supervising licenses and other agreements, and assembling financial packages and other deal-making functions require considerable investments in management. The return from most developing country markets are, however, too small to justify such investments for major corporations, and smaller companies cannot afford them. Public-private cooperation may be able to fill this gap by creating new intermediary mechanisms.

V.5 Management Policy

Since the technology to solve environmental problems will be developed almost exclusively by industry, management policies constitute probably the single most important force for—or against—technological transformation. Many, but by no means all, major companies have realized that environmental improvement is vital to their future.

A fundamental challenge of environmental management is to convince those who design and control technology in private firms that their competitive agenda complements the societal goal of sustainable economic growth. An important first step is to ensure that corporate accounting systems charge the full costs of waste generation to the responsible processes and plants, including not only processing losses and the costs of waste disposal but also regulatory costs, liability risks, and losses in community goodwill. Accountability is the cornerstone of management responsibility.

Changing management's focus away from "end-of-pipe" pollution-control devices toward pollution prevention is another important step. The constraints on widening the use of pollution prevention techniques are not predominantly financial or technical. More often, pollution prevention is ignored because of informational, attitudinal, or institutional problems. Plant managers and workers often do not look for pollution-prevention opportunities because they may not perceive acting on them to be in their interest. In too many companies, neither career incentives nor accounting practices make pollution reduction appear worthwhile. Eliminating these barriers is a critical management responsibility. As discussed earlier, an external regulatory framework emphasizing economic incentives that put pollution prevention on an equal footing with pollution control and other methods of cost reduction can reinforce management efforts.

A third critical element of environmental management is to engender a new perception of the stakeholders in corporate decision-making. As Richard Mahoney, the chief executive officer of Monsanto puts it, "Companies must earn the right to do business" (Ehrenfeld 1990). He suggests that management must involve local communities, workers, government, and other interested groups in decisions previously made in relative isolation inside the firm. Public policies that give these stakeholders access to information about companies' environmental performance—for instance, Title III of the U.S. Superfund Amendments and Reauthorization Act—have had a remarkable effect on corporate policies (Baram et al. 1990).

Since market preferences are the most important shaper of business decisions, managers also need to reevaluate long-term market trends. Many companies have already grasped the competitive advantages in "green" products and processes (Cairncross 1990). Although markets are autonomously moving in this direction, management—and public—policy should be directed toward capitalizing and reinforcing the trend.

V.6 Education

In the long term, the best hope for an environmentally sustainable future rests in the education of the general population. If people demand environmental quality as citizens and consumers, technology will ultimately respond. However, the likelihood of technological transformation depends largely on the designers and manipulators of technology, the managers and engineers. Changes in how managers and engineers are educated are thus especially important.

Recently, American management education has been accused of myopic emphasis on short-term financial returns at the expense of fundamental, longer-term development of technology and manufacturing competence (Dertouzos et al. 1989; Hayes and Abernathy 1980). A similar critique can be leveled at management education's neglect of the environment. Few business schools offer courses in environmental management. The traditional curriculum typically emphasizes the mastery of skills field by field, as if such crosscutting concerns as environmental management did not exist. Continuing this educational pattern almost ensures that tomorrow's managers will neither appreciate environmental problems nor have the skills to attack them.

The horizons of managers in industry may have changed more quickly than those of their educators. Spurred by government regulation, legal liability, citizen demands, and consumer preferences, top managers and many corporations vocally emphasize the importance of environmental concerns in the business world and their proper management. Business schools are just beginning to respond with new courses and integrative approaches to curriculum development (Post 1990).

Engineering education looms even more critical: engineers design the technologies that create—and solve—environmental problems. Here, engineering education seems a few steps ahead of the business schools, since courses in environmental sciences, regulation, and design have long had a place in the engineering curriculum. However, such courses are usually offered in the context of separate environmental engineering curricula and are not integrated into the training of students in traditional engineering disciplines.

A few environmental courses, taught on the periphery, will not be sufficient. Instead, an environmental consciousness must pervade engineering, especially in design courses. Industrial design is an exercise in integrating many competing criteria. If the education of designers emphasizes environmental concerns, environmental factors will complement other design considerations in new product and process technology. If environmental concerns intrude as an afterthought, forced by regulation or external pressure, the technical solutions are likely to fall short.

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APPENDIX

Background Papers Commissioned for "Toward 2000: Environment, Technology and the New Century"

Benbrook, Charles M. "Agriculture's Next Technological Fix: A Sectoral Review."
Clark, Joel P. and Frank R. Field, III. "Recycling: Boon or Bane of Advanced Materials Technologies? Automotive Materials Substitution."
Ehrenfeld, John R. "Technology and the Environment: A Map or Mobius Strip?"
Hammond, Allen L. "Putting the Right Gene in the System: How Technology Changes."
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Ross, Marc H. and Robert H. Socolow. "Technology Policy and the Environment."
Smart, Bruce. "International Technology Transfer."
Speth, James Gustave. "Needed: An Environmental Revolution in Technology."

Symposium Reports

Heaton, George R., Jr., Marc H. Ross and Robert H. Socolow. "Technological Transformation for Sustainable Development: A Public Research Agenda." A report produced with financial support provided by the National Science Foundation.

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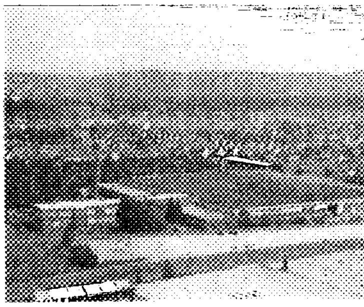

CLEANER
PRODUCTION
WORLDWIDE

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INTRODUCTION

This booklet aims to show through examples that by applying cleaner production, industry and consumers anywhere in the world can gain environmental benefits while reducing costs.

Cleaner Production Programme

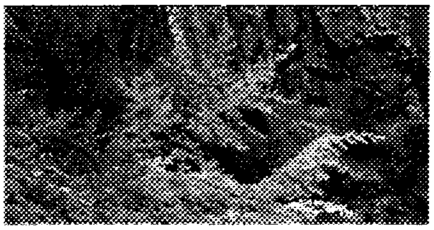
The concept of cleaner production is not new but it is receiving new recognition today. Industrialisation in all countries – developed and developing – has proven to be at some cost to public health and the environment. When no care is taken this is especially true. When end-of-pipe pollution controls are added to industrial systems, less immediate damage occurs. But these solutions come at increasing monetary costs to both society and industry and have not always proven to be optimal from an environmental aspect. End-of-pipe controls are also reactive and selective. Cleaner production, on the other hand, is a comprehensive, preventative approach to environmental protection. It requires people to be creative and to investigate all phases of manufacturing processes and product life cycles, including product usage in offices and homes. Cleaner production, thus, encompasses such actions as energy and raw materials conservation, eliminating toxic substances (as raw materials and as product constituents), and reducing the amount of wastes and pollutants created by processes and products, thereby lowering the amounts emitted to air, land and water.

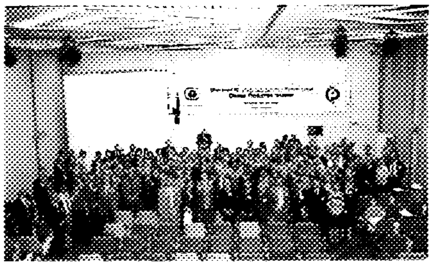
The term cleaner production was coined by the UNEP IE/PAC when it launched the Cleaner Production Programme in 1989. Many other similar terms exist today. Among them are: clean technology, pollution prevention, waste reduction, waste prevention, eco-efficiency and waste minimisation. There is no universal consensus on what they mean. Sometimes they are synonymous with cleaner production; and sometimes they are not. This confusion of terminology requires people to look beyond the words and analyse the actions.

The purpose of this booklet is to illustrate the variety of approaches that are possible and to stimulate readers to find similar cost-effective solutions. The applications here range from low to high technology. They show examples from small and medium sized enterprises, large industrial companies, and from plants in rural locations to those in overcrowded and highly industrialised cities, in a variety of countries. They show how seriously the concept of cleaner production is being taken by some governments, industries and individuals. The fundamental point is this: It is better for society to prevent, than cure.

Striving for cleaner production is like striving for efficiency and quality in products and manufacturing processes. People must continue to reassess and fine tune, to apply the latest ideas and recalculate the economics. Thus the examples here are not necessarily optimal everywhere today but they are typical of recent projects and show the variety of creative solutions that people have found.

We hope that this is only the first volume of this booklet. We look to you to send us new ideas that you have implemented that we can share with others. What new product have you developed? What process reconfigured? How much have you managed to save in operating costs by changing a raw material? What energy savings have you made at work? Remember that cleaner production is the way to reconcile the environment and development. It reduces the risks to humans and the environment of industrial activities in the most cost-effective way possible.





The Editorial Board for this booklet was Mme Jacqueline Aloisi de Larderel, Director of the Industry and Environment Programme Acitivity Centre, United Nations Environment Programme, Paris and David L Pounder, Environmental Protection Technology Adviser, United Kingdom Department of the Environment (DoE), London.

The booklet was produced by Robert Flain, Clean Technology Coordinator for DoE, Warren Spring Laboratory, Stevenage, UK, assisted by Ms Kirsten Oldenburg and John Kryger, Senior Consultants, IE/PAC UNEP, Paris.

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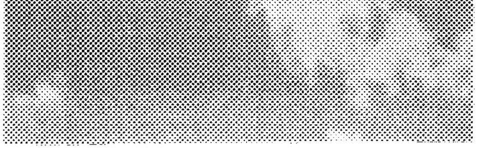
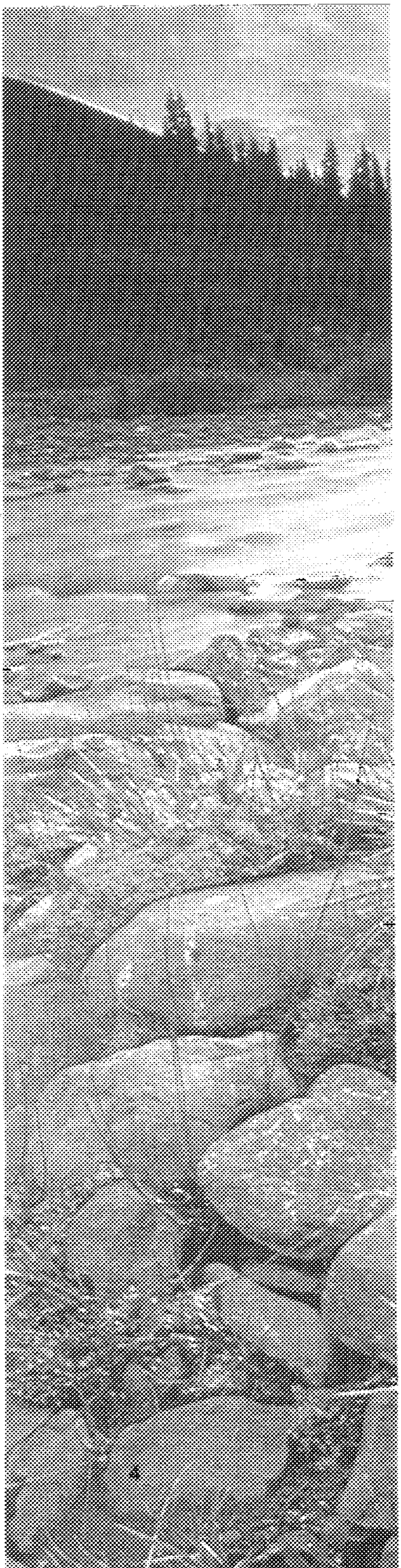
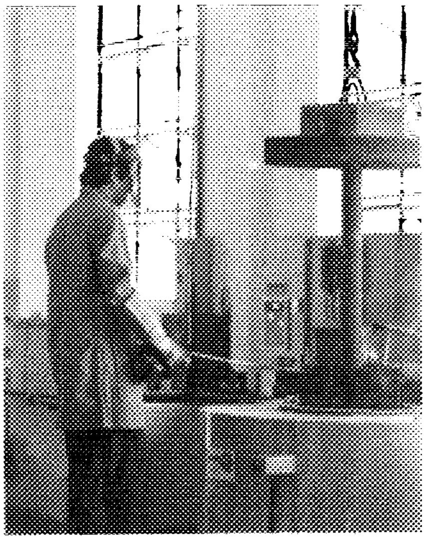


Gas Phase Heat Treatment of Metals



Background

The hardening, carburising and nitrocarburising of steel are heat treatment processes usually carried out in baths of molten salts, such as nitrites, nitrates, carbonates, cyanides, chlorides or caustics. The combination of chemicals and high temperature means that there are risks of explosion, burns and poisoning. Environmental problems arise from the resulting vapours and the removal, transport and disposal of the toxic salts. Disposal of cyanide salt costs US$3,300 per tonne. Neutralisation of quench water, oil, cleaning water and washing water has to be carried out before discharge to the sewer, but is not always carried out. Off-gases can be cleaned by passing the exhaust gases through a chemical scrubber, although this is also not always done.



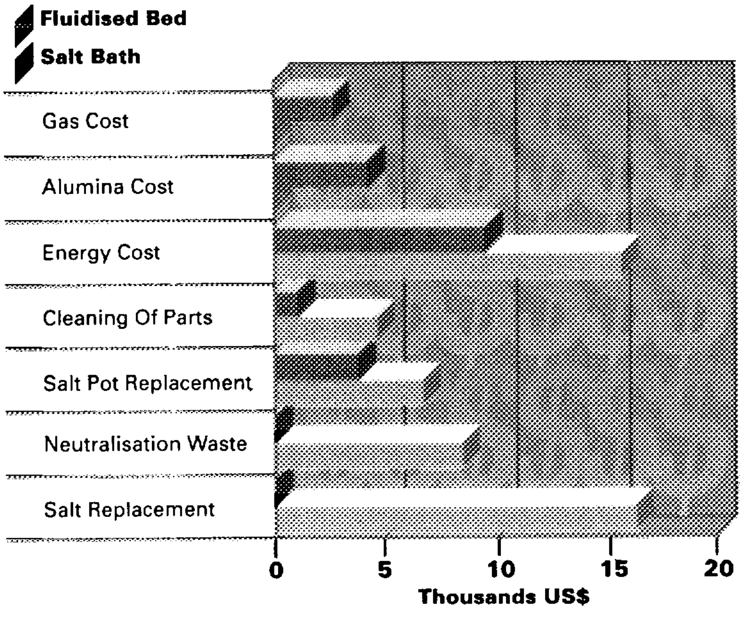
Cleaner Production

The new process avoids these problems by gas phase treatment using a fluidised bed of alumina particles. A mixture of air, ammonia, nitrogen, natural gas, lpg (liquified petroleum gas), and other gases are used as the fluidising gas to carry out the heat treatment. The bed is heated by electricity or gas and quenching is also carried out in a fluidised bed.

Enabling Technology

Fluidised beds have been used for some years in a variety of roles; heat exchange, gas absorption, chemical reaction and combustion. In this case the mixture of gases produce the fluidising atmosphere for heat treatment of the material immersed in the fluidised bed. Hydrocarbon gases are used for carburising, ammonia for nitriding and nitrogen for neutral hardening. The hot exhaust gases are used for heat exchange.

COMPARISON OF CONSUMABLE COSTS FOR CARBURISING IN SALT BATH AND A FLUIDISED BED



Advantages

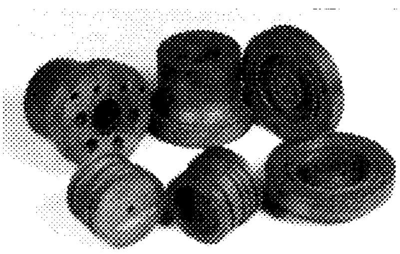
The most obvious advantages are the reduction in effluents and the improved working atmosphere. The safety aspects have also been improved to a very large extent and the quality of the product in many cases is superior to that produced by the older methods. All forms of heat treatment are amenable to fluidised bed techniques, but austempering is the most cost effective, in spite of the nitrate bath method being less troublesome than other traditional methods.

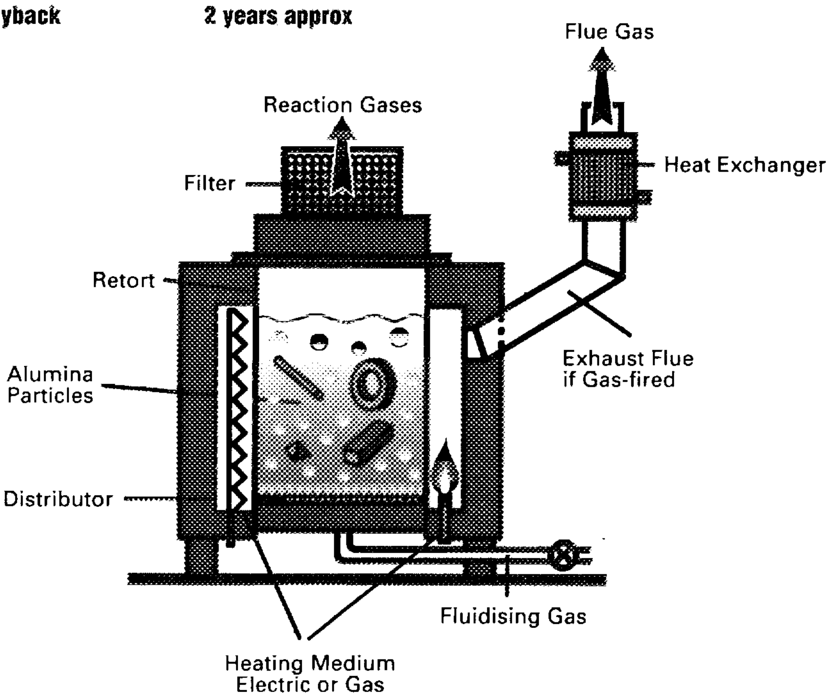
Economic Benefits

The figure shows typical savings achieved in the annual operation of a fluidised bed over salt bath methods of the same capacity.

The installation consists of four fluid beds used to replace their existing salt bath lines.

Cost saving	**US$/year**
Energy	36,000
Salt & maintenance	51,000
Total	**87,000**
Capital Investment	**US$180,000 approx**
Payback	**2 years approx**





Country
Singapore

Industry
Metal Processing

Companies
Chartered Metal Industries Toolroom produces a wide range of standard and customised products to support manufacturers in the metal industries. Their production includes high volume, batch-run precision parts, prototype components, sub-assemblies, tooling, fixtures and gauges.

Quality Heat Treatment Pty Ltd is an Australian company that designs and sells advanced technology heat treatment processing equipment for the metal processing industry.
The company also carries out specialised heat treatment services for the industry.

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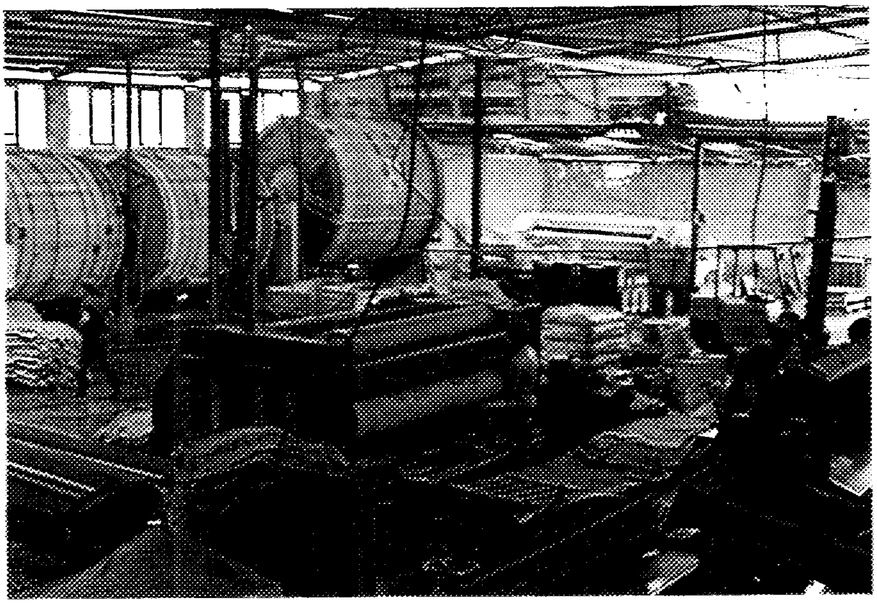
Chrome Recovery and Recycling in the Leather Industry



Background

The Greek and Dutch governments have a framework of bilateral collaboration in the field of environmental protection. One result of this has been that clean technology developed at TNO has been applied in a full scale co-operative R & D project between the two countries at the Germanakos tannery. The project was carried out from 1988 to 1990 with the support of the Commission of the European Communities.

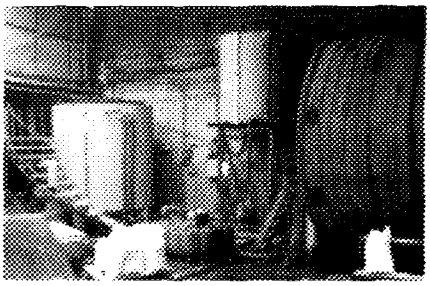
Tanning is a chemical process which converts putrescible hides and skins into a stable material. Vegetable, mineral and other tanning agents may be used – either separately or in combination – to produce leather with different qualities and properties. Trivalent chromium (Cr^{+++}) is the major tanning agent since it produces a modern, thin, light leather suitable for shoe uppers, clothing and upholstery. However recent limits for discharge to the environment have limited Cr^{+++} discharge to levels as low as 2mg/litre in waste waters.

Cleaner Production

The technology developed involves the recovery of Cr^{+++} from the spent tannery liquors and its reuse.

Tanning of hides is carried out with basic chromium sulphate, $Cr(OH)SO_4$, at a pH of 3.5–4.0. After tanning the solution is discharged by gravity to a collection pit. The liquor is sieved during this transfer to remove particles and fibres that have come from the hides. The liquor is then pumped to the treatment tank and a calculated quantity of magnesium oxide is added with stirring until the pH reaches at least 8. The stirrer is switched off and the chromium precipitates as a compact sludge of $Cr(OH)_3$. After settling the clear liquid is decanted off. The remaining sludge is dissolved by adding a calculated quantity of concentrated sulphuric acid (H_2SO_4) until a pH of 2.5 is reached. The liquor now contains $Cr(OH)SO_4$ and is pumped back to a storage tank for reuse.

In conventional chrome tanning processes 20–40% of the chrome used is discharged into waste waters. In the new process 95–98% of the waste Cr^{+++} can be recycled.



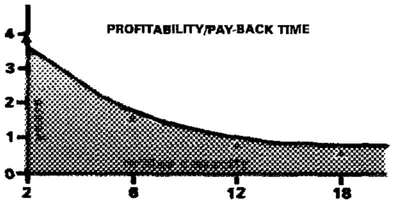
Advantages

Very little change to production process.

More consistent product quality.

Easier to monitor amounts of water and process chemicals used.

Much reduced chromium content of effluent waters.



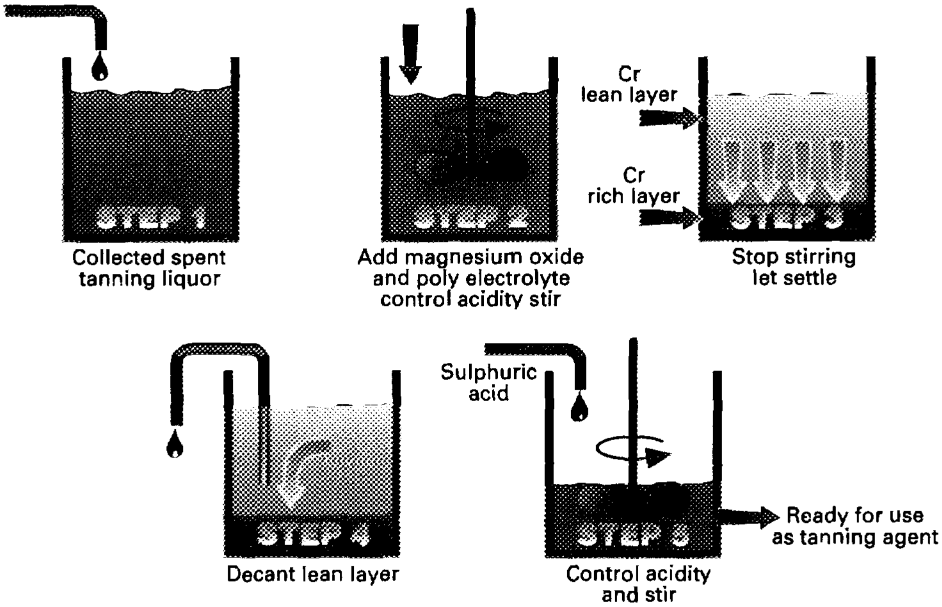
Economic Benefits

For the Germanakos tannery, which has a chrome recycling capacity of 12 m^3/day, the approximate costs were as follows:

Cost saving	**US$/year**
Savings	73,750
Operating cost	30,200
Total net savings	**US$43,550**
Capital investment	**US$40,000**
Payback	**11 months**

Savings can be made with any plant processing more than 1.7 m^3/day.

FIVE STEPS TO PROFIT IN CHROMIUM RECYCLING (Batch Process)



Country

Greece

Industry

Leather Industry

Companies

The Germanakos SA tannery near Athens in Greece was founded in 1978. Today it produces good quality upper leather from cattle hides, processing 2200 tons per year and with an annual turnover of US$8.4m and a staff of 65.

The Toegepast Natuurwetenschappelijk Onderzoek (TNO) is the Netherlands organisation for applied scientific research, and the project was carried out by their Institute of Environmental and Energy Technology.

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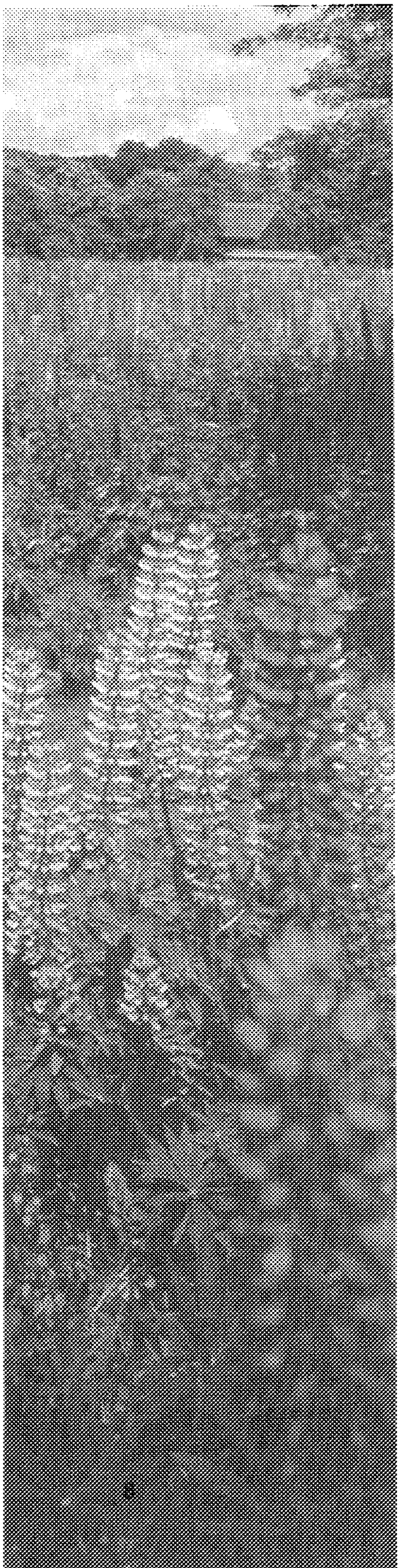
Minimised Environmental Effects in Cotton Production



Background

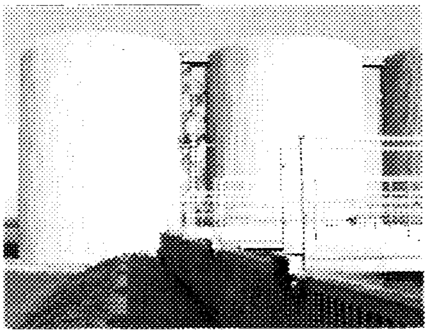
Cotton is a fibre obtained from the cotton plant and it is grown and processed widely throughout the world. Novotex's philosophy is to produce cotton with the smallest possible impact on the environment, by minimising emissions, energy conservation and waste minimisation. This can be seen to be cleaner production in the widest meaning of the term, involving all of the stages from growing to recycling of unwanted garments.

Novotex uses two approaches to all the stages of garment production. They have attempted to put a measure on the term environmentally friendly by means of an 'environmental value' for products between 0 and 100. An unattainable green product would be 100 and nuclear weapons could be thought of as 0. This principle has been applied to the stages of spinning, knitting, dyeing, finishing, garment production, packaging and transport. The company also carries out a Life Cycle Analysis of each stage of production. In this analysis the environmental aspects of every operation are examined in detail from beginning to end – 'from the cradle to the grave'. These two overlapping philosophies are frequently re-examined so that continuing improvements may be made.

Cleaner Production

The process starts with the cotton growing. The company is trying to insist that all the cotton they process is organically grown. This means growing without artificial fertilisers, chemical pesticides and defoliant sprays. Apart from the more obvious advantages, cotton pickers can suffer woefully from the effects of these chemicals. Machine harvested cotton additionally requires crop dusting with chemicals.

Company policy demands that all of the cotton used by Novatex is handpicked to avoid defoliants and does not contain pesticide residues. When the company started 1% of their cotton was organically grown, this is now 10% but the figure will increase with enlightenment of consumers around the world. In order that the term organic cotton is understood, the cotton is grown according to the ECO-labelling standards required for organic food production. The cotton is grown in various countries including Turkey, Peru, Morocco and Greece. New methods are allowing these principles to be applied. Vegetable compost and manure can supply the soil with sufficient nitrogen needs and organic materials.

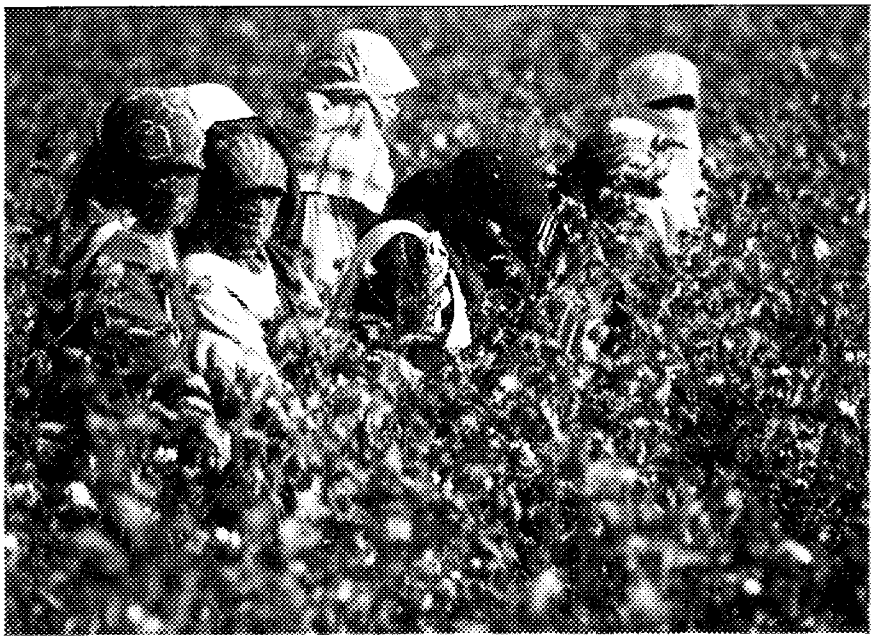


Spinning and knitting is usually accompanied by large volumes of dust. The cotton is spun on advanced computer controlled machines that need greater control of an otherwise dusty atmosphere. Only water soluble dyes are used and chloride for bleaching is eliminated by using hydrogen peroxide. The dyeing process is carried out in fully enclosed high pressure jet machines with reduced water consumption and no air pollution. In the drying process mechanical finishing is carried out, eliminating the use of chemicals, eg formaldehyde, resulting in an improved material quality. The making up of cotton garments is also a dusty operation and is carried out with dust extraction at the cutting and sewing machines.

When a user disposes of a garment they should think of its potential for recycling either for continued reuse by others or for conventional recycling to another use.

All wastewater is purified in a neighbouring treatment plant.

Most of the dye and phosphorus is removed by chemical precipitation with lime and iron salts. Biological purification is carried out in 14m high towers using the activated sludge process. The water is then passed through sand filters and aerated before discharge.



Country

Denmark

Industry

Textiles

Company

Novotex A S is textile company that was founded in 1983 with nine employee shareholders. The company now has 100 people employed directly and another 100 in closely related companies. Its turnover is approximately US$18m.

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Economic Benefits

As might be imagined it is difficult to quantify all the benefits. The water consumption is reduced, with all of the cooling water being recycled. The dyeing processes now use only 50% of the original water consumption, the new cleaning processes use only one-third of the original heated cleaning water, the drying machines recycle 75% of the hot air used. The effluent water from the plant carries only a small fraction of the toxic material limits set by the water authority.

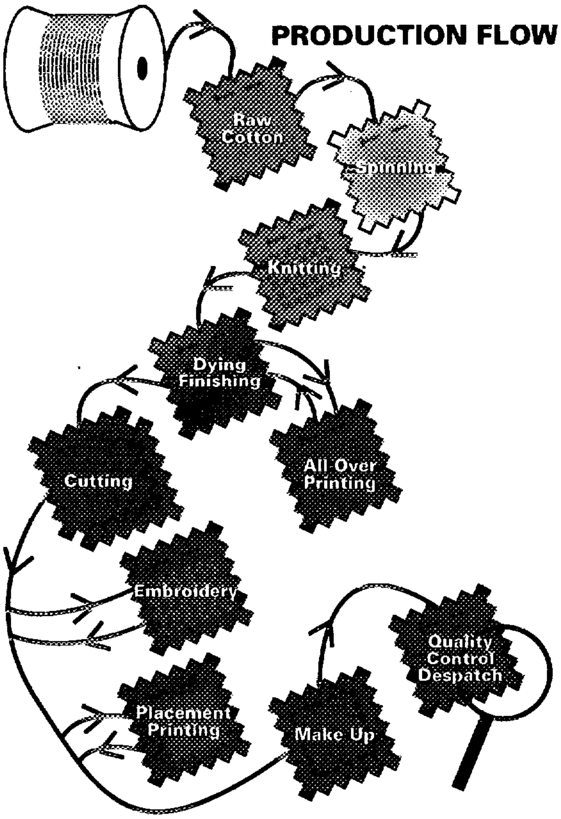
Advantages

Organic methods produce healthy plants, without polluting the soil and the surrounding environment.

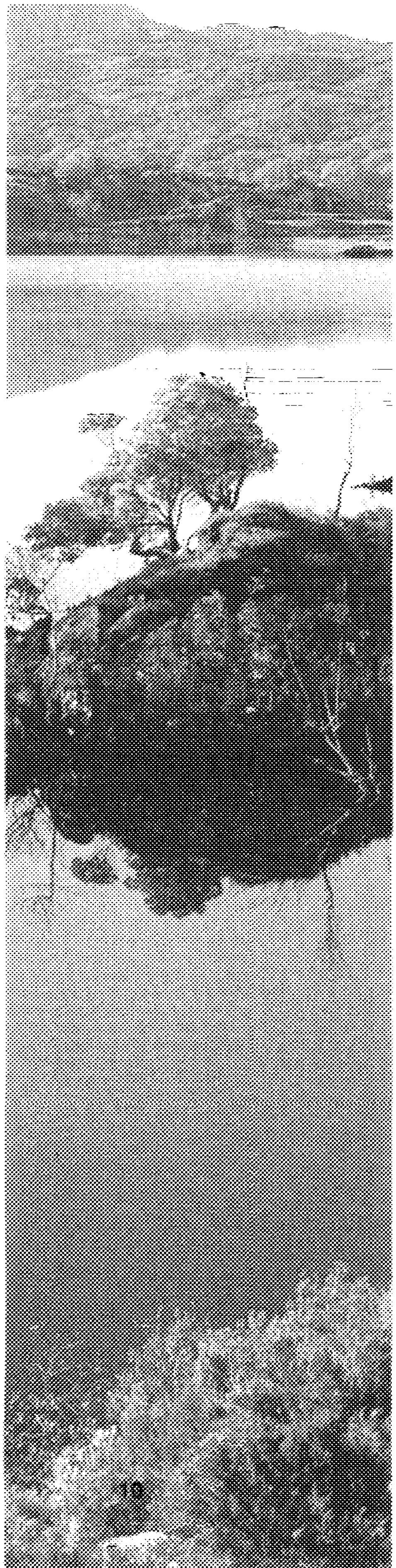
Improved environment for workers at all stages.

The environmental impact of each stage of production has been minimised.

PRODUCTION FLOW



Pollution and Waste Reduction by Improved Process Control

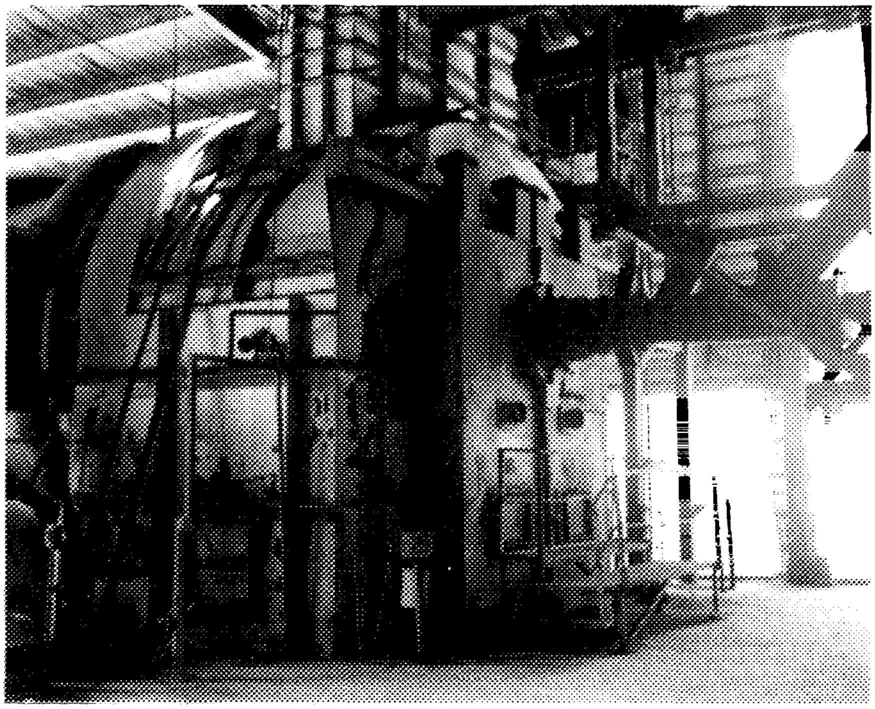


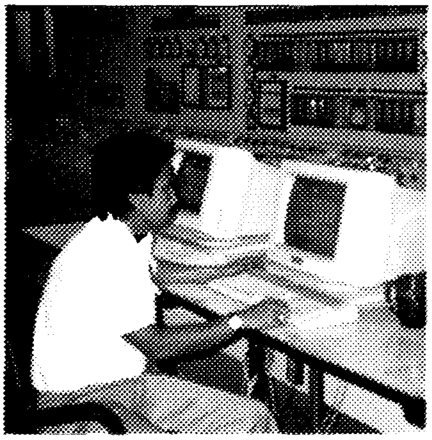
Background

Cement is made by burning a fuel together with limestone and clay, shale or slate, (shale being used here), yielding a clinker which is then ground with gypsum to produce cement. The process, which is carried out in large rotating kilns, is a complex one, and it is easy to lose control and make substandard product. Conversion of the kilns from oil/gas to coal firing has the penalty of making control even more difficult. The limestone and shale are quarried locally, combined and ground to a fine powder, referred to as raw meal. Heat transfer between the kiln exhaust gases and the raw meal initiates the calcination process which continues in the kiln. When the calcination is complete, the material temperature rises rapidly causing sintering that produces clinker. The clinker is discharged, cooled and ground to give the finished product. The small amount of sulphur in the coal takes part in the chemical reactions and is transformed into part of the sulphur content of the cement. The use of coal increases slightly the dust content of the exhaust gases which is removed in the bank of electrostatic dust precipitators usually used with these plants.

Cleaner Production

The quality of the cement is determined largely by the firing temperature. However, both the NO_x and SO_x levels increase with higher temperatures. The process must, therefore, be operated within a certain band of temperature with the optimum at the lower end. If the process is operated too far below this optimum, off-specification product is produced. If the temperature is too high the fuel is wasted, cement quality is reduced and air pollution is increased. The LINKman system is designed to mimic best operating practice and maintain optimum process conditions. The objectives were to stabilise the running of the kiln, reduce fuel consumption and increase output, and produce a consistent quality of clinker with optimum free-lime levels. This final objective also reduces the energy required to grind the clinker. Note that the temperature is not uniform along the length of the kiln. The LINKman system monitors the NO_x, CO and O_2 levels, the temperature at the bottom of the four-stage preheater and the power required to turn the kiln. The process is optimised by controlling the feedrate to the kiln, its rotational speed, the fuel supply to the main and auxiliary burners and the speed of the kiln induced draft fan.





Enabling Technology

The system has been made possible by improvements in:

The science of expert system control.

Measurement technology using a reliable and sensitive NO_x analyser.

Economic Benefit

9% capacity increase

3% fuel saving

40% reduction in off-specification material produced.

The clinker requires less energy to grind.

Cost saving	**US$/year**
Power & fuel savings approx	**350,000**
Capital investment	**375,000**
Payback period	**less than one year**

Advantages

The wastage of coal at high temperature is avoided.

Higher quality clinker is produced.

The lining of the kiln has a longer life.

Some reductions in NO_x and SO_x emissions.

Country
Indonesia

Industry
Cement Production

Companies
PT Semen Cibinong is a cement company near Jakarta, who operate two 2000 tonne per day dry process kilns converted for economic reasons from a gas/oil fuel to a low sulphur coal.

ABB LINKman Systems of London was set up six years ago to develop expert systems and laser scanning devices. The company is now part of the Asea Brown Boveri Group.

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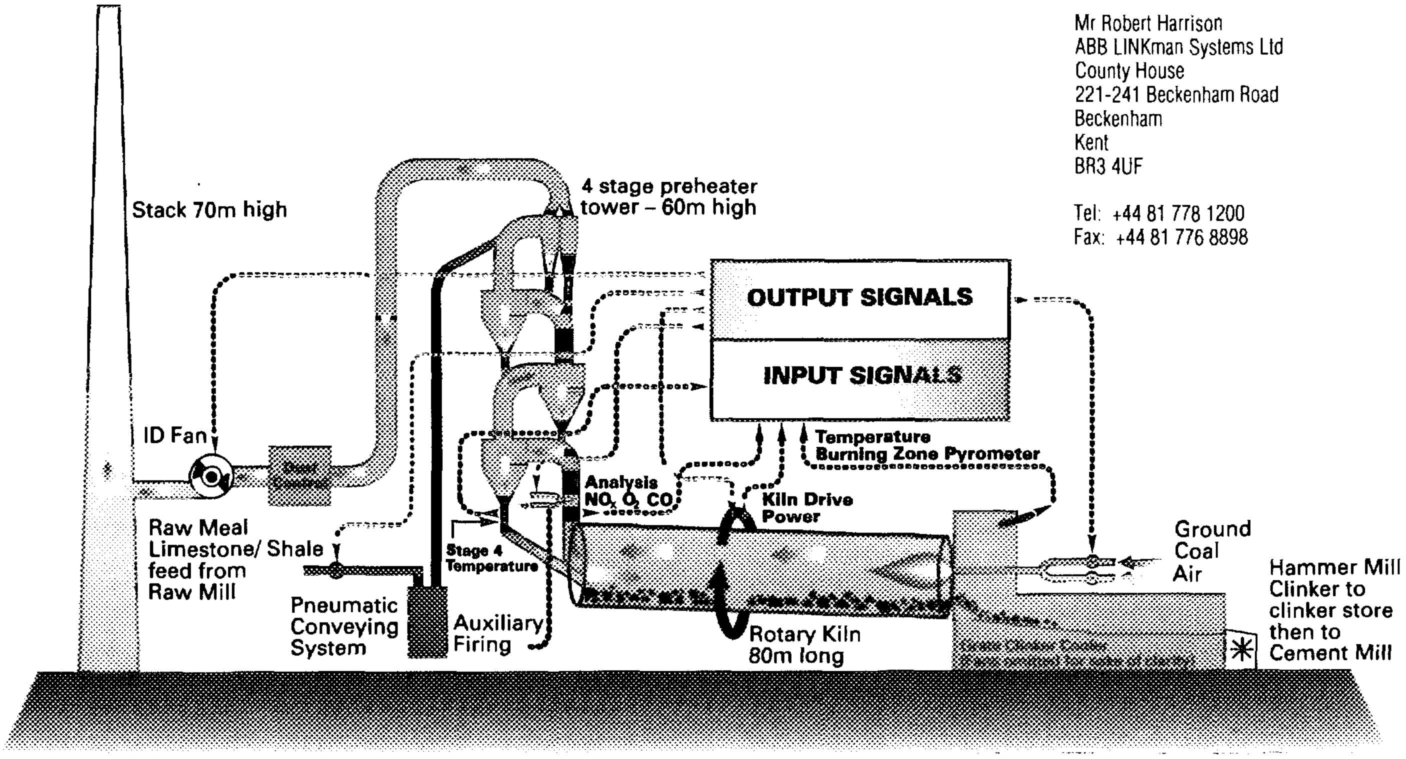
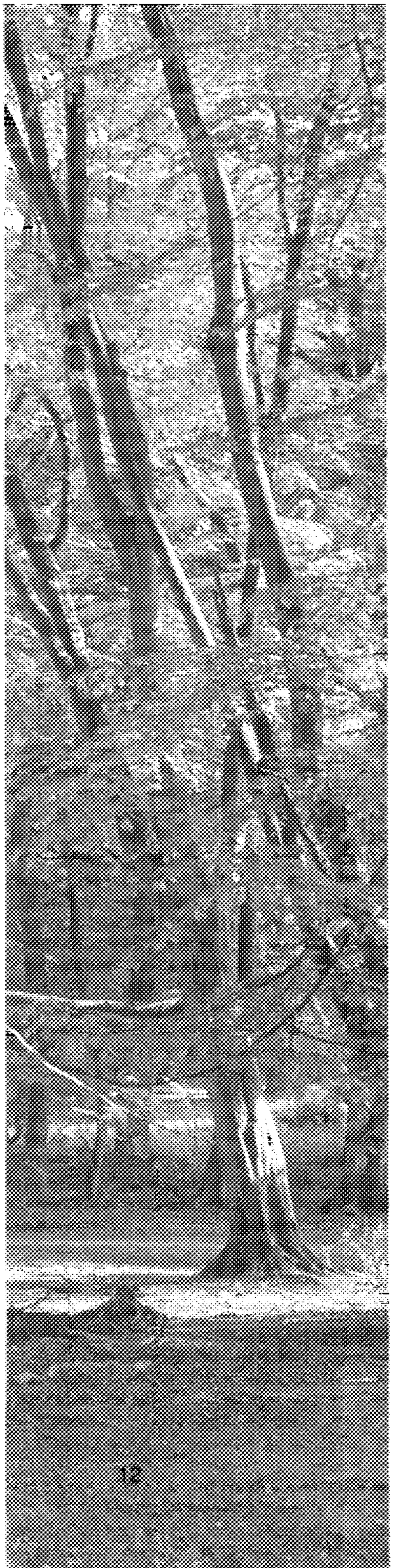
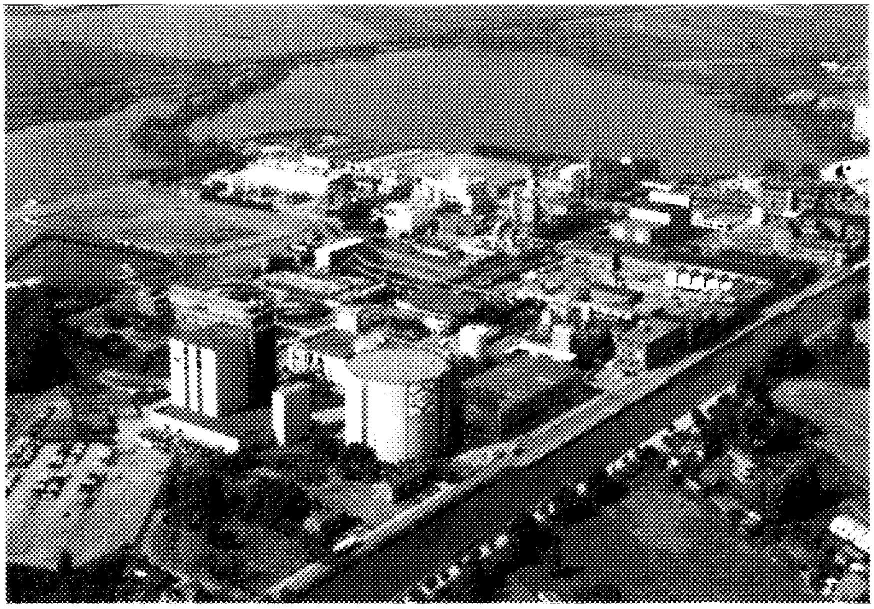


Recovery of Protein from Potato Starch Effluent





Background

The Avebe Foxhol site produces starch from potatoes. Potato starch production involves washing and grinding potatoes to produce a pulpy liquor of potatofruitwater, starch and fibres. The starch is extracted and refined by hydrocyclones, and the fibres are then separated from the liquor by centrifuge. The residual potatofruitwater contains protein, sugars and minerals at a concentration previously too dilute to recover.

The Foxhol site alone produces 2.2 million cubic metres per year of this potato water, which was originally disposed of without treatment into the North Sea and into Holland's canals. The effect was a major contamination of the waterways, the contaminants giving rise to strong odours and killing water life. This caused a public outcry.

Cleaner Production

In the late 1970's and early 1980's, Avebe made a major effort to clean up its production. After several years of test work, internal recycling has become possible by installing a reverse osmosis plant to concentrate the potatofruitwater to a level at which the protein could be recovered economically by coagulation.

The process installed at Avebe utilises open-channel tubular membranes which can handle high levels of suspended solids without clogging, and which are easy to clean. Since the concentration process is non-thermal and does not involve a change of phase, it is energy-efficient and does not change the nature of the proteins. The system which is designed for continuous operation, comprises six parallel process lines.

Following concentration of the potato water, protein is extracted from the concentrated stream by steam coagulation and dried. The product is a high grade protein concentrate used in animal feeds for small animals, such as piglets, poultry, furred animals including dogs, cats and minks. The residual potato water is evaporated and used for the enrichment of the potato fibres and incorporated in a cattle feed. The process thus produces two saleable products.

Due partly to the reverse osmosis process and partly to a counter-current extraction process installed at the same time, the volume of process water intake was reduced from 7 m^3/tonne of potatoes to 0.6 m^3/tonne, saving 17 million m^3 of water per annum. The process also recovers 1.1 million cubic metres per year of water (the filtrate from the reverse osmosis process) which is recycled within the factory to further reduce process water intake. Effluent emissions are thus greatly reduced.

Enabling Technology

Reverse osmosis is a process which separates water from dissolved and suspended solids using a membrane made of organic material.

A pressure of 40–50 Bar is applied to force water through the membrane while dissolved substances are retained. The process thus produces two streams: a concentrated liquor and clean water. The equipment is in the form of robust, open-channel membranes with the features of high retention and low-fouling.

Advantages

Major reduction in the volume of process water consumed through the recycling of wastewater.

The reduction in the quantity of water handled enables the heat coagulation and evaporation plant to be half the size, so giving capital and energy cost savings.

Production of two by-products from the effluent.

■ Economic Benefits

An effluent treatment problem is solved and wastewater disposal costs are avoided. Water consumption is also reduced, with further savings. Two by-products are produced, both of which generate revenue. The overall cost to Avebe of concentrating the liquor with reverse osmosis at the time of installation was approx. US\$0.54/m^3 of potato water treated. The economic benefits depend upon the market value for the by-products as well as water and wastewater charges.

Country

The Netherlands

Industry

Starch Manufacture

Companies

Avebe is the largest potato starch producer in the world. Founded in 1919, Avebe is now an international cooperative with four starch production plants in Holland, the largest being at Foxhol. The company also have plants in Germany, France, Sweden, Thailand and the USA.

PCI Membrane Systems Ltd is a specialist in membrane filtration equipment with 25 years experience in solving a wide range of effluent and processing problems. The company has a UK manufacturing base, and up to 90% of its business is exports.

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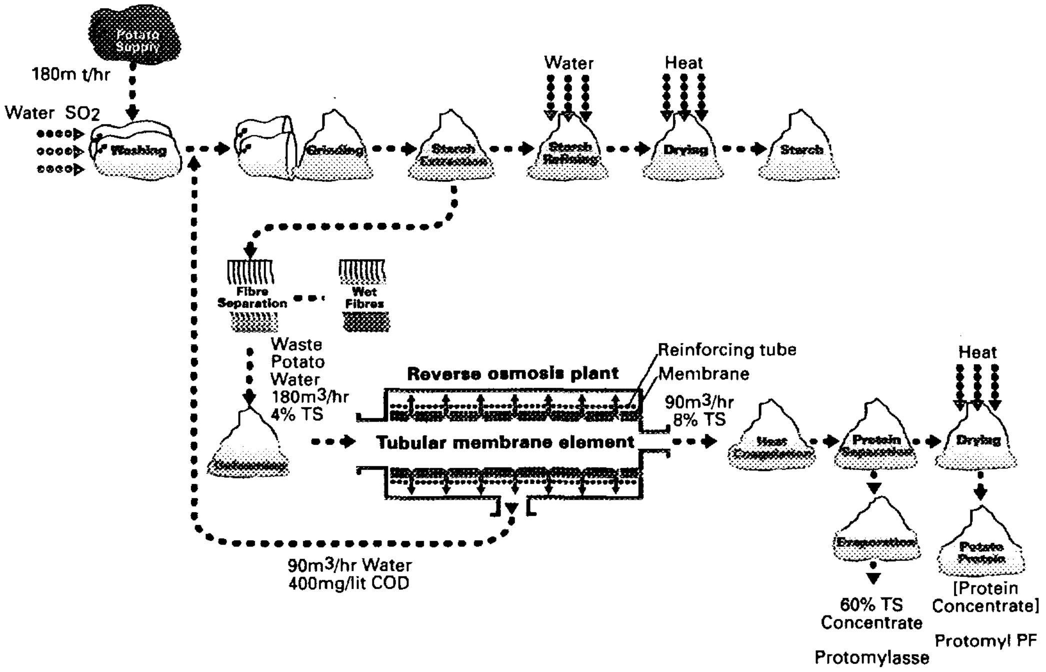
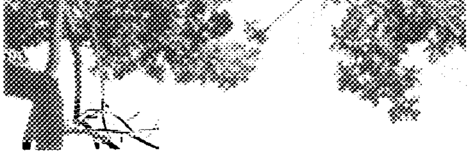
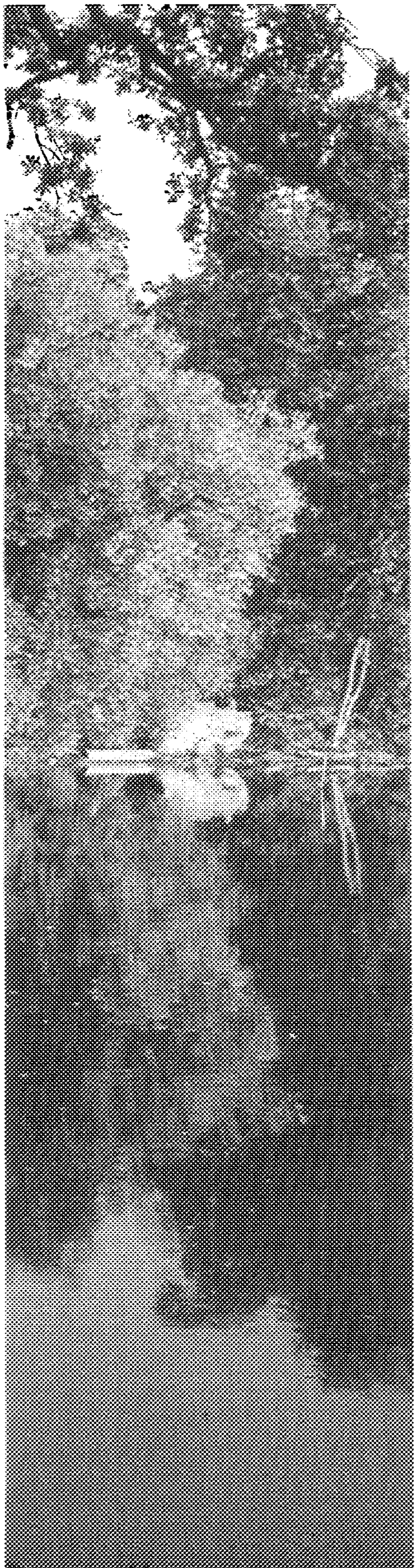




New Technology: Galvanising of Steel



Background

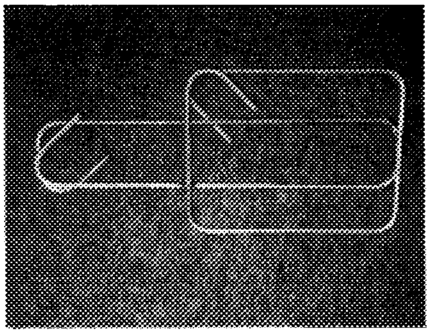
Galvanising is an anti-rust treatment for steel. The traditional technique consists of chemically pretreating the steel surface, then immersing it in 10–16 metre long baths of molten zinc at 450°C. The process involves large quantities of expensive materials, which increases the cost of the finished steel. In addition there are significant quantities of waste from the chemical and zinc baths. There is also the problem of fumes from these operations.

Cleaner Production

The company's objective was to galvanise steel products of constant cross-section, such as reinforcing and structural steel, tubes, wire, etc on a more compact production line, using up to two to three times less zinc, with reduced energy consumption and the suppression of all forms of pollution.

The raw steel is fed in automatically. The process can be operated continuously or in batches, depending on the material to be coated. The surface preparation is performed by controlled shot blasting. The steel is heated by induction and enters the coating chamber through a window profiled to match the cross-section of the steel. The zinc is melted in an inert atmosphere by an electric furnace and flows into the galvanising unit. The liquid zinc is held in suspension by an electromagnetic field. The speed of the production line is controlled by computer. Measuring the thickness of the coating using electromagnetic methods allows precise control of the process.

The first stage of the project has been to develop the technology for coilable material, ie wire and thin rod. The company are now developing the technology to handle rigid steel.

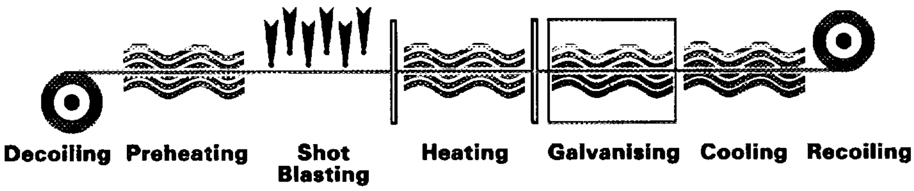


Enabling Technology

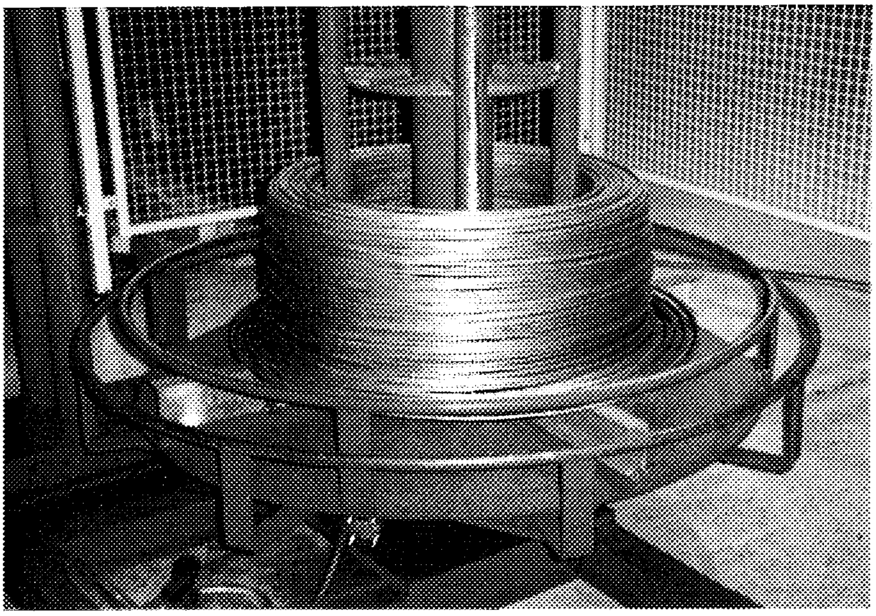
Induction heating to melt the zinc.

The use of an electromagnetic field to control the distribution of the molten zinc.

Modern computer control of process.



SKETCH OF THE PROTOTYPE LINE



Advantages

Total suppression of conventional plating waste.

Smaller inventory of zinc.

Better control of the quality and thickness of the zinc coating.

Reduced labour requirements. Reduced maintenance. Safer working conditions.

Economic Benefit

Capital cost reduced by two-thirds compared to traditional dip-coating process. Lower operating costs resulting in coating process being 18% of steel cost, compared to 60% with traditional methods.

Payback period three years when replacing existing plant.

Country
France

Industry
Metal Processing

Company
Delot Process S A is a company specialising in the development of new processes and services. It was founded in 1990 by Mr José Delot in partnership with Unimetal and Metaleurop, and has a staff of thirteen.

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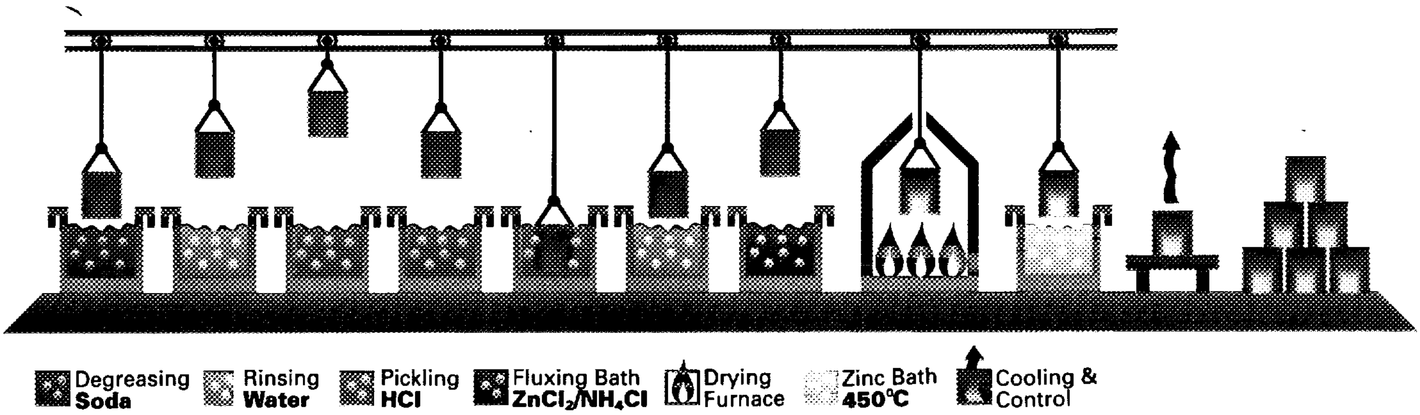

SKETCH OF A CLASSICAL HOT DIP

De-inking Process for Waste Paper

Background

This booklet is printed on Reprise paper containing almost 80% recycled fibres produced in a plant situated in a National Park in the south-west of England. Rather than just print a 'recycled paper' logo on the booklet we decided to describe the process by which waste paper is de-inked and processed into a feedstock suitable to make new paper.

The process includes a two stage de-inking treatment that allows a wider range of available waste papers to be converted to high quality printing paper.

Water is drawn from a stream passing through the plant. During the production process, the water is recycled and reused, and eventually passes to the effluent control plant. This plant treats the water by screening, settlement, and controlled microbic action. The discharges meet the strict requirements of the regulatory authority, the UK National Rivers Authority.

Pulping

The initial pulping is intended to breakdown and detach the ink from the fibres of the base paper. This process requires the use of some chemicals but the most significant factors are temperature, consistency and an efficient mechanical action. The conditions achieved disintegrate the waste paper and aid the detachment of the ink from the paper surface. This pulping stage is achieved at relatively low temperature with a low energy output. Considerable attention is given to the timing of the pulping cycle which contributes to the agglomeration of sticky contaminants and aids their removal at a later stage.

To ensure that the ink has been detached and dispersed, a sample sheet of paper is prepared and checked before the stock is diluted and discharged though a coarse dumping screen, to remove large foreign objects, to a holding tank at 5% concentration. Following further stages of progressively high density screening the stock is diluted to 1.5% concentration prior to de-inking.

First Stage De-inking

De-inking is carried out using a flotation cell which provides good de-inking efficiency and high fibre yield with minimal water and energy consumption. Flotation de-inking places a minimal load on the effluent system with both flow rate and chemical oxygen demand being kept relatively low. The process requires the generation of a foam by the injection of air in the presence of a chemical mix containing caustic soda for pH control, a proprietary 'soap' as a foaming agent, with sodium silicate and hydrogen peroxide to brighten and clean. Chemical usage is low and being progressively reduced as further technical developments allow. No chlorine bleaching is used.

Overall de-inking efficiency is aided by recirculating the liquids by pumping from the top of the cell to the bottom. The foam is removed at the top of the cell by suction heads and sent to a centrifuge where the ink-loaded sludge waste is concentrated to around 50% solids for landfill disposal. The landfill site is managed by the company and is subject to strict environmental control covering the emission of landfill gases and groundwater seepage. Special attention is given to any possible heavy metal contamination. Liquid waste is directed from the centrifuge to the effluent plant for treatment.

On leaving the cell, the de-inked stock is further diluted before passing through another fine screening process to remove small solids. The material is then pumped to a drum thickener prior to the dispersion stage.

Dispersion and Secondary De-inking

Dispersion is carried out at the lowest acceptable temperature (to minimise energy requirements) and is designed to complement the preliminary dispersion action in the pulper. Thickened stock is progressively dewatered to around 40% concentration in preparation for the kneader disperser stage which breaks down the ink/fibre bonding of more difficult printed materials.

Dewatering ahead of kneading is an essential requirement but throughout the entire process emphasis is placed on water recovery and re-use.

The intermediate dispersion stage contributes substantially to the reduction in dirt particles in the finished paper and allows the processing of a wider range of waste papers. The kneading action grinds down contaminants and produces an unavoidable 'greying' of the stock, however, the 'whiteness' is more than regained through the second stage of flotation de-inking which follows.

While operation of the second cell is similar to that of the first, no further chemicals are added, as the inevitable carry-over from the first stage is sufficient.

Following de-inking, the stock is pumped to a second drum thickener from which, at around 6% concentration, it is available to be blended with other constituents, if required, ahead of the papermaking process.

Advantages

The process allows the use of a wider range of printed waste paper.

The amount of dirt in the finished paper is reduced thereby improving quality and reducing the amount of reject paper.

The brightness of the finished paper is improved without the use of chlorine bleaching.

The energy requirements are low.

The demands on effluent and waste disposal are minimal.

The plant is safe to operate giving minimum risk to personnel and the environment.

Country

United Kingdom

Industry

Paper making

Company

St Regis Paper Co Ltd is owned by David S Smith (Holdings) plc. St Regis Paper, in addition to eight paper mills, includes Severnside Waste Ltd which supplies large quantities of waste paper for recycling.

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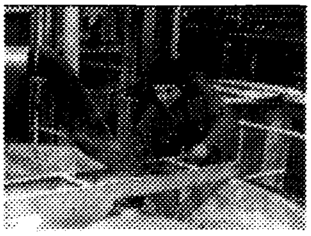
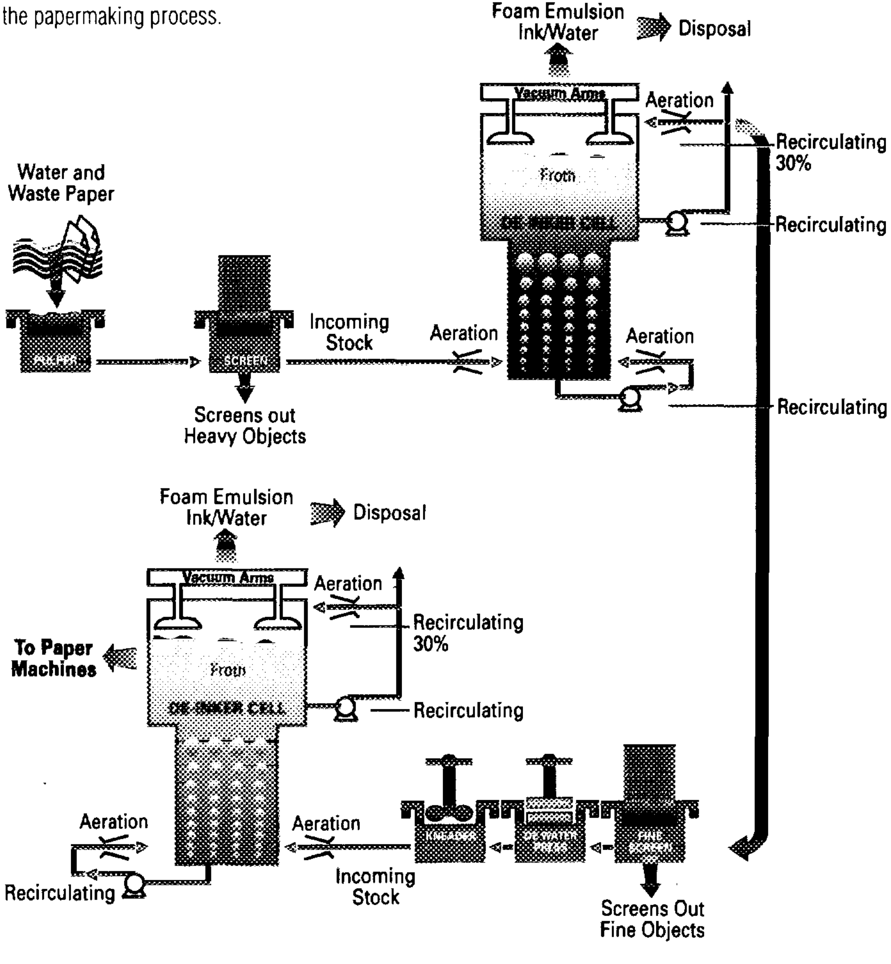
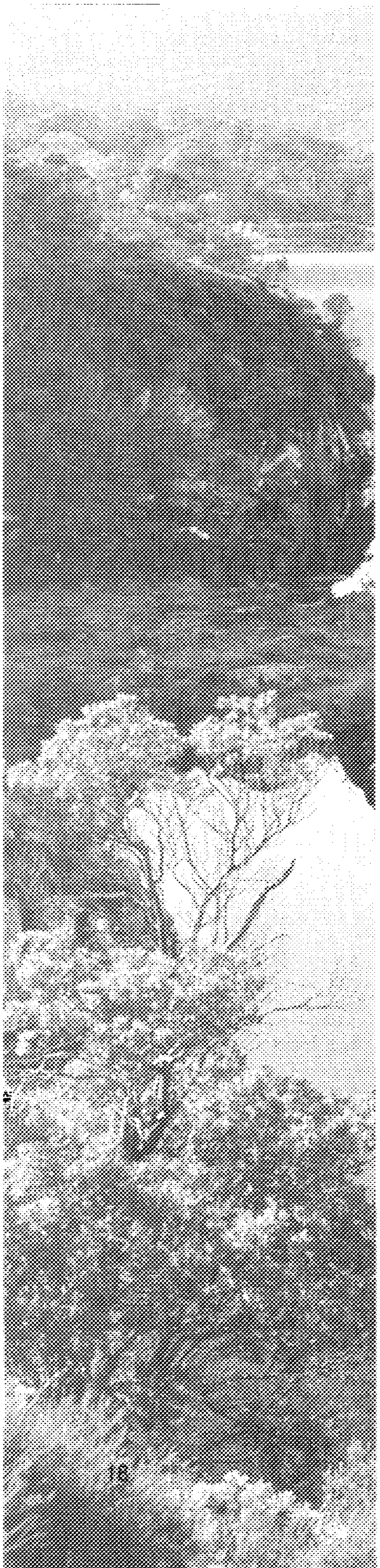
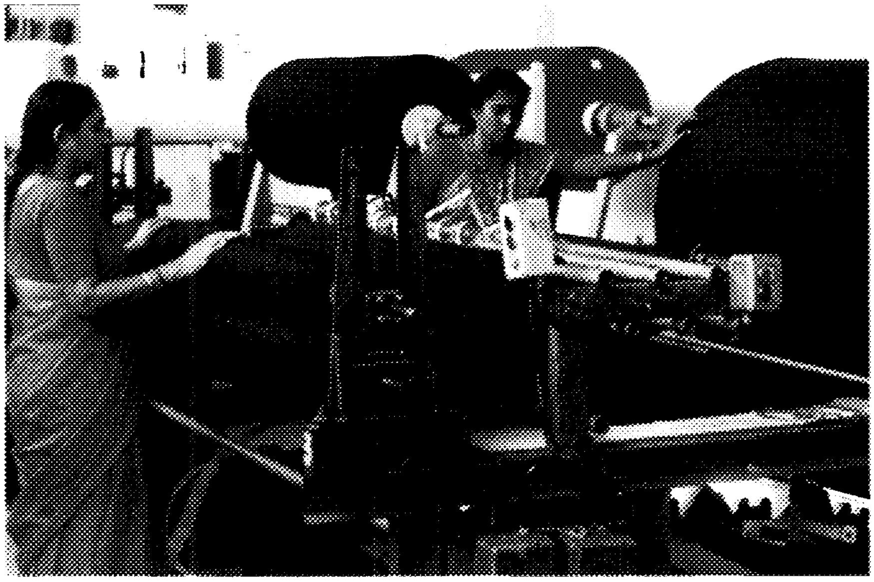




Reduction of Sulphide in Effluent from Sulphur Black Dyeing





Background

Sulphur dyes are an important range of dyes yielding a range of deep colours, but they cause a pollution problem due to the traditional reducing agent used with them. The black sulphur dye has excellent washing fastness, good light fastness and is relatively cheap.

Sulphur dyes are water insoluble compounds that have first to be converted into a water soluble form and then into a reduced form having an affinity for the fibre to be dyed.

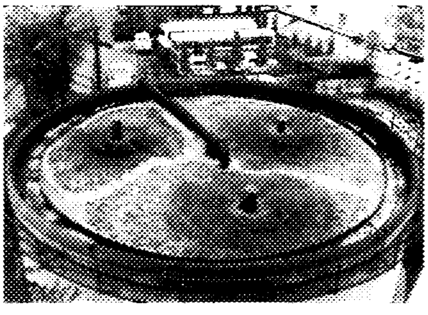
In the diagram representing the chemical equations involved, D represents the part of the molecular structure of the dye that produces the colour. The original dye ***(1)*** is dissolved in an alkaline solution of caustic soda or sodium carbonate. The dye ***(2)*** is then reduced to the affinity form ***(3)***. After dyeing the fabric the dye is converted back into the insoluble form ***(1)*** by an oxidation process. This last reaction prevents washing out of the dye from the fabric.

The traditional method of taking the original dye to the affinity form is treatment with an aqueous solution of highly polluting sodium sulphide. This causes an increase in the sulphide content of the mill's effluent. On account of its toxicity the State Pollution Control Board prescribes a limit of 2 ppm for sulphide in the treated effluent.

■ Economic Benefits

No capital expenditure was involved in this substitution and in fact the operating costs were found to be marginally lower. The saving in not having to install additional effluent treatment facilities was about US$20,000 in capital expenses and about US$3,000 in running expenses per annum. The substitution has not incurred any additional operating costs and there has been a considerable but unquantified saving in money and convenience due to the reduction in handling and storage.

The substitute chemical used was essentially a waste stream from the Maize Starch industry, which saved them an estimated US$12,000 in capital expenses with running costs at about US$1,800 per annum.



Cleaner Production

A study of the available methods of sulphur black colour dyeing and the treatment options was made. An investigation was also made into an alternative to sodium sulphide.

It was found that an alkaline solution of glucose could bring about satisfactory conversion of sulphur dyes. However, the high cost of glucose was the main constraint in practice.

A market survey was conducted for procuring an equivalent chemical at a competitive price. This lead to the identification of a by-product of the maize starch industry, hydrol, which contained about 50% of reducing sugars. Experiments revealed that 100 parts of sodium sulphide could be substituted by 65 parts of this alternative plus 25 parts of caustic soda. The dissolving and the affinity reactions are carried out in a single stage.

The substitution with hydrol was implemented with a redesigned mixing strategy. The dyeings obtained after this substitution were seen to be equivalent to conventional dyeings in depth of shades, fastness properties, etc, plus there were some other improvements in the quality of the dyed product. The process has been in use since April 1990 and has resulted in the reduction in the sulphide concentration of the effluent from 30 ppm to less than 2 ppm. The substitution resulted in a slight increase in the Biochemical Oxygen Demand (BOD) load on the plant but this increase was found not to be critical and was easily manageable with the existing biological treatment system.

Enabling Technology

Theoretical understanding of the chemistry involved and a search for suitable reagents.

Advantages

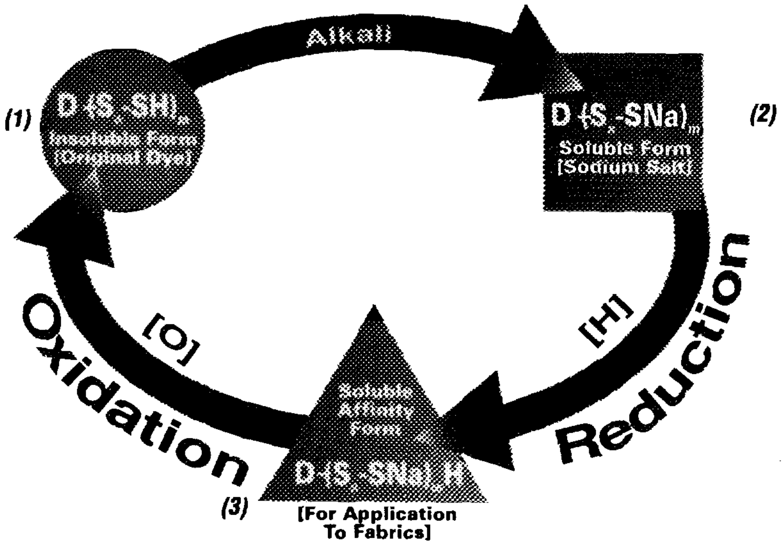
Reduction of sulphide in the effluent.

Improved settling characteristics in the secondary settling tank of the activated sludge unit.

Less corrosion in the treatment plant due to reduced sulphide levels in the effluent.

The foul smell of sulphide in the work place was eliminated.

THE DIFFERENT FORMS OF SULPHUR DYE



Country

India

Industry

Textiles

Company

Century Textiles and Industries Limited was established in Bombay, India in 1897. Its Textile Division employs 7,000 workers. The Company manufactures 100% cotton yarn and fabrics and is the world's largest exporter of 100% cotton fabrics. The turnover of the Textile Division for the year 1991–92 was US$99.75m, with 80% of its production being exported. The company has won many national and international awards for export performance and energy conservation.

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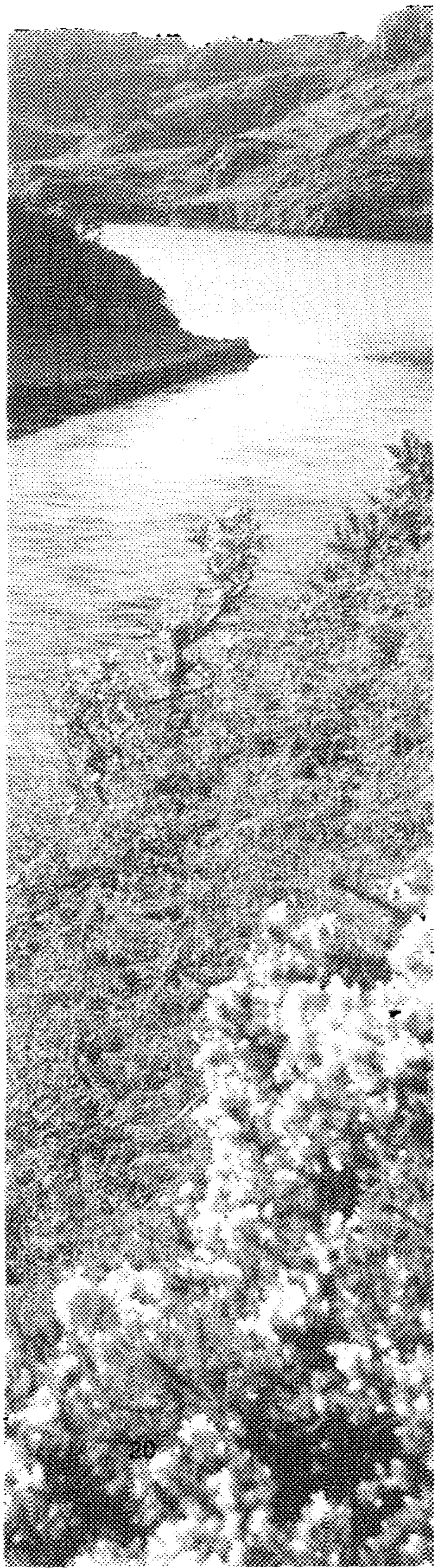
Waste Reduction in Electroplating



Background

FSM Sosnowiec manufactures automobile lamps, door locks and window winders. The lamp bodies are made of zinc-aluminium alloy and then copper-nickel-chromium plated. The door locks and window winders are made of steel and zinc plated. The waste streams contain cyanide and the following heavy metals: chromium-6, copper, zinc and nickel. The company carries out traditional treatment of detoxification, neutralisation and dewatering.

Cleaner Production

A pollution prevention audit was carried out to reduce environmental pollution, improve working conditions and improve efficiency. One of the results was that low concentration plating and pacifying is now being introduced. All of the rinsing systems have been modified so that some of the circulating (overflow) rinses have been changed to static rinses. The old and new system for chromium is shown. A similar system has been installed for nickel and cyanide. The final rinse tank in each rinsing sequence has been equipped with ion exchange columns which permit water recycling and raw materials recovery.

Advantages

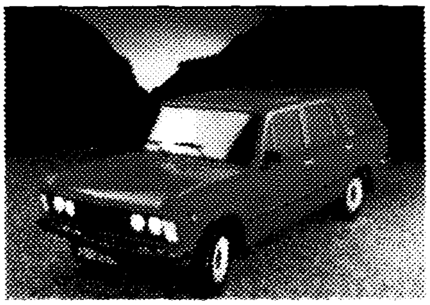
A decrease in both water and raw materials consumption.

The reduction in both waste stream quantities are as follows:

chromic acid	80%
copper	95%
cyanide	80%
nickel	98%
zinc	96%
waste water	93%

The waste water is purified to the following levels:

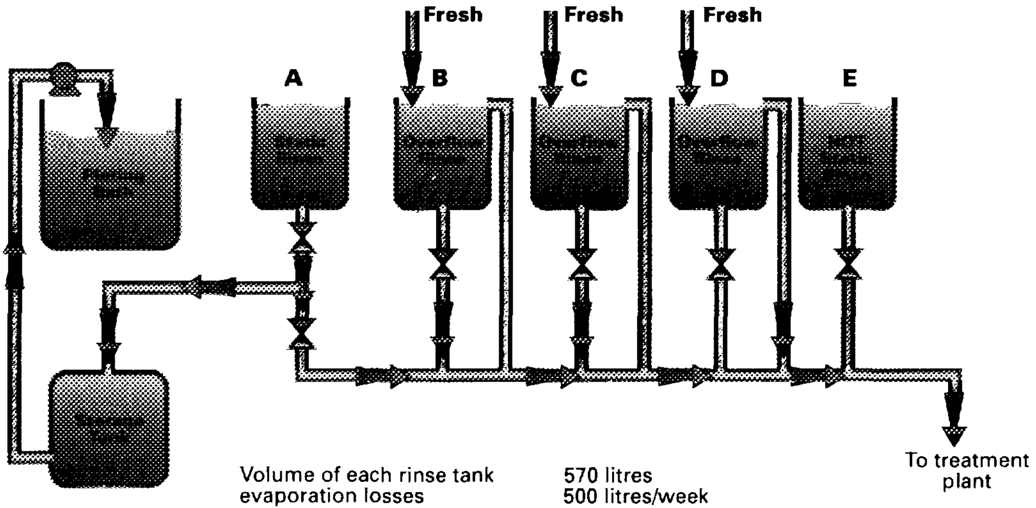
chromium	0.1 mg/litre
copper	0.1 mg/litre
nickel	1.0 mg/litre
cyanide	2.0 mg/litre
zinc	0.9 mg/litre



■ Economic Benefits

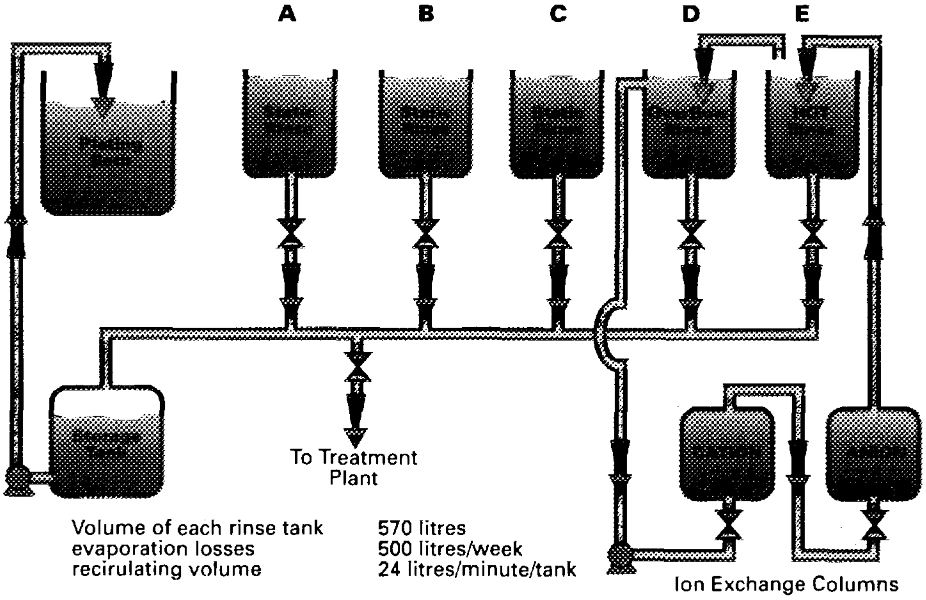
Cost saving	**US$/year**
Total savings	**193,000 approx**
Capital investment	**36,000**
Payback period	**2 months**

ORIGINAL RINSING SYSTEM



Volume of each rinse tank	570 litres
evaporation losses	500 litres/week
recirulating volume	24 litres/minute/tank

NEW RINSING SYSTEM



Volume of each rinse tank	570 litres
evaporation losses	500 litres/week
recirulating volume	24 litres/minute/tank

Country

Poland

Industry

Automobile Component Manufacture

Company

FSM Sosnowiec is a manufacturer of automobile components for the Polish manufactured FIAT cars.

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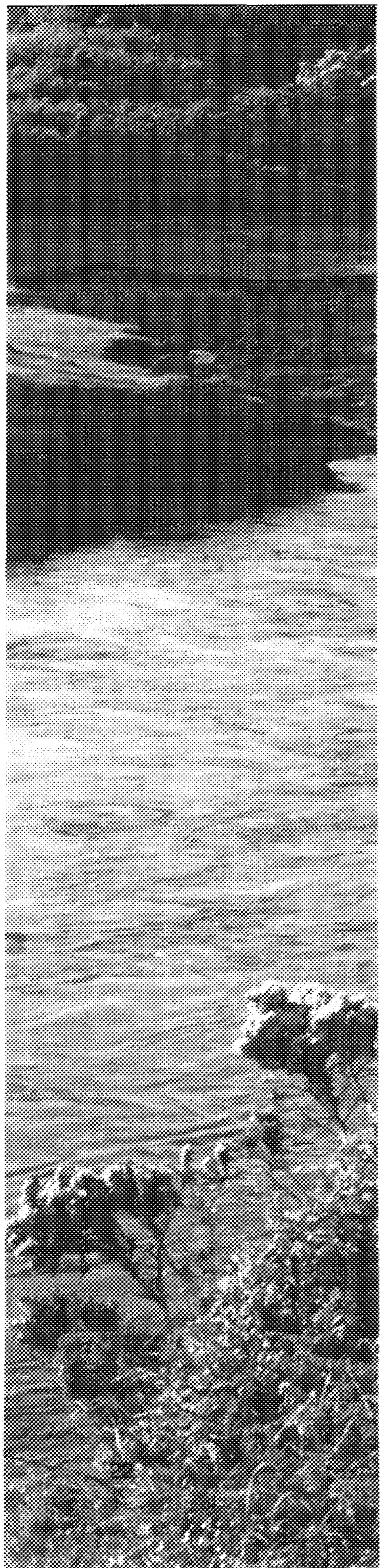
Waste Reduction in Steelwork Painting



Background

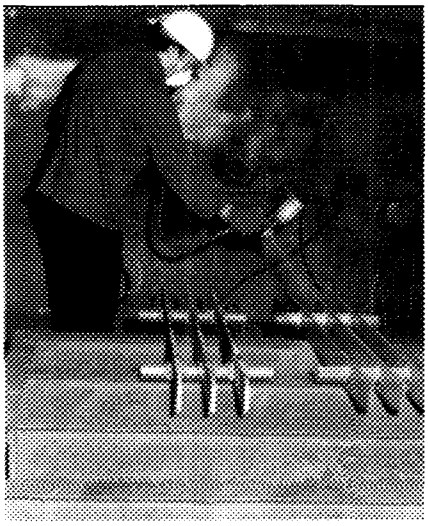
In the 'Ostrowiec' Steelworks the manufacture of steel products is carried out using production-line methods. The final operations required for almost all products are surface treatment and painting. In the Machinery Building Department these operations are carried out with shot-blasting machines and manually operated spray booths. The original painting method was air-atomised spraying which has the lowest transfer efficiency of the coating methods and yields large quantities of waste.

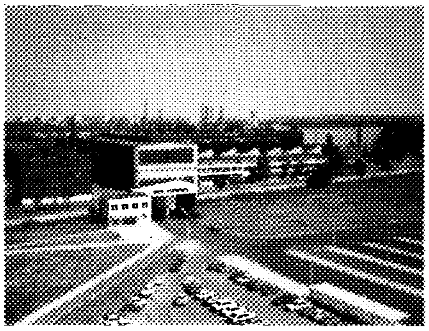
Cleaner Production

A pollution prevention audit was carried out to improve the environment and efficiency and working conditions in the painting areas. The objective of this programme was to reduce the quantity of wastes and costs of painting by a combination of improvements to the technology and good housekeeping. The overall aim was to improve the quality of coating, to reduce the amount of paint raw material and to reduce the quantities of wastes.

The existing painting method was compared with two more advanced painting technologies. The transfer efficiency for the different methods are as follows:

air-atomised spray (conventional)	30–50%
airless spray	65–70%
pressure atomised electrostatic spray	85–90%





In conventional spraying compressed air is used both to atomise the paint and carry it to the surface to be painted, Fig.1. With airless spraying the paint is pumped under high pressure to a small jet where the high velocity is sufficient to induce atomisation. The lack of any expanding compressed air stream eliminates unwanted spray mist, reduces the loss of paint by overspray and most of the paint adheres to the work surface, Fig.2. With pressure atomised electrostatic spray, paint is delivered at high pressure as before, but it is fed to a insulated nozzle. An electrostatic charge of about 100kV is applied to this nozzle. The charging of the paint particles assists the atomisation and causes them to repel each other. Additionally the charged paint moves along the field lines to the earthed work piece. As the electrostatic field lines envelop the object the paint particles cannot fly straight past, but 'wrap' themselves uniformly around the surface. It is this effect that gives the high paint efficiency and reduces waste, Fig.3. Note that electrostatic hand spray guns require a small mains transformer and a very reduced current to avoid accidental electrical shock. Tests carried out with the two improved painting methods showed the following results:

Comparison of raw material consumption and waste quantities of the different methods:

	Air-atomised spray	Airless spray	Pressure atomised electrostatic spray
Paints	8.0 m^3	6.8 m^3	5.6 m^3
Solvents	6.5 m^3	1.6 m^3	1.6 m^3
Wastes	2,400 kg	1,400 kg	500 kg

Advantages

Reduction of high disposal costs.

Reduced running costs.

Decreased financial liability by generating a smaller quantity of hazardous wastes.

Improved public perception and acceptance in the business community.

Also indicated were potential reductions in the effluent concentrations of about 45% for sludge and 75% for organic solvents.

Economic Benefits

(Estimates, based on Trials)

	Airless spray	Pressure atomised electrostatic spray
Cost saving	**US$/year**	
Total savings	**38,500**	**39,400**
Capital investment	**US$4,800**	**US$13,000**
Payback	**1.5 months**	**4 months**

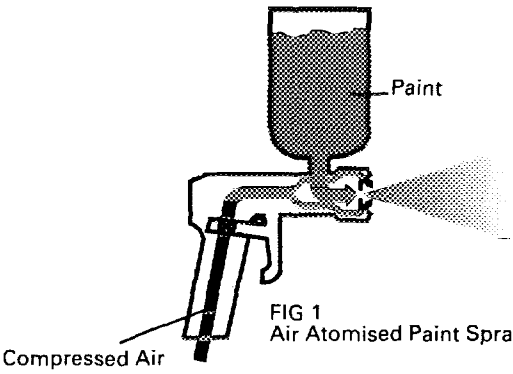


FIG 1
Air Atomised Paint Spraying

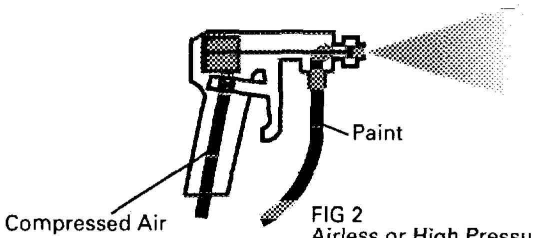


FIG 2
Airless or High Pressure
Paint Spraying

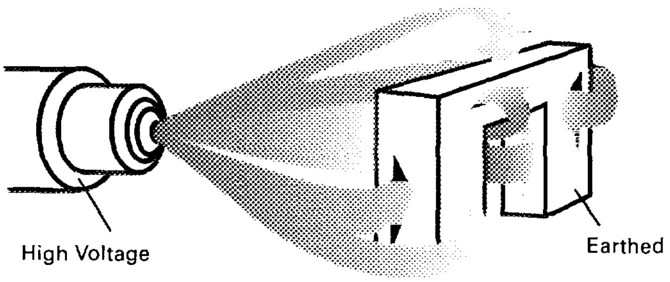


FIG 3
The 'Wrap-Around' Effect
of Electrostatic Paint Spraying

Country
Poland

Industry
Iron and Steel Industry

Company
The 'Ostrowiec' Steelworks consists of eleven Departments, the main production departments are Steelworks, Processing, Steel Construction, Machinery Building and the Foundry.

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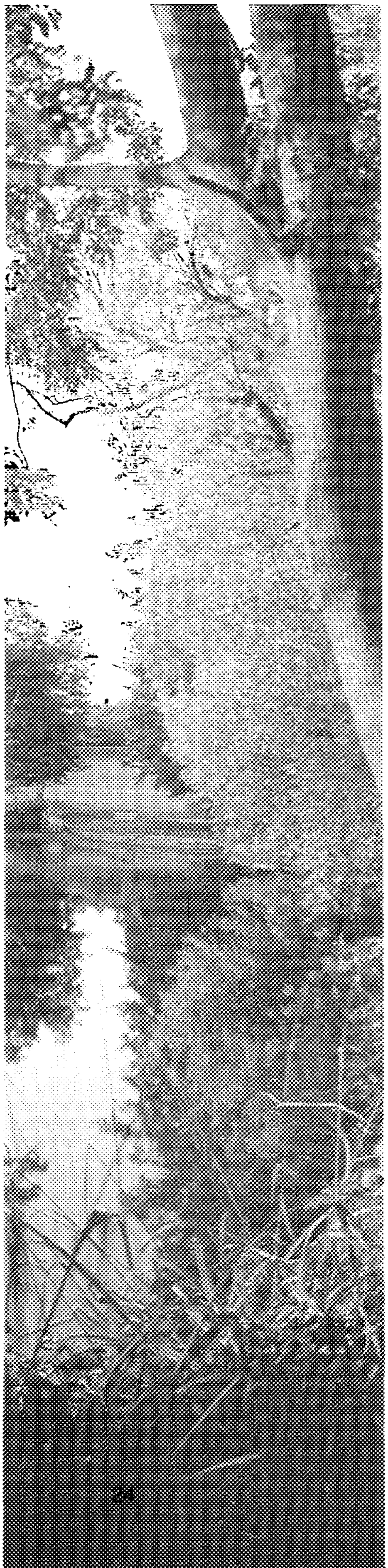
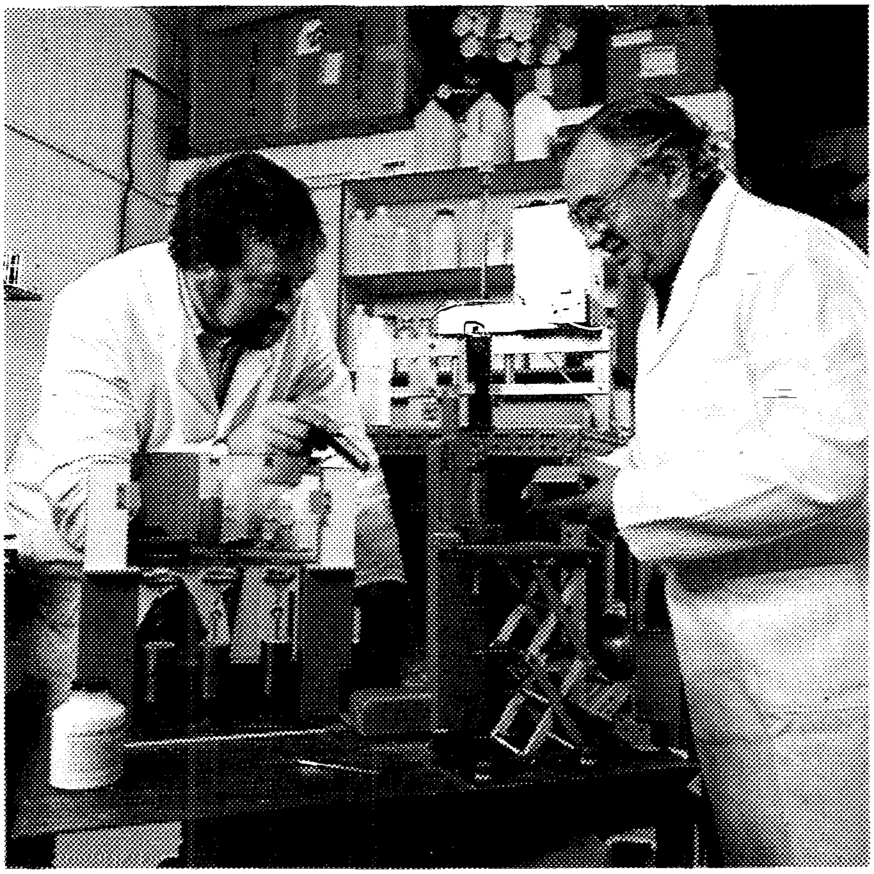
New Product: Water-Based Adhesives





Background

Blueminster have developed the technology of water-based adhesives by the production of a wide range of resin dispersions which enable solvent-free adhesive systems to improve upon and replace solvent-based adhesives. Water-based adhesives have a much higher solids content than solvent-based adhesives and less energy is required to remove water from the adhesive film. Various trials have been carried out and small-scale production has started.

Cleaner Production

When solvent-based adhesives are used the components of the adhesive, normally a polymer and a resin, (capable of becoming tacky), are dissolved in a suitable organic solvent. The adhesive film is obtained by laying down the solution and then removing the solvent by evaporation. In many adhesives, the solvent is a volatile organic compound (VOC) which evaporates to the atmosphere thus contributing to atmospheric pollution. In other cases, the solvent is removed by high energy drying and, in some cases, subsequently recovered. Hot-melt adhesives, which do not use solvents, are also high energy consumers.

These new adhesives are now finding application in flooring and mounting large sheets in exhibition and studio use, pressure sensitive tapes, food packaging and labelling, including use at low temperatures for frozen food.

Economic Benefits

The benefits are derived mainly from the lack of use of solvents and can amount to significant savings on equipment, raw materials, safety precautions and overheads.

Users have not been prepared to release any information on economic savings at this stage.

Enabling Technology

Blueminster have developed resin dispersion technology that can be applied to a very wide range of resins that have the necessary 'tackifying' properties. These resins are free from organic solvents, proteins and starches and are compatible with most polymer dispersions in all proportions. The dispersed resins remain liquid at all practical temperatures and, when intimately mixed with the polymer, allow uniform continuous adhesive films to be laid down having a very high degree of flexibility.

Advantages

Water-based adhesives are non-toxic, they do not pollute the atmosphere or water systems, they do not require special handling and are not a fire hazard.

Solvent-based adhesives require three to five times the drying energy of water-based adhesives, which need no special solvent recovery systems or explosion-proof equipment.

Water-based adhesives can generate higher levels of adhesion through penetration of absorbent substrates, such as cellulose, and will also allow more time for the precise positioning of adherents.

Particularly suitable for food packaging.

Country

United Kingdom

Industry

Adhesives

Company

Blueminster Ltd is a small research-based company which was founded as a chemical consultancy in 1981.

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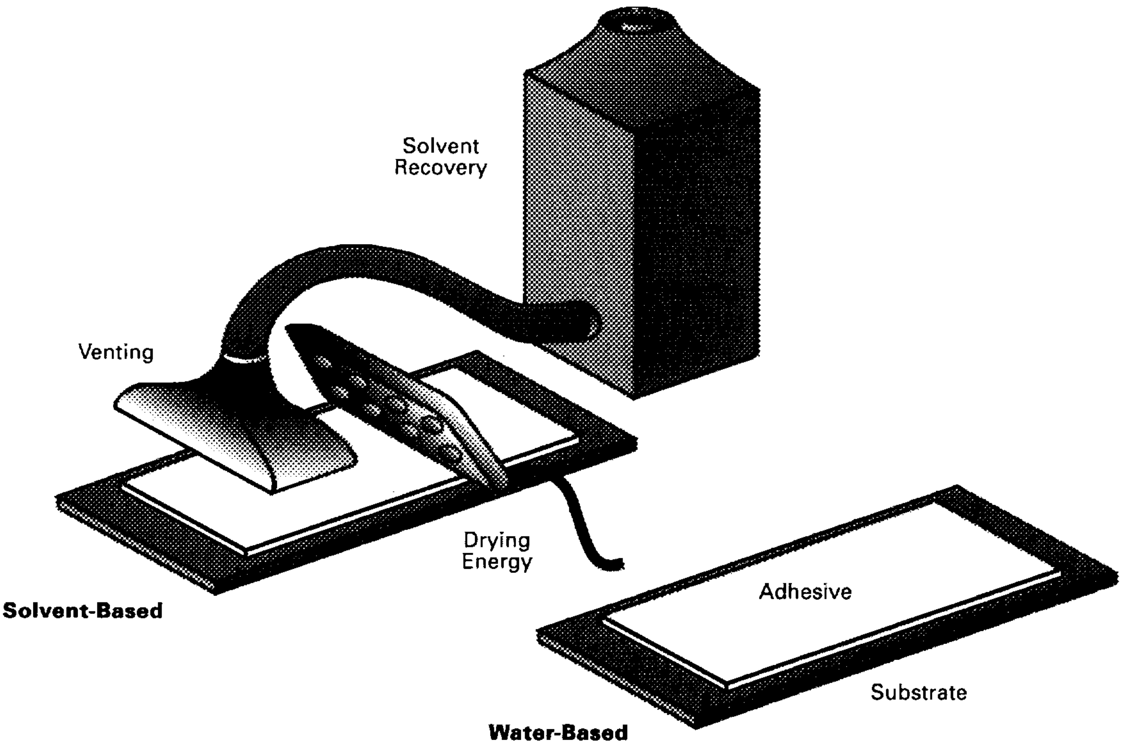
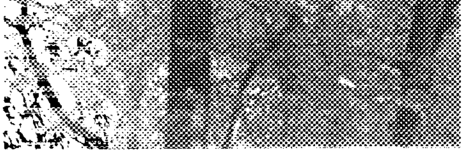
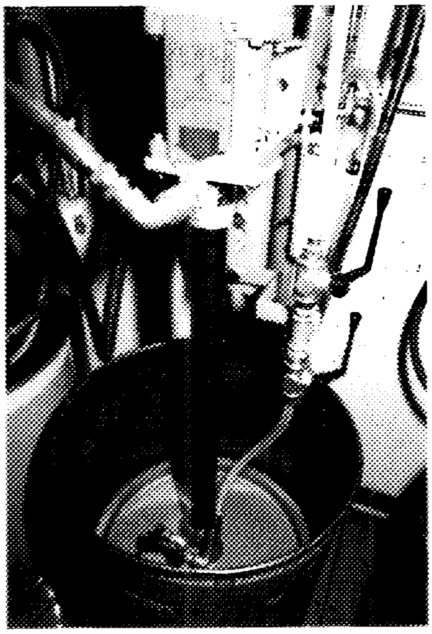


THE ADVANTAGES OF WATER-BASED ADHESIVE DRYING



Cleaner Production in a City-based Project



Background

The Environmental Protection Agency of the City of Graz in Austria and the Chemical Engineering Institute at Graz University of Technology combined together to put forward a clean technology initiative called **ECOPROFIT**, **ECO**logical **PRO**ject **F**or **I**ntegrated environmental **T**echnology in April 1991.

Eleven companies and their suppliers co-operated to carry out a total of 26 projects. We give here details of some of the projects carried out by just two of the companies in the first year. Company information is on p29. Three projects relate to a printing company and three projects relate to an automobile repair company. Substantial improvements in air emissions and wastes have been achieved. Emissions of halogenated hydrocarbons and some toxic wastes could be reduced by 100%. The emission of volatile organic compounds (VOC's) have been reduced in some instances by 70–90% and several substances are now recycled. There have also been substantial cost savings.

Cleaner Production

PRINTING SHOP EXAMPLES

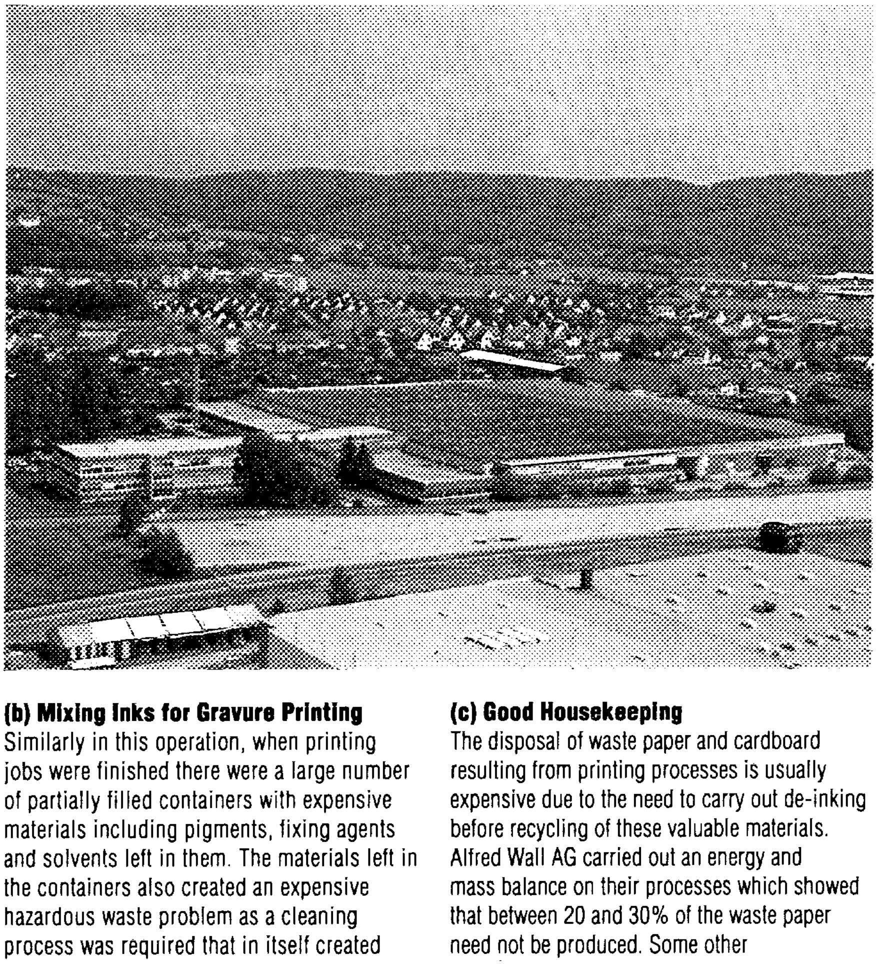
Alfred Wall's three projects involved (a) Ink in Bulk, (b) Mixing of Ink and (c) 'Good Housekeeping'.

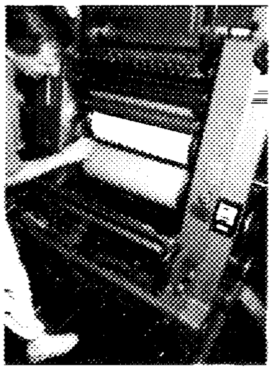
(a) Ink in Bulk

Even large users of inks have the ink delivered in containers of 1 – 2.5 kg. This entails a large number of empties that have to be disposed of as hazardous waste, because of the contamination with ink. The drying process of inks also causes considerable emissions to the air. The development has been a system for delivering ink in 25 to 300 kg barrels, known as 'ink fountains', which are refilled by the manufacturer. The ink is transferred to the printing machine under pressure, so reducing solvent evaporation. The advantages of these bulk containers are: less work and time needed for handling, no problems of disposal, reduced pressure on the environment, reduction in cost from the previous empties disposal and no ink is wasted.

So far this method has only been introduced for black ink, but will be progressively introduced for the more popular colours.

The ink suppliers were: K & E Farbbrunnen, Vienna, Austria; Stehlin & Hostag AG, Lachen, Switzerland and Prismatec GmbH, Bad Camberg, Germany.

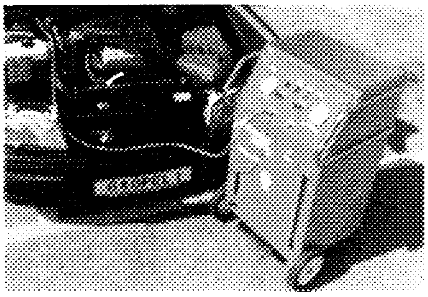




(b) Mixing Inks for Gravure Printing
Similarly in this operation, when printing jobs were finished there were a large number of partially filled containers with expensive materials including pigments, fixing agents and solvents left in them. The materials left in the containers also created an expensive hazardous waste problem as a cleaning process was required that in itself created further effluent for disposal.

The inks are now delivered in large containers (200 litres). Surplus ink is now returned to the containers as the containers are fitted with a stirring mechanism which prevents the settling of the suspended ink pigments even during long periods of storage. These more expensive containers are simply refilled by the manufacturer once they are empty. The evaporation of solvent that previously occurred in handling has been reduced substantially. A computer controlled mixing and dosing system has been developed which facilitates optimal dosing. This also contributes to the reduction of emissions, as mistakes during mixing are largely eliminated. Alfred Wall AG designed and built the equipment using their own resources.

(c) Good Housekeeping
The disposal of waste paper and cardboard resulting from printing processes is usually expensive due to the need to carry out de-inking before recycling of these valuable materials. Alfred Wall AG carried out an energy and mass balance on their processes which showed that between 20 and 30% of the waste paper need not be produced. Some other improvements in the production process were also shown up immediately.



CAR REPAIR WORKSHOP EXAMPLES

Salis and Braunstein's three projects involved
(a) working with two-component paints,
(b) repair of automobile air-conditioning units
and (c) mixing systems for topcoat paints.

(a) Working with two-component paints

Single component paints do not have sufficient chemical and physical strength to be used on cars and therefore two-component systems are used. Two-component paints have a hardener which reacts chemically when mixed. This mixed paint has to be used within hours or it dries up and has to be disposed of as an expensive hazardous waste.

The solution was to mix the two components in a specially designed metering hopper. A more exact dosage of paint was possible guaranteeing a good surface and reducing the amount of sanding and the production of dust. In the spray gun itself the compressed air is heated up to 85°C, causing the paint to heat up to 65°C. This ensures that even paints with a solids content of up to 70% can be mixed without any problems. A pulsating air flow also aids the subsequent cleaning of the device, reducing the use of cleaning fluids by a factor of four.

(b) Repair of automobile air-conditioning units

Up to 5% of new cars in Austria have an air-conditioning system containing 1–1.5 kg of chlorofluorocarbons, CFC's, (usually CFC-12). Major repairs of the units entailing a refill of CFC generally occur three times during the ten year life of the vehicle. It is estimated that 27 tonnes of CFC per year are released from the repair of these units and 2.5 tonnes are released with the scrapping of vehicles.

This cleaner production exercise suggests that only repair agents who have facilities for extraction of the CFC should be allowed to carry out such repairs to air-conditioning units. Garages that carry out less than 50 air-conditioning repairs a year should use CFC extraction units. These suck out the refrigerant which can be recycled (or destroyed) by the manufacturer. If more than 50 repairs per year are carried out, combined extraction and recycling units should be used. Currently only 12% of Austrian garages have facilities for extracting or recycling CFC.

Additionally it is suggested that CFC-12 (CCl_2F_2) is replaced by HFC-134a ($C_2H_2F_4$) which has an eleven times less affect on the ozone layer. Unfortunately units must be

designed for HFC-134a and existing units cannot simply be recharged with the new refrigerant.

The total cost of recycling equipment for CFC-12 is US$3,300 whilst for HFC-134a it is US$5,700. At the moment HFC-134a costs more than CFC-12, but this factor is likely to decrease with its increasing use and the effect of the Montreal Protocol ban on CFC-12 production.

This study was based on 1991 figures and work from the air-conditioning system supplier Ginner of Vienna, Austria and the refrigerant supplier Bruckner & Novak KG of Wr. Neudorf, Austria.

Editors note: Some British made Rolls-Royce, Jaguar and Rover cars are now fitted with Klea 134a based air-conditioning units.

(c) Mixing systems for Finalcoat Paints

A repair shop will require a very large number of colours for the vehicles likely to come in for repairs. The paints have to be prepared using fixed quantities of paint, taken from 0.5, 1, 2 and 3 litre cans. To spray a fender or mudguard takes only 0.3 litres of paint, but the minimum that can be prepared is 0.5 litre. Similarly to spray a hood or bonnet takes 0.7 litre of paint, but 1 litre has to be mixed. Not only is this wasteful of paint, but there is always the disposal problem.

It is suggested that computerised paint mixing systems could easily be developed that would dispense 40,000 shades of colour using only a hundred basic colours, in quantities of 0.1 to 6 litres. It is estimated that systems could be produced for US$4,750–US$9,520 and that the payback period could be as short as 1 year, depending on the throughput of the paint shop. These estimates are based on information supplied by Austro Lesonal GmbH and Elixhausen of Austria.

Results

The overall results from these studies showed that the following reductions could be achieved.

Printing shops	
solvent emissions	90%
metal hydroxide sludge (preparation of cylinders)	40%
wash water (reproduction)	90%
use of chemicals (reproduction)	70%
waste of small containers (lithographic printing)	50%

Car repair workshops	
halogenated materials	100%
oil-containing materials	100%
solvents	> 50%
waste	30%

■ Economic Benefits

Cost saving	**US$/year**
Based on 10 car respray jobs per day	50,000
Capital cost	**US$13,000**
Payback	**3 months**

Material and emission reduction	
hardener	30%
sanding	15%
solvents	1,400 kg
dried-up paints/ hazardous waste	350 kg

The equipment supplier was MGV Moest, Landsberg, Germany.

Country

Austria

Industry

Printing
Automobile Repair

Companies

Alfred Wall AG is Austria's largest printer of wrapping materials. It was founded in 1868 and is one of the largest and most modern companies of its kind in Europe. In spite of this it has found further opportunities for cleaner production. The company has 500 employees and a turnover of US$100m.

Salis and Braunstein was formed in 1938 with two car mechanics and an apprentice. In those days there were only 33,000 cars in all Austria. Nowadays, there are three million cars, and Salis and Braunstein employ 235 people. The company has a turnover of US$80m.

Contact

This programme of cleaner production projects was instigated by

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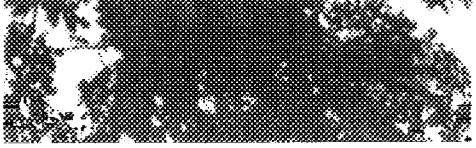
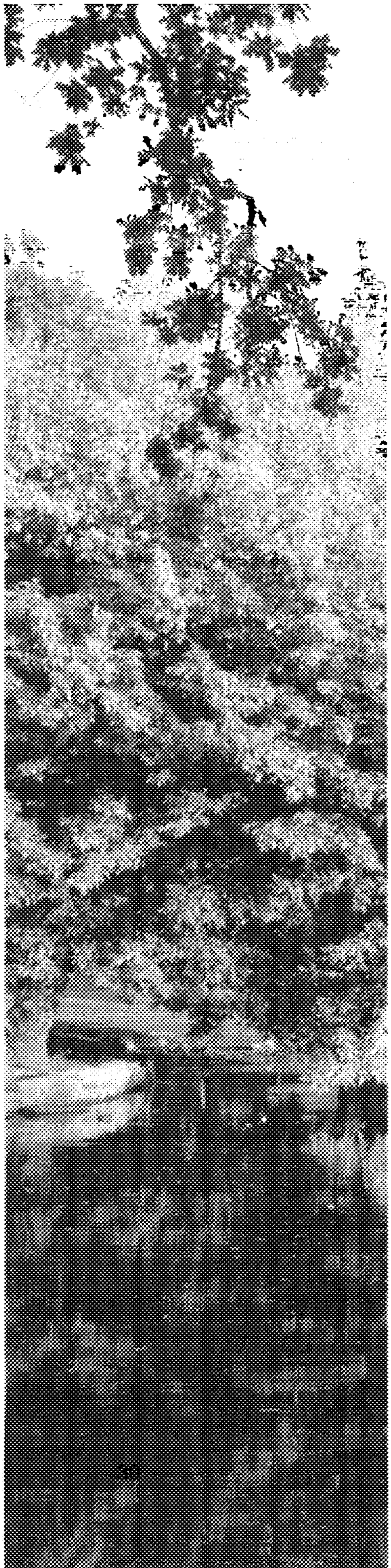


Minimisation of Organic Solvents in Degreasing and Painting



Background

Thorn make light fittings from aluminium or steel sheets. Metal working, degreasing and painting are the main phases in this production process. The degreasing of the metal sections has been carried out in the past by using the volatile organic compound, trichloroethylene, which is a pollutant and is now recognised as an environmental hazard.

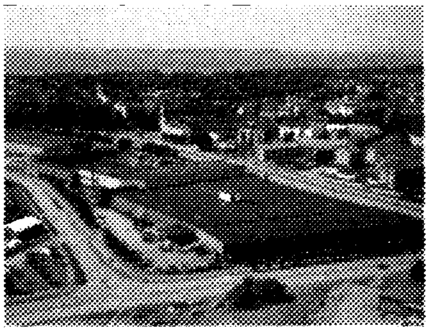
The painting plant consisted of an automatic liquid lacquer line, with differing colours using different organic solvents. The air pollution and the accumulated remaining products were a considerable problem, both within the plant and externally.

When the company planned to expand production the local authorities ordered the company to reduce its current air emissions. As a result the company intended to install equipment to capture the trichloroethylene and incinerate the solvents from the painting plant. However, an independent research organisation, by carrying out a pollution prevention audit, suggested an alternative approach having environmental benefits.

Cleaner Production

The pollution prevention audit started with an analysis of the material flow in the degreasing process. It was shown that by better housekeeping, the need for trichloroethylene degreasing could be reduced by 50%, but this has now been cut to zero. The cutting of aluminium sheets required cutting fluids which were difficult to remove without the use of chlorinated solvents. A change to biodegradable cutting oils allowed an alkaline degreasing procedure in place of the previous trichloroethylene method.

The degreasing is carried out in a new piece of equipment in the form of a totally enclosed 'tunnel', 30 metres long. The metal products are suspended from an overhead conveyor and then pass through five zones where they are sprayed with various liquids. The stages carried out are degreasing, water rinse, iron phosphating to aid the adherence of the paint, water rinse, a de-ionised water rinse and drying. The liquid runs off the metal items into tanks below where it is recirculated back to the spray nozzles.



Electrostatic powder painting uses polymer based paints that do not have any solvent in their formulation. A long-term problem was that of changing to a different colour of paint. This is now accomplished by changing the whole module with containers of different colours. The company has now installed a new electrostatic powder painting line having twelve automatic powder guns. The paint is positively charged relative to the metal items. Now only 5% of the colours have organic solvents and are used only for the painting of short production runs in special colours or for retouching of the automatically sprayed items where necessary. Manual spraying is carried out in a ventilated booth fitted with two electrostatic guns.

Economic Benefits

The alkaline degrease turned out to be US$25,200 cheaper a year than the trichloroethylene degrease and did not require the installation of recovery equipment.

The powder painting techniques have led to considerably lower working costs. The following costs for solvent painting have disappeared with the use of powder painting.

Cost savings	**US$/year**
Paint	206,000
Cleaning	62,000
Disposal	47,000
Pumping	33,000
Labour	112,000
Total	**460,000**
Capital Investment	**US$430,000**
Payback	**11 months**

Advantages

Changed degreasing techniques

The environmental advantages that have been achieved are external and also within the workplace. The company more than adequately meets the demands from the authorities.

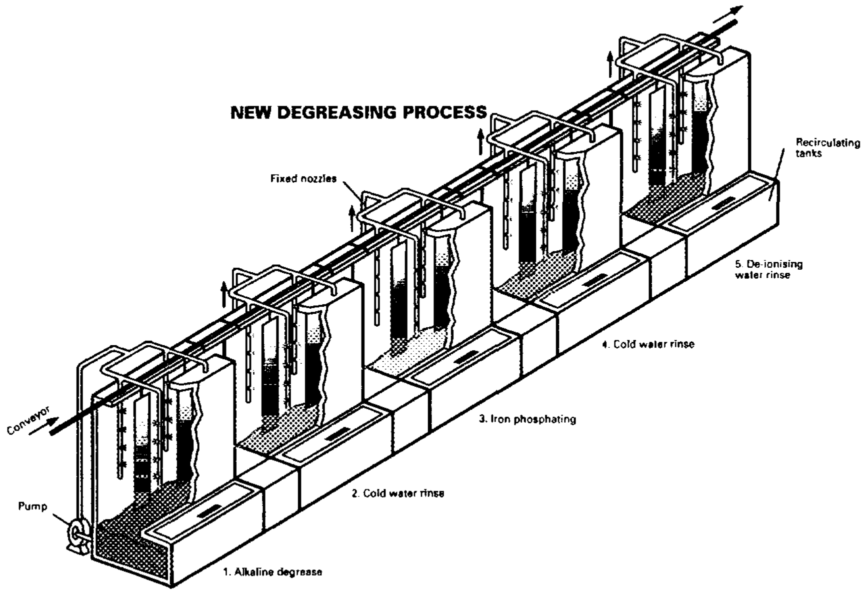
Environmental charge per annum	**Previous trichloroethylene degrease**	**Present alkaline degrease**
Air emission	11 ton trichloroethylene	0
Water emission	0	water purification plant
Hazardous waste	5 ton trichloroethylene sludge	< 2 ton sludge

The water purification plant, which is also used for other process baths, can be used for the alkaline degreasing too and results in little additional water pollution from the degrease stage.

Changed painting techniques

The environmental advantages are considerable with a large reduction of the discharge of organic solvents, reduction of hazardous waste, improved work environment and a situation which enabled production to expand without conflicting with environmental demands.

Environmental charge per annum	**Previous liquid lacquering**	**Present powder painting (including 5% liquid lacquer)**
Air emission (organic solvents)	65 ton	7 ton
Hazardous waste		
Solvents	10 m^3	2 m^3
Colour residues	47 ton	0.2 ton
Powder residues	< 0.5 ton	3 ton



Country
Sweden

Industry
Metal fabrication

Company
Thorn Järnkonst produces lighting fixtures for indoor and outdoor use. The production amounts to 750,000 units. They employ about 650 people and the turnover is US$93.45m per year. In 1988 the company merged with Thorn EMI, the main branch being in England.

Suppliers
5-zone degreasing plant –
Br Michaelsen AB, Kungälv,
Sweden

Automatic powder plant –
Gema-Volstatic AG, St Gallen,
Switzerland

Manual powder painting plant –
Eisenmann AG, Böblingen,
Germany

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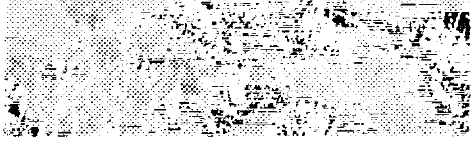


Recovery of Copper from Printed Circuit Board Etchant

Background

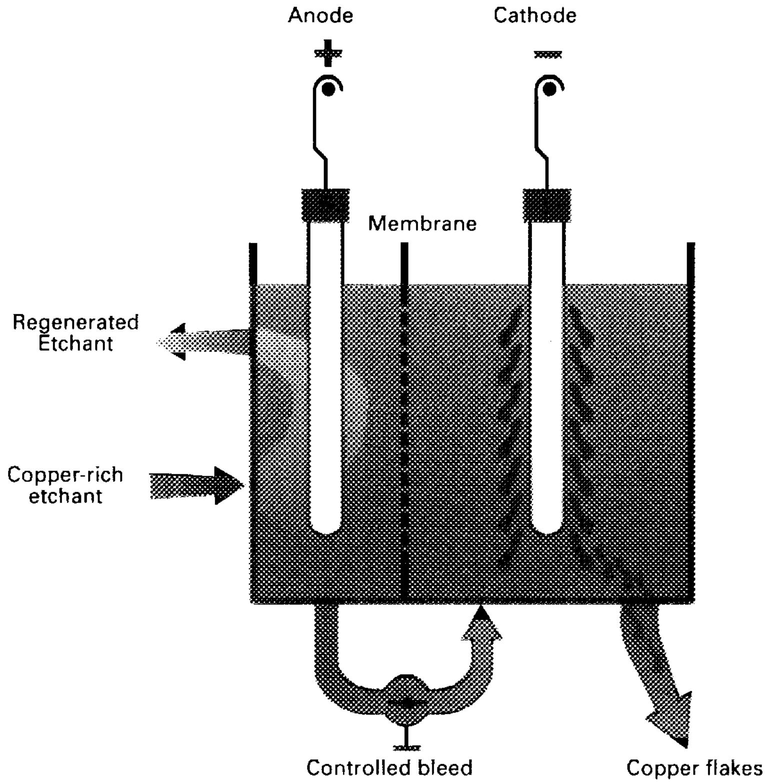
In the manufacture of printed circuit boards, the unwanted copper is etched away by acid solutions of cupric chloride, see Equation 1. As the copper dissolves, the effectiveness of the solution falls and it must be regenerated. The traditional way of doing this is to oxidise the cuprous ion produced with acidified hydrogen peroxide. During the process the volume of solution increases steadily and the copper in the surplus liquor is precipitated as copper oxide and usually landfilled.

Cleaner Production

The original proposal for recovering the copper in high quality form came from the UK Electricity Research Council. Using an electrolytic technique involving a divided cell, simultaneous regeneration of the etching solution and recovery of the unwanted copper is possible. A special membrane allows hydrogen and chloride ions through, but not the copper. The copper is transferred via a bleed valve and recovered at the cathode as pure flakes, see Equation 2.

IN THE ETCHING PROCESS

Equation 1 $\mathrm{Cu} + \underset{\textbf{cupric chloride}}{\overset{\textbf{acid}}{\mathrm{CuCl_2}}} \rightarrow \underset{\textbf{cuprous chloride}}{\mathrm{2CuCl}}$



IN THE ELECTROLYTIC PROCESS

Equation 2 $\mathrm{2CuCl} \rightarrow \underset{\textbf{goes to anode}}{\mathrm{CuCl_2}} + \underset{\textbf{goes to cathode}}{\mathrm{Cu}}$

Enabling Technology

The development of a suitable cell dividing material. The process development where the excess etchant is pumped to the recovery circuit and the copper is obtained in a recoverable form. Control of the process by means of the oxidation-reduction potential.

Advantages

The quality of the circuit boards is improved.

The disposal costs are virtually eliminated.

The etching solution is maintained at its optimum composition.

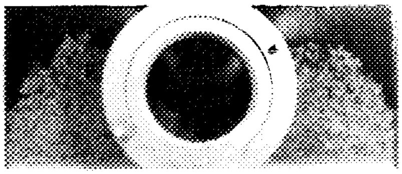
The copper is recovered in high value form.

There are no hazardous chemicals to be handled.

Economic Benefits

Based on 50 tonnes of copper recovered per year

Cost saving	**US$/year**
Copper	50,000
Materials	80,000
Disposal	25,000
Total	**155,000**
Capital Investment	**220,000**
Payback	**18 months**



Country

United States of America

Industry

Printed Circuit Board Manufacture

Companies

Praegitzer Industries Inc, founded in 1981, is a leading designer and manufacturer of advanced circuit boards. The company employs 500 people in three locations.

FSL was founded in 1967 to supply automated etching machines for the large scale production of printed circuit boards. They have a staff of 55 in the UK, have subsidiary companies in Germany and the USA and export through agencies to many countries throughout the world.

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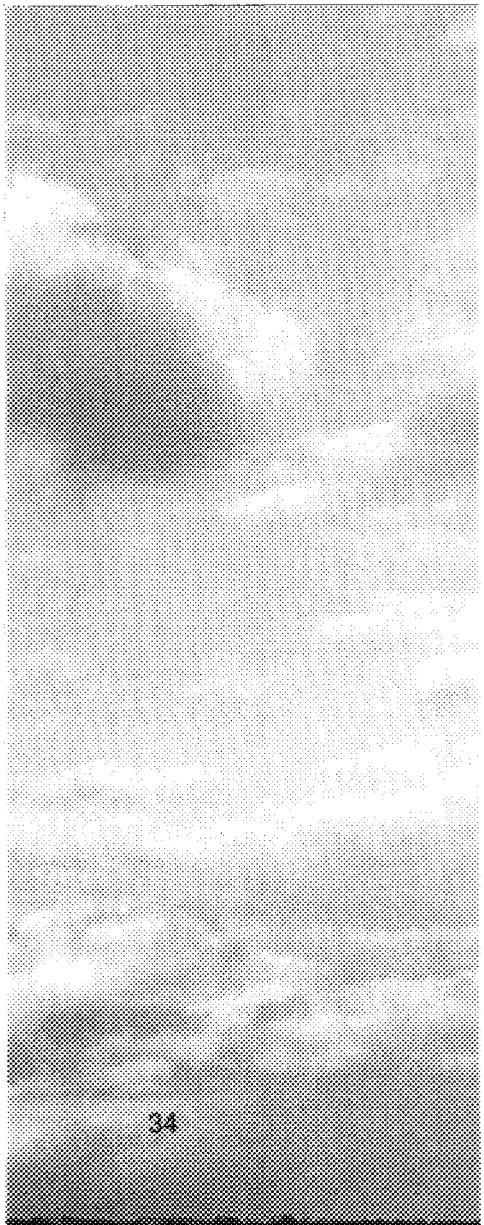
The United Nations Environment Programme

UNEP is dedicated to bridging the gap between awareness and action. Since it was created in 1972 it has worked closely with other members of the UN network and forged new relationships among scientists and decision-makers, engineers and financiers, industrialists and environmental activists on behalf of the environment. It seeks the balance between national interests and the global good, aiming to unite nations to confront common environmental problems. Unique among UN bodies, it exists as a catalyst, spurring others to act and works through and with other organisations, including UN agencies, industrial bodies and governments.

The Industry and Environment Programme Activity Centre

The IE/PAC dates back to 1975. The office was created by UNEP to bring together industry and governments to work in cooperation towards environmentally sound development.

The UNEP-IE/PAC Cleaner Production Programme



This programme was launched in response to a decision from the UNEP Governing Council to reduce global pollution and waste.

The objectives of the programme are to:
- Increase worldwide awareness of the cleaner production concept;
- Help governments and industry develop cleaner production programmes;
- Foster the adoption of cleaner production throughout society;
- Facilitate the transfer of cleaner production technologies.

To meet these objectives, the programme focuses on training and the collection and dissemination of information on cleaner production that:
- Explains the concept;
- Illustrates technical applications;
- Helps people develop cleaner production programmes.

These efforts, initiated through a number of different activities, have cultivated an ever expanding informal network of cleaner production experts, both in industry and government agencies. Further details are available from the IE/PAC Office in Paris.

What to do next?

There is a variety of information and advice available from:

United Nations Environment Programme
Industry and Environment
Programme Activity Centre
Tour Mirabeau
39–43 quai André Citröen
75739 Paris Cedex 15

Tel: +331 40 58 88 50
Fax: +331 40 58 88 74
Telex: 204 997F
Cables: UNITERRA PARIS

TELEPHONE NUMBERS:

Note that all telephone numbers in this booklet have been shown in the internationally agreed format. The plus sign indicates the code for international dialling for the country you are in, these are generally different for each country. The next group of figures are the unique code for the country into which you are dialling If you are telephoning from the same country, the international code is not required, but you may need a national code, often a zero

UNEP

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Industry and Environment
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France

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