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**STUDY OF CLEANER PRODUCTION TECHNIQUES AND TECHNOLOGIES  
COVERING CLUSTERS OF SMALL-SCALE INDUSTRIES  
IN SELECTED AREAS**

NC/IND/92/032

INDIA

**Report**

Prepared for the Government of India  
under UNDP-financed TSS-1 facility

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# The DESIRE project: summary, results and recommendations

The purpose of the DESIRE project was to establish successful case-studies of the application of the waste minimization approach in small-scale industries (SSIs) in India and to create the conditions for continuing and expanding waste minimization activities after the project was over. There were five separate, but closely interrelated, objectives:

1. To show Indian SSIs in three sectors that waste minimization is possible in the short term and that it has financial and environmental advantages. The agro-residue-based pulp and paper industry, the pesticides formulation industry and the textile dyeing and printing industry were selected as the industry sectors.
2. To devise and test the usefulness of a systematic approach to waste minimization. The resulting audit methodology has been published in two forms: A generic guideline for waste minimization and three sector-specific technical manuals.
3. To identify obstacles to the introduction and maintenance of waste minimization options and to formulate strategies for overcoming them. A number of obstacles were identified in the course of the DESIRE project and various approaches were applied to overcome them.
4. To recommend to various stakeholders, in both the Government and the industrial and professional community, policies that would promote waste minimization.
5. To disseminate the results of the case-studies and the policy recommendations.

The case-studies in companies constituted the core of the DESIRE project. To prove the financial and environmental benefits of waste minimization in practice the technical study team joined with committed industries. In turn, those joint task forces were coached by a waste minimization consultant and received technical backup from international experts in

the sectors. Dissemination of the results was from the very outset of the DESIRE project one of the main concerns and activities. To that end, a survey was made of constraints and incentives for waste minimization and one generic and three sector-specific technical manuals were prepared. The results of the project were presented at sectoral workshops and a national seminar.

## Waste minimization

The DESIRE project has developed and applied the following definition:

*Waste minimization is a new and creative way of thinking about products and the processes that make them. It is achieved by the continuous application of strategies to minimize the generation of wastes and emissions.*

Waste minimization comprises several techniques:

- **Good housekeeping:** appropriate actions to prevent leaks and spills (such as preventive maintenance and frequent equipment inspections) and to enforce by means of supervision and training existing working instructions.
- **Input material change:** replacement of hazardous or non-renewable inputs by less toxic or renewable materials or by materials with a longer service lifetime.
- **Better process control:** modification of the working procedures, machine instructions and process record keeping in order to run the processes at higher efficiency and lower rates of waste and emission.
- **Equipment modification:** modification of the existing production equipment and utilities (for instance by including measuring and controlling devices) in order to run the processes at higher efficiency and lower rates of waste and emission.
- **Technology change:** replacement of the technology.

processing sequence and/or synthesis pathway in order to minimize the rates of waste and emission.

- *On-site recovery and reuse:* reuse of the wasted materials in the same process or for another useful application within the company.
- *Production of useful by-products:* transformation of the wasted material into a material that can be reused or recycled for another application outside the company.
- *Product modification:* modification of product characteristics in order to minimize the environmental impacts of the product during or after its use (disposal) or to minimize the environmental impacts of its production.

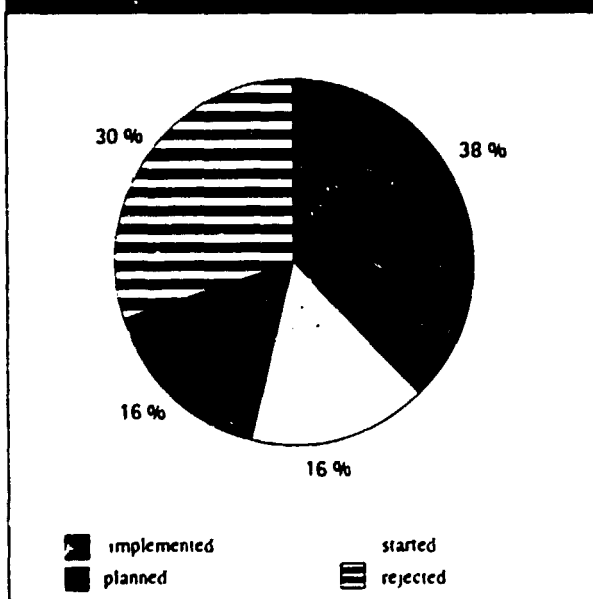
## Results

The results of the DESIRE project have been organized according to the five objectives of the project.

### Objective 1: Demonstrate the opportunities and benefits of waste minimization in practice

The results of the demonstration projects in 12 companies in three industry sectors are summarized and evaluated in

Figure 1. Implementation status of the waste minimization options (all sectors: 540 options)



chapter 4 of this report. Participation in the DESIRE project enabled all of the companies to identify a large number of waste minimization options, most of which could be implemented over the course of the DESIRE project. Figure 1 shows the implementation status of the 540 waste minimization options. Thirty-eight per cent of the options could be fully implemented within 15 months of the start of the plant-level activities. Another 32 per cent of the options are feasible: their implementation either has already started (16 per cent) or is planned for the near future (16 per cent). Only 30 per cent of the options generated proved not to be feasible and were rejected by the companies. For these options, the technology was either not yet available or not yet available at an appropriate scale for small-scale industries or far too expensive in relation to the potential cost savings and/or total investments in plant equipment.

Table 1 summarizes the financial impact of the first batch of feasible options, that is, of the 196 options implemented within the time-frame of the DESIRE project. The investments and the net annual savings are by far the greatest in the agro-residue-based pulp and paper industry. The overall payback time of those 196 options was less than six months; the economic feasibility of waste minimization in the textile dyeing and printing industry was significantly greater than in the other two sectors; and in the pesticides formulation industry it was significantly less. However, care is needed in the interpretation of these figures, since they include only the options explicitly evaluated by the technical study team, not the additional, highly cost-effective waste minimization options that some companies identified and implemented on their own (these were presented by the participating companies at the sector specific workshops).

The implementation of these waste minimization options has contributed significantly to an improvement in areas such as discharge of wastewater, emissions to the air, and generation of solid waste, as well as in the conservation of materials, energy and water and the reduced use of toxic materials. Since most of the options contribute to environmental improvement in several areas, it is not feasible to describe the total environmental impact with one set of environmental indicators.

With respect to the first objective of the DESIRE project, the following can be concluded:

- There are many opportunities for waste minimization in the SSIs of India. These can be detected by making a thorough integrated analysis

**Table 1: Financial impact of the options implemented in the course of the DESIRE project**

Financial Indicator	Pulp and paper industry	Pesticides formulation industry	Textile dyeing and printing industry	Total
Number of options implemented	72	73	51	196
Investments (\$1.000)	347	23.55	50.65	421.2
Net annual savings (\$1.000)	672**	20.85	244.5	937.35
Overall pay back period (months)	6	< 14	< 3	< 6

\*figures exclude Three Star Paper Mill

\*\*figures exclude financial benefits from reduction of waste water treatment cost

of the company, including – but not limited to – its production processes, input materials, waste streams and emissions.

- Many waste minimization opportunities can be implemented by small-scale industries in the short term (within 1 to 3 years).
- Waste minimization goes beyond technical modifications; it can also be achieved by improving operating practices and changing input materials and recycling practices.
- The implementation of waste minimization will benefit the company. These benefits will take the form of monetary savings as well as less tangible benefits such as better working conditions, better product quality and better environmental conditions around the facility.

### Objective 2: Develop and test an audit methodology

The development and application of a systematic waste minimization audit methodology is described and evaluated in chapter 3 of this report. The DESIRE project proved the need for a methodology tailored to the needs and capabilities of small-scale industries. To this end, international waste minimization methodologies were merged with the practical experiences of the companies participating in the DESIRE project. The hybrid methodology has in turn been elaborated in two forms: generic waste minimization guidelines aimed at catching the interest of industrialists and getting their commitment to waste minimization and sectoral waste minimization manuals

aimed at helping technical staff in SSIs to identify, evaluate and implement practical waste minimization options.

The DESIRE audit methodology divides the waste minimization audit into stages:

- *Getting started:* planning and organizing the waste minimization audit, including the establishment of a project team and the selection of the audit focus.
- *Analysing process steps:* evaluation of relevant unit operations in order to quantify the waste being generated, its costs and its causes.
- *Identification:* development and preliminary selection of waste minimization opportunities.
- *Choosing solutions:* evaluation of the technical and financial feasibility and the environmental desirability of the waste minimization options in order to select the most promising ones.
- *Implementation:* putting the chosen solutions to work and monitoring of the results achieved by them.
- *Sustaining waste minimization:* perpetuating the continuous search for waste minimization opportunities.

Each of the stages has been elaborated into a series of tasks. The technical manuals contain more details on how to conduct each task in the particular industry sector and suggest typical waste minimization options.



With respect to the second objective of the DESIRE project, the following can be concluded:

- Using the DESIRE audit methodology and outside assistance from the technical study team, every SSI should be able to develop, and partially implement, an appropriate set of waste minimization options.
- Experience shows that some impediments are to be expected if SSIs are left to implement the audit methodology on their own. Given the lack of organizational and management skill, it would be better to offer them continuing guidance from outside experts. If any audit methodology is in use, the outside experts might be able to limit themselves to supervising the tasks specified in the methodology.

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### Objective 3: Identify constraints and enabling measures for waste minimization

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The results of the inventory and evaluation of constraints, catalysts and enabling measures are summarized in chapter 2 of this report. They formed the basis for mid-course action, which allowed the successful completion of the case-studies in the participating companies.

The constraints that can arise when introducing waste minimization in SSIs were analysed to identify catalysts and enabling measures to deal with them. It was useful to divide these constraints as follows:

- *Attitudinal*: the attitudes, skills and perceptions of the entrepreneur and other key persons in the company.
- *Systemic*: the immaturity of the information and management systems in the company.
- *Organizational*: the division and allocation of tasks and responsibilities among persons and departments in the company.
- *Technical*: outmoded plant equipment.
- *Economic*: the costs of materials, energy, technology, labour and utilities and the financial and fiscal incentives for waste minimization.
- *Governmental*: the incentives and disincentives for

waste minimization created by industrial and environmental policies.

- *Others*: basically the factors beyond control, such as seasonal variations.

In its own way, each type of constraint can delay or even block the waste minimization process.

There appears to be a set sequence in which the five types of constraints normally appear when waste minimization is being introduced. The first constraints facing both companies and external agencies are attitudinal. These become evident in various misunderstandings over opportunities for waste minimization and the financial and environmental benefits. This means that a great deal of attention must be devoted to these attitudinal constraints. Once they have been broken down and management has decided to start a waste minimization assessment, it is systemic constraints that are encountered (especially the lack of information for conducting the assessment) and organizational constraints (especially in respect to the establishment of a properly functioning waste minimization team in the company). Later, when waste minimization opportunities have to be generated and evaluated, there might be technical constraints. In the last stage – the actual implementation of waste minimization solutions – the main constraints might be economic.

The following can be concluded with respect to the third objective of the DESIRE project:

- Since each type of constraint can thwart the waste minimization process, it is essential to set up waste minimization policies to tackle the broadest possible spectrum of potential constraints and to develop the broadest possible set of enabling measures.
- Experience shows that intensive on-site guidance and supervision by outside trainers-cum-consultants can eliminate a remarkable number of these potential constraints.

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### Objective 4: Formulate recommendations for waste minimization policies

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The policy lessons from the DESIRE project are elaborated in chapter 5 of this report. The dissemination and promotion strategy should suit the

local industrial structure. To this end, the enabling measures identified by the DESIRE project have been classified as being either internal or external to firms (see table 2). Generally speaking, government agencies should be able to create the external enabling measures. The internal enabling measures, while they cannot be created directly by government activity, might in the long run be helped by training and social policies.

A number of implementation mechanisms have been developed in discussions with governmental and industrial representatives:

- *Waste minimization circles*: area-wide voluntary cooperation among industries with a view to exchanging waste minimization solutions to common environmental problems.
- *Obligatory waste minimization audits*: mandatory submission of a waste minimization audit in procedures for obtaining financial benefits, like sales tax exemption, soft loan for investments etc.
- *Waste minimization demonstration projects*: external assistance to selected industries in a sector

or region to demonstrate the waste minimization potential. Dissemination of the results and training of waste minimization experts are crucial to ensure that waste minimization will be carried out by companies other than those participating in the demonstration project.

Expected outcomes as well as necessary conditions for the fruitful development of these implementation mechanisms are elaborated in table 3.

With respect to the fourth objective of the DESIRE project, policies that foster waste minimization might start by setting up waste minimization circles, introducing obligatory waste minimization audits and carrying out demonstration projects.

#### Objective 5: Disseminate the results of the DESIRE project

Three industry-specific workshops and a national seminar were organized to begin disseminating the results and experiences of the DESIRE project. The present report along with the DESIRE audit manual and the associated video, should serve to substantiate

**Table 2: Classification of enabling measures identified in the DESIRE project**

Type	Internal to the enterprise	External to the enterprise
1. Attitudinal	<ul style="list-style-type: none"> <li>• Encourage experimentation.</li> <li>• Publicize early successes.</li> <li>• Develop simple management indicators.</li> </ul>	
2. Systemic	<ul style="list-style-type: none"> <li>• Hold training session for plant-level waste minimization team.</li> <li>• Carry out top down housekeeping drive.</li> </ul>	<ul style="list-style-type: none"> <li>• Disseminate success stories.</li> </ul>
3. Organizational	<ul style="list-style-type: none"> <li>• Organize capable waste minimization team.</li> <li>• Recognize waste minimization efforts.</li> <li>• Assign costs to production and waste generation.</li> </ul>	
4. Technical		<ul style="list-style-type: none"> <li>• Disseminate waste minimization techniques and technologies.</li> <li>• Provide need-based support for environment-driven R&amp;D.</li> </ul>
5. Economic	<ul style="list-style-type: none"> <li>• Allocate costs properly and plan investments.</li> </ul>	<ul style="list-style-type: none"> <li>• Formulate long-term industrial policies</li> <li>• Offer financial incentives.</li> </ul>
6. Governmental		<ul style="list-style-type: none"> <li>• Form area-wide, voluntary waste minimization groups.</li> <li>• Enforce environmental legislation.</li> </ul>

and sustain those initial dissemination efforts.

## Recommendations

To multiply the impact of the DESIRE project, two things should be done:

1. Disseminate the results and experiences from it;
2. Develop policies that foster waste minimization.

Each of these calls for a series of interrelated initiatives.

### Recommendation 1: Disseminate the results of the DESIRE project

The preliminary results of efforts to disseminate project achievements in the first series of workshops show that industrial experience is most powerful force for convincing companies, industrial organizations, governmental organizations and other stakeholders of the opportunities and benefits of waste minimization. Industrial experience should therefore be at the core of dissemination activities.

A properly planned dissemination strategy is needed to maximize the effect of the DESIRE project. The

Table 3: Key features of the waste minimization implementation mechanisms

Implementation mechanism	Expected outcome	Conditions	Remarks
1. Waste minimization circles	<ul style="list-style-type: none"> <li>• Increasing number of companies in region and sector starts with waste minimization.</li> <li>• Dissemination and implementation of comparatively obvious, low- and no-cost options via social mechanisms.</li> <li>• Cooperation between companies for environment-driven technology development.</li> </ul>	<ul style="list-style-type: none"> <li>• Environmentally conscious industrialists will have to take the lead.</li> <li>• Appropriate technical and methodological back up.</li> <li>• Establishment of a national network for information exchange.</li> <li>• Funds for support to, and activities of, waste minimization circles</li> <li>• Strong drive for the implementation of both low and high cost waste minimization options.</li> </ul>	<ul style="list-style-type: none"> <li>• Common effluent treatment plant (CETP) boards are probably not the best organizations to start waste minimization circles, given the non-voluntary nature of the CETPs.</li> <li>• It is suggested to link the waste minimization circle to a local demonstration project.</li> </ul>
2. Obligatory waste minimization audits	<ul style="list-style-type: none"> <li>• Strong drive for the implementation of both low- and high-cost waste minimization options.</li> <li>• Preferential allocation of finances for waste minimization as compared to end-of-pipe control and treatment.</li> </ul>	<ul style="list-style-type: none"> <li>• Establishment of provisions for independent quality evaluation for the approval of the waste minimization audits submitted by industry.</li> <li>• Agreement with industrial authorities on financial schemes to be used to this end.</li> </ul>	<ul style="list-style-type: none"> <li>• Impact depends heavily on the selection of the financial schemes that will be subjected to obligatory audits.</li> <li>• Only effective for the organized sector companies.</li> </ul>
3. Waste minimization demonstration projects	<ul style="list-style-type: none"> <li>• Convincing company-level examples of the implementation of waste minimization.</li> <li>• Inventory of practical waste minimization opportunities for dissemination to other companies.</li> <li>• Training of experts and institutional capacity building for waste minimization.</li> </ul>	<ul style="list-style-type: none"> <li>• Willingness of companies to act as demonstration units.</li> <li>• Interest of industry associations, professional organizations and technical research institutes to become involved in the dissemination of results.</li> <li>• Funds for providing subsidized waste minimization consultancy to the demonstration companies.</li> </ul>	<ul style="list-style-type: none"> <li>• Demonstration projects can be used to catalyse the establishment of a waste minimization circle.</li> <li>• Opportunities for participation of local environmental authorities in the demonstration projects should be explored.</li> </ul>

following guidelines can be given for the development of such a strategy:

- **Use proven options and indicators to get started**  
The results achieved in the case-studies exemplify the benefits of waste minimization. However, the options implemented in those cases were the best practical solutions to those particular waste generation problems, they are not necessarily the best solutions for all companies in the sector. Indicators should be developed for the range of savings and environmental benefits that can be achieved per unit of production. Sector-specific manuals already contain such indicators, but they may need to be supplemented by outreach materials (flyers, advertisements etc.).
- **Use the audit methodology to persuade companies to participate**  
The achievements of some companies in a sector can be presented as evidence that a waste minimization audit will bring benefits to any company willing to invest in its implementation.
- **Foster cooperation for environment-driven technology development**  
It should not be expected that all causes of waste generation can be eliminated by existing equipment and technology. Cooperation between companies facing the same waste generation problems might motivate technical institutes and equipment suppliers to develop technical solutions for a particular sector. This approach, referred to above as a waste minimization circle is a promising one.

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## **Recommendation 2: Develop policies that foster waste minimization**

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Given their perceived effectiveness, waste minimization circles, obligatory waste minimization audits and waste minimization demonstration projects, efforts should be made to implement and to assure that industries will make use of them.

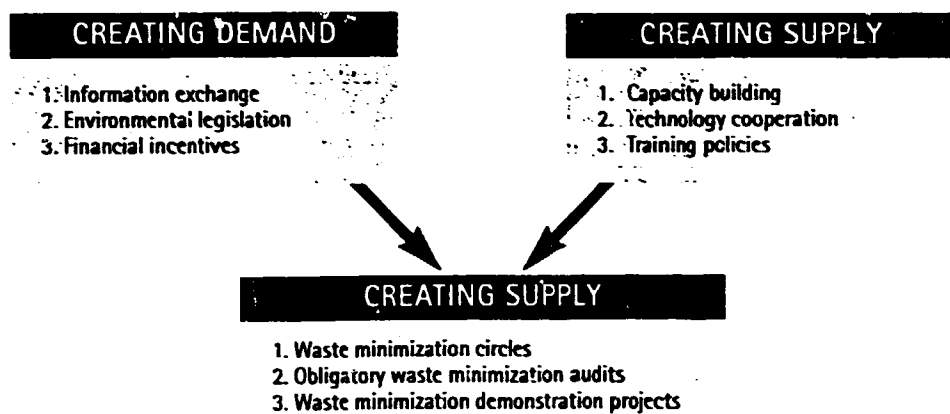
Initiatives will be needed in three areas:

- **Generation of demand for waste minimization services by**
  - Information exchange and awareness raising
  - Enforcement and improvement of environmental regulations
  - Development of financial incentives.
- **Creation of a supply of waste minimization services,**
  - Capacity building
  - Establishment of the technology cooperation chain
  - Training policies.
- **Development and formalization of implementation mechanisms, including procedures, criteria and the allocation of funds.**

The interrelatedness of these initiatives is illustrated in figure 2.

The involvement and cooperation of industrial, governmental, environmental and professional stakeholders is crucial for the success of waste minimization. The Indian National Cleaner Production Centre could take the lead in establishing an institutional network for this purpose.

Figure 2: Recommended strategy for promotion and dissemination of waste minimization



# DESIRE project

## 1.1 Background

The incorrect notion that environmental protection makes the production of goods and services more costly and therefore a luxury developing countries cannot afford is deeply rooted in industrial as well as environmental management agencies and industries in developing countries (and only to a lesser extent in developed countries). This argument is no longer valid, and the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992, established new goals for the world community which involve environmentally benign forms of development. Cleaner production can contribute to the sustainable forms of economic development endorsed in Agenda 21 (see chapters 20, 30 and 34). Cleaner production can minimize the need to make trade-offs between economic growth and environment, between worker safety and productivity, and between consumer safety and competition in international markets. Optimizing several goals at the same time in this way leads to 'win-win' situations in which everyone gains. Cleaner production is such a 'win-win' strategy; it protects the environment, the consumer and the worker while improving industrial efficiency, profitability and competitiveness. Cleaner production is especially attractive to developing countries because it provides industries for the first time an opportunity to 'leap frog' over older, more established industries. Thus countries that start to adopt cleaner production might be able to take full advantage of a rare window of opportunity which for once favours developments in poorer countries over those in the industrialized countries (UNEP, 1994).

The above proposition attracted the interest of the Indian Government, especially the Ministry of Environment and Forests (MOEF). They thought that practical demonstration of cleaner production techniques and technologies would be the first step to institutionalize and propagate the cleaner production concept. Accordingly, they requested UNIDO to conduct a study of cleaner production techniques and technologies covering clusters of small-scale industries (SSIs). The initiation of the exercise especially emerged from the

long-standing experience of UNIDO on industrial development. Upgrading or rehabilitating industrial plants at times led to environmentally benign production but this was not explicitly sought. The project was therefore launched with an explicit objective of demonstrating ways and means to make existing industrial units less waste intensive (Luken, 1994).

There appeared to be considerable scope to demonstrate the financial and environmental benefits of cleaner production to SSIs in India. There are between 2.0 and 2.2 million SSIs in India. They account for approximately half of the industrial output of India and an even larger share of industrial pollution, in the range of 60 to 65 per cent, given their poor utilization of raw materials. Although pollution from SSIs individually may not create significant environmental damage, their collective discharge in industrial estates poses a severe threat to human health and the environment.

The project was built upon the experiences from successful cleaner production projects in North America and western Europe. Most notable was the PRISMA project in the Netherlands, that worked with 10 firms over a 1.5 year period. It identified 164 prevention options, of which 45 were implemented during the life of the project (Dieleman, 1991). A majority of these preventive solutions were cost-effective and had payback periods of less than three years. The mode of implementation consisted of a small group of firms that learned the techniques of waste minimization auditing (a systematic approach to waste and emission reduction) and applied them to their own establishments with the assistance of outside advisers. Similar projects have been implemented in other European countries, such as Austria, Denmark, Finland, Italy, Norway, Portugal and the United Kingdom of Great Britain and Northern Ireland, amongst others, under the umbrella of the PREPARE network (EU, 1994).

The National Productivity Council (NPC) was entrusted with the main technical responsibility of conducting the project because of its earlier pollution prevention experience in companies like M/s Nirulas (ice cream

factory), Palam Potteries and JR Fabrics (textile Dyeing) (NPC, 1994). The Confederation of Indian Industries (CII) was also drawn in because of its close relationship with industry and the experience of its Head of Environment Division in the field of pollution prevention. The project was given the name DESIRE (DEMonstrations in Small Industries for Reducing waste). Within the framework of the DESIRE project, 12 demonstrations were carried out at companies in three industrial sectors. In addition, a barriers and incentives study was conducted by Corporate Insight.

## 1.2 Waste minimization

Over the past few decades, industries have responded to environmental degradation in four typical ways: ignoring the problem, diluting the pollution, controlling or treating the pollution and preventing pollution and waste generation at the source of production. The last activity has become the ultimate goal of cleaner production or waste minimization. It combines maximum positive effects on the environment with substantial financial gains for industry and society. As such, cleaner production can be defined as "the continuous use of industrial processes and products to prevent the pollution of air, water and land, to reduce waste at the source and to minimize risks to human population and the environment" (UNEP, 1994). Essential features are:

- *Cleaner production is a problem-solving strategy rather than a solution*; cleaner production puts the waste generating process (the root problem) in first place and employs a preventive mind-set to develop alternative solutions (options). A variety of technical, operational, educational and managerial practices can be used to this end, but not exclusively to this end, which illustrates that cleaner production cannot be considered as a fixed set of solutions and technologies.

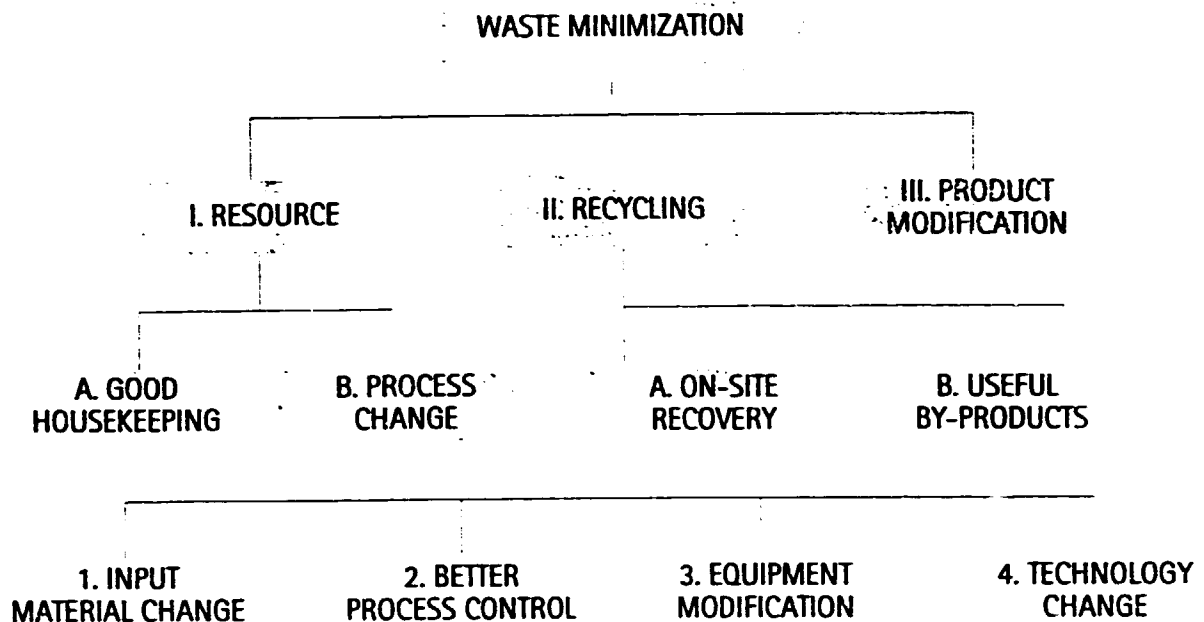
- *Cleaner production is 'built in' instead of 'added on' industrial activity*; cleaner production requires integration of environmental concerns into the design and operation of industrial activity, being either the delivery of products or the application of processes. For products and services, it aims at reduction of the environmental impacts along the entire life cycle of the product, from raw material extraction through materials processing, product manufacturing, trade and consumption, to disposal of the discarded product. For processes, cleaner production aims at conserving raw materials and energy, eliminating the use of toxic materials and reducing the quantity and toxicity of all emissions before they leave a process.

With a view to facilitating the acceptance of the cleaner production concept and methodologies by Indian entrepreneurs, the term waste minimization (WM) was adopted rather than cleaner production. The interpretation given to waste minimization is however essentially equal to the one given to cleaner production above. Within the DESIRE project, the following definition has been developed and applied (NPC, 1994):

*Waste minimization is a new and creative way of thinking about products and the processes that make them. It is achieved by the continuous application of strategies to minimize the generation of wastes and emissions.*

Waste minimization is best practised by reducing the generation of waste at the source itself. After exhausting the source reduction opportunities, in the second step, attempts should be made to recycle the waste within the unit. Finally, one might also think of modifying or reformulating the product itself so as to be able to manufacture it with minimal waste generation. The types of techniques which are available in these areas are given in figure 1.1.

Figure 1.1: Overview of waste minimization techniques



Waste minimization thus includes the following eight techniques (or approaches):

1. *Good housekeeping*: appropriate provisions to prevent leaks and spills (such as preventive maintenance schedules and frequent equipment inspections) and to enforce the existing working instructions (through proper supervision, training etc.).
2. *Input material change*: substitution of input materials by less toxic or renewable materials or by adjunct materials with a longer service lifetime.
3. *Better process control*: modification of the working procedures, machine instructions and process record keeping in order to run the processes at higher efficiency and lower waste and emission generation rates.
4. *Equipment modification*: modification of the existing productive equipment and utilities – for instance by the addition of measuring and controlling devices – in order to run the processes at higher efficiency and lower waste and emission generation rates.
5. *Technology change*: replacement of the technology, processing sequence and/or synthesis pathway in order to minimize waste and emission generation during production.
6. *On-site recovery and reuse*: reuse of the wasted materials in the same process or for another useful application within the company.
7. *Production of useful by-product*: modification of the waste generation process in order to transform the wasted material into a material that can be reused or recycled for another application outside the company.
8. *Product modification*: modification of the product characteristics in order to minimize the environmental impacts of the product during or after its use (disposal) or to minimize the environmental impacts of its production.

Table 1.1 Contains illustrative examples for each waste minimization technique.



Table 1.1: Examples of the waste minimization techniques (NPC, 1994)

Waste minimization technique	Examples
1. Good housekeeping	<ul style="list-style-type: none"> <li>• Repair all leaks.</li> <li>• Keep taps closed when not in use.</li> <li>• Avoid spillage.</li> </ul>
2. Input material change	<ul style="list-style-type: none"> <li>• Change from citric acid to citric W in textile dyeing.</li> <li>• Use alkaline water based degreasers instead of organic solvent for metal parts cleaning.</li> </ul>
3. Better process control	<ul style="list-style-type: none"> <li>• Adoption of better firing practices in down draught kilns.</li> <li>• Maintain process parameters (temperature, pressure etc.) as close as possible to the desired level with basic minimum instruments.</li> </ul>
4. Equipment modification	<ul style="list-style-type: none"> <li>• Install drip hangers to recover drag out from plating operations.</li> <li>• Use of storage tanks of appropriate capacity to avoid overflows.</li> </ul>
5. Technology change	<ul style="list-style-type: none"> <li>• Apply static rinse instead of continuous rinse in electroplating.</li> <li>• Use low dye-liquor jet dyers instead of kier dyers.</li> <li>• Apply electrostatic spraying techniques to minimize paint over-spray.</li> </ul>
6. On-site reuse	<ul style="list-style-type: none"> <li>• Reuse rinse solvents from formulation equipment in the make up of the next batch of the same product.</li> </ul>
7. Useful by-products	<ul style="list-style-type: none"> <li>• Reuse used moulding sand for the preparation of new moulds.</li> <li>• Recover short fibre in pulp-making to make paper boards.</li> <li>• Convert rice husk ash into white ash for teeth filling.</li> </ul>
8. Product reformulation or modification	<ul style="list-style-type: none"> <li>• Eliminate excessive product packaging.</li> <li>• Manufacture of liquid dyes instead of powder dyes for textile industries.</li> </ul>

### 1.3 Objectives

The DESIRE project has been designed to demonstrate to the Ministry of Environment and Forest, State and Central Pollution Control Boards, selected industrial sectors and research and professional organizations, the financial and environmental benefits of the waste minimization approach to industrial environmental management. The study was designed to test a proactive approach to waste minimization that could be adopted by industrial organizations and facilitate the implementation of industrial and environmental policies in India.

In order to persuade the above-mentioned parties of the advantages of waste minimization and to enable them to become active players in the dissemination of waste minimization upon completion of project, it had five separate, but closely related objectives:

1. To show Indian SSIs in three sectors that waste minimization is possible in the short term and that it has *financial and environmental advantages*;
2. To devise and test the usefulness of a *systematic approach* (audit methodology) to waste minimization;
3. To identify *obstacles* to the introduction and sustainability of waste minimization and to formulate strategies for overcoming them;

4. To formulate *policy recommendations* for the promotion of waste minimization for various stakeholders, both within the Government and within the industrial and professional community;
5. To *disseminate the results* of the case-studies and proposed policy recommendations by a written report and by seminars and workshops.

The DESIRE project has been focused in three ways:

- It is primarily targeted to *small-scale industries* as they have been identified as having one of the largest waste generation ratios per unit of productive output (Nyati, 1992). The large number of SSIs (estimated over 2.0 million) is therefore responsible for a greater share of industrial pollution than large scale industries;
- It focuses on *sectors* of small-scale industries to facilitate replication of the measures identified in the demonstration units;
- The targeted area is limited to a small *geographical region* to enable faster dissemination and absorption of information.

The sector selection was done by MOEF based on general criteria of seriousness of pollution problems.

expected potential for waste minimization and potential for dissemination. Agro-residue-based pulp and paper production, textile dyeing and printing and pesticides formulation have been selected as the target industries because they cause significant environmental problems and are predominantly made up of SSIs. The study team would have preferred to add willingness to participate in the DESIRE project as well as general commitment to implement waste minimization to the above mentioned selection criteria, which in turn might have excluded the pesticides formulation industry, given its inability to innovate without support and assistance from large-scale multinational pesticides production companies.

Agro-residue-based pulp and paper mills are located throughout India, with concentration areas in the agricultural states, especially around the Ganges River. Therefore, Delhi and Uttar Pradesh have been selected as the geographical location for the DESIRE project in the agro-residue-based pulp and paper sector. Both the textile dyeing and printing sector and pesticides formulation sector are concentrated in the state of Gujarat. It was therefore initially decided to select demonstration companies from Ahmedabad for these two sectors. However, given the interest of a number of textile dyeing and printing houses in Surat (a second industrial city in Gujarat state), the DESIRE project finally included textile dyeing and printing units from both Surat and Ahmedabad.

This final report completes the fifth aim of the DESIRE project. In the following chapters, the results and experiences have been organized according to the above mentioned aims. Chapter 2 ("Constraints, catalysts and enabling measures"), summarizes the results with regard to the second aim (identification of the obstacles for waste minimization). Chapter 3 ("Company audit methodology") explains how the systematic working method has been developed and tested in DESIRE (objective 3) and how it can be used with a view to the dissemination of the results (objective 5). Chapter 4 ("Financial and environmental dividends in companies") summarizes the financial and

environmental advantages that could be achieved in the participating companies (objective 1). Next is the discussion of the policy recommendations (objective 4) in chapter 5 ("Towards an action plan").

#### 1.4 Workplan

The practical demonstrations in selected plants constitute the core of the DESIRE project. In each industrial sector four to six plants have been motivated to act as demonstration units in which consultants of the National Productivity Council (NPC) conducted a waste minimization assessment. International methodology and industrial subsector experts have provided guidance to these assessment activities during two visits to the plants and from a distance. The assessment activities have also been monitored by Human Resource Development experts from Corporate Insight in order to identify the key barriers and incentives for waste minimization. For the dissemination of the results, two different approaches have been chosen. First the results are disseminated at the level of the industry sector, targeted to SSIs in the respective sector, in close cooperation with the respective industry associations. This took place via specific workshops in the immediate vicinity of the demonstration plants and the preparation of sectoral waste minimization manuals. Next, dissemination took place at the general level, targeted at industrial and environmental stakeholders, in close cooperation with the Confederation of Indian Industries. A national workshop on waste minimization took place as well as the preparation of a general waste minimization guide. The dissemination approach chosen in the DESIRE project is depicted in figure 1.2.

The activities undertaken in the DESIRE project and their planning have been summarized in table 1.2. Details of the company assessment will be covered in chapter 3; details of the barriers and incentives review will be covered in chapter 2. At the project level, the organization of the sectoral introduction and review workshops as well as the expert reviews have been crucial conditions for the successful implementation of the DESIRE project.

Figure 1.2: Dissemination approaches in the DESIRE project (Van Berkel et al, 1994)

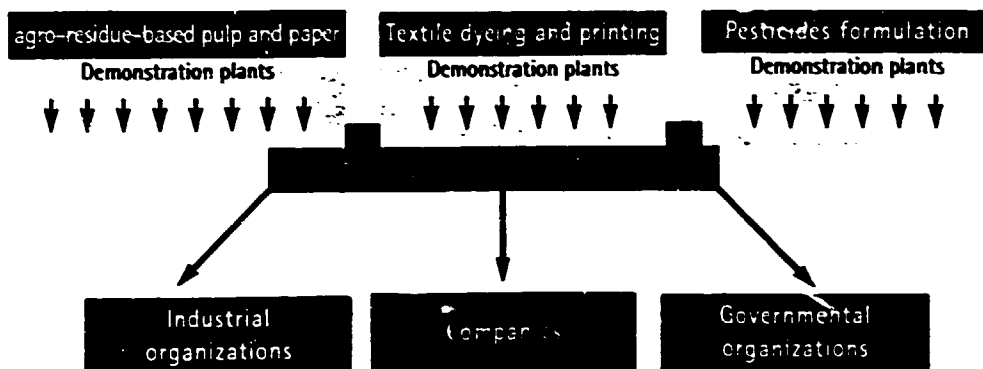


Table 1.2: Workplan of the DESIRE project

Project Phase	Time	Activities
1. Preparation	P and P: 1-3/93 PF: 3-6/93 TD and P: 3-6/93	<ul style="list-style-type: none"> <li>Adaptation of international manuals to Indian SSIs.</li> <li>Establishing working relations with industry associations and professional institutes.</li> <li>Preliminary data collection and evaluation at one company per sector.</li> <li>Obtaining interest from companies to participate.</li> </ul>
2. Sectoral introduction workshop	P and P: 3/93 PF: 7/93 TD and P: 7/93	<ul style="list-style-type: none"> <li>Introduction to waste minimization concept, working method and obvious options per sector.</li> <li>Company visits by international technical and methodology experts to boost commitment and involvement and to provide initial on-site guidance.</li> </ul>
3. Company pre-assessment work	P and P: 4-8/93 PF: 8-11/93 TD and P: 8-11/93	<ul style="list-style-type: none"> <li>Two or three visits by NPC team to organize waste minimization team, to collect baseline data and to generate first batch of waste minimization options.</li> <li>Data analysis and evaluation by NPC team to compile material and energy balances and evaluate feasibility of first batch of options.</li> </ul>
4. Sectoral mid-term review workshop	P and P: 9/93 PF: 12/93 TD and P: 12/93	<ul style="list-style-type: none"> <li>Review of preliminary waste minimization experiences by international industry sub-sector and methodology experts.</li> <li>Expert visits to generate additional waste minimization options and to contribute to option evaluation and implementation.</li> <li>Preparation of draft waste minimization guide.</li> </ul>
5. Company assessment work	P and P: 9/93-4/94 PF: 12/93-4/94 TD and P: 4/94	<ul style="list-style-type: none"> <li>Two to four visits by NPC team to generate and evaluate additional waste minimization options and to evaluate progress in implementation of these options.</li> <li>Completion of the generic waste minimization guide.</li> <li>Completion of the barriers and incentives survey.</li> </ul>
6. Implementation period	5-11/94	<ul style="list-style-type: none"> <li>Final evaluation of the company achievements by NPC team.</li> <li>Preparation of draft sectoral technical waste minimization manuals.</li> <li>Ongoing implementation activities in the companies.</li> </ul>
7. Dissemination workshops	12/94	<ul style="list-style-type: none"> <li>Sectoral workshops.</li> <li>National seminar.</li> <li>Preparation of policy recommendations.</li> </ul>
8. Reporting	4-10/95	<ul style="list-style-type: none"> <li>Preparation of final report.</li> <li>Completion of the sectoral technical waste minimization manuals.</li> <li>Preparation of video.</li> </ul>

Notes: P and P Pulp and paper industry  
 PF Pesticides formulation industry  
 TD and P Textile dyeing and printing industry  
 3/93 March 1993 etc

The general programme of the sectoral introduction workshops consisted of:

- Introduction to objectives, workplan and expected outcomes of the DESIRE project (by UNIDO);
- Introduction to waste minimization concept and working methods (by international waste minimization expert);
- Summary of environmental profile of the industry sector (by industry association);
- Summary of obvious waste minimization opportunities for the sector (by UNIDO);
- Summary of the preliminary findings at one of the companies (by NPC);
- Establishing working relations with interested companies.

This programme required two working days and was attended by 5 to 10 companies. The workshops facilitated team building among the participating companies as well as with the study team. The working relations with the interested companies have been formalized with a memorandum of understanding between the companies and NPC. This formalized – on one hand – the commitment of the company to supply the necessary company data to the study team, to implement the feasible waste minimization options and to share the results and experiences of the DESIRE project with other companies and – on the other hand – the obligation for NPC to treat the company data as confidential. In addition, it was agreed that the participating companies would pay a token fee (Rs10,000 (S330)) to participate in the project.

The first visit by the international experts to the companies (after the sectoral introduction workshop) was aimed at creating additional support for the execution of the waste minimization assessment at each company. In order to do so, the waste minimization concept as well as the general requirements for a successful company level assessment (management commitment, workers' involvement and an organized approach) were presented to the factory management and staff. Additionally, a plant tour was made in order to identify obvious areas for waste minimization, such as lapses in housekeeping, maintenance and process control practices. The experts' impressions of the site were reported as guidance to the factory management and the technical study team.

The programme of the sectoral mid-term review workshops included:

- Presentation of the company-level achievements (by company representatives);
- Summary of sector-level achievements (by NPC);
- General comments on organization of waste minimization activity in companies (by HRD expert);
- General comments on technical content of company achievements (by UNIDO);
- General comments on methodological aspects of company assessments (by international waste minimization expert).

The sectoral mid-term review workshops were informal in character, with ample opportunity for discussion and exchange of ideas among the participating companies as well as between the participating companies and the national and international experts.

The second company visit by the international experts took place immediately after the sectoral mid-term review workshops. The objective was to generate additional technical as well as managerial waste minimization options and assist in their implementation. During these visits, the review remarks to the mid-term reports were discussed as were the general technical and managerial problems that had been encountered.

## 1.5 Project organization

A project of such magnitude and complexity can only be successfully conducted with an active involvement of various institutions and stakeholders. The following organizations were actively involved in conducting the DESIRE project:

- Governmental organizations: Ministry of Environment and Forest (MOEF);
- Professional institutes: National Productivity Council (NPC, Delhi), Corporate Insight (CI, Delhi) and Indian Institute of Technology (IIT, Bombay);
- Technical institutes: Central Pulp & Paper Research Institute (CPPRI, Sahanpur), Ahmedabad Textile Industries Research Association (ATIRA, Ahmedabad) and Institute of Pesticides Formulation Technology (IPFT, Delhi);

- Industry associations; Confederation of Indian Industries (CII, Delhi), Association of Small Scale Pulp and Paper Industry (ASSPPI, Delhi), South Gujarat Pesticides Formulators Association (SGPFA, Ahmedabad), Waste Minimization Group (WMG, Surat) and Gujarat Textile Processors Association (GTPA, Ahmedabad).

UNIDO took care of overall project management and provided either in-house or international experts in four areas: a general waste minimization expert (to examine assessment methodologies, management of demonstration projects and design of national programmes); a pulp and paper expert (to examine technical aspects of waste minimization in the pulp and paper industry); a textile expert (to examine technical aspects of waste minimization in the textile dyeing and printing industry) and a pesticides expert (to examine technical aspects of waste minimization in pesticides formulation). Over the course of the project, the functions of textile and pesticides experts were fulfilled by two different persons, while the general and paper experts were involved from beginning to end.

The planning, organization and implementation of the project were realised in joint consultation between UNIDO and MOEF. The Project Management Board consisted of the UNIDO senior environmental adviser, a representative of the MOEF, the managers of the technical study team (from NPC), the meta review study team (from CII and the Indian Institute of Technology (IIT)) and the international waste minimization expert. The technical study team was organized within NPC and consisted of the project manager of the technical study team, the senior experts in charge of each industry sector and the energy expert. The three industry sector technical teams were in charge of the actual demonstration projects in the companies as well as of the preparation of sectoral technical manuals. These teams were headed by a senior expert from NPC and consisted of all involved experts from NPC as well as from the technical institutes and industry associations. The methodology team was in charge of the development of the DESIRE working method; it was headed by the project manager of the technical study team and gathered inputs from all other study teams as well as from CII and IIT. Finally, the meta review study team was in charge of the review of the company projects in order to identify barriers and enabling measures. It was organized within Corporate Insight and interacted extensively with the technical team of NPC. This project organization structure is depicted in figure 1.3.

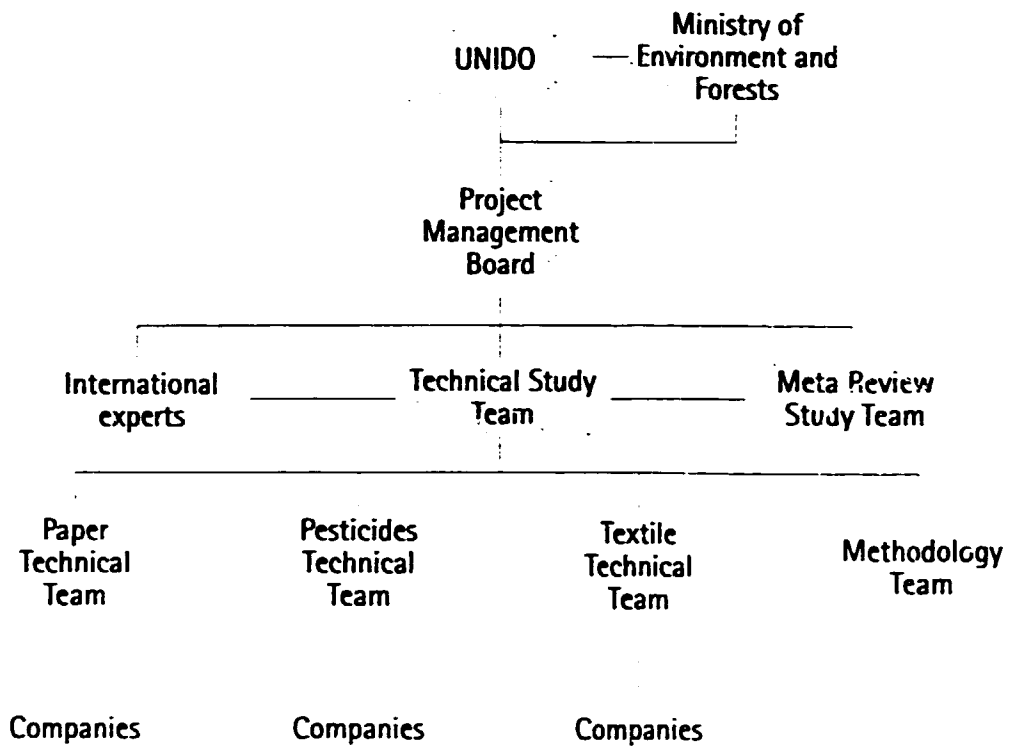
## 1.6 Concluding remarks

The DESIRE project was designed in order to create successful examples of the application of the waste minimization approach in small-scale industries in India and to create the necessary starting conditions for dissemination and continuation of waste minimization activities upon completion of the project. The demonstration projects in companies constituted the core of the DESIRE project. To that end, the technical study team joined forces with committed industries to prove the financial and environmental benefits of waste minimization in practice. In turn these joint task forces were coached by a general waste minimization consultant and received technical back up by international industry subsector experts. Dissemination of the results was from the very outset of the DESIRE project one of the main concerns and activities. To that end, a survey was made of constraints and incentives for waste minimization in order to identify possible enabling policy measures. In addition, one general and three sectoral technical waste minimization manuals were prepared. The results have been presented at sectoral workshops and a national seminar.

Given the complexity of the project and the need to visit all participating companies frequently, it has proven very valuable to concentrate the project in selected geographical regions. In addition, in the DESIRE project, the advantages of working with sectors of industries instead of mixed industries, have outweighed the disadvantages. The most obvious advantages of doing so proved to be fewer resource requirements for getting access to technical information and for familiarising the technical team with the sector specific waste minimization opportunities, less vulnerability to drop out by participating industries (due to reasons outside the project), cross-fertilization opportunities amongst participating companies and ease of dissemination of project results. The major disadvantage of companies not willing to share information considered confidential with competitors was eliminated in the DESIRE project by selecting industries willing to innovate and by signing confidentiality agreements with the participating companies.

The DESIRE project merged a waste minimization demonstration project with a project to train consultants/trainers. As part of DESIRE, the technical team received practical waste minimization training and implemented it in a number of selected industries. The coaching of the national experts was crucial for the success of the project. Coaching was provided by international sector experts (at the beginning and at the

Figure 1.3: DESIRE organization structure



mid-point of the company assessments), a general waste minimization consultant/trainer (throughout the project) and national HRD consultants (at the mid-point of the company assessments). It is felt that the coaching model can be improved to allow input from HRD consultants at the start of the project (supporting the establishment of company level teams and setting the stage for the systematic identification, evaluation and implementation of waste minimization opportunities) and to postpone

input from the industry subsector expert to the mid-term review (in order to provide tailor-made technical solutions to the problems identified in the companies). The ongoing involvement of the general waste minimization trainer then provides continuity in the coaching of the national technical experts and serves as a liaison between the organizational and technical opportunities for waste minimization.

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# Constraints, catalysts and enabling measures

## 2.1 Introduction

The implementation of waste minimization requires a shift in the way environmental factors are dealt with at the company level. Instead of dealing with environmental problems once wastes and emissions are generated, a proactive approach should be developed in which environmental concerns are integrated into the design and operation of industrial activity, thereby avoiding waste generation in the first place. International experiences, however, show that the development of such proactive approaches is hampered by a number of constraints and they might be fostered by various incentives. These might be as diverse as attitudes (such as resistance to change), organizational factors (such as inappropriate job division), economic factors (such as low resource prices) and technical factors (such as non-availability of technologies to solve waste-generating processes) (OTA, 1986; Dieleman, 1991; Hirshorn, 1991; UNEP, 1994). Some of these factors encourage a company to take a preventive approach, while others inhibit or even obstruct a company from doing so. One of the goals of the DESIRE project was therefore to map out this field of influences in order to be able to formulate recommendations for waste minimization fostering policies.

The main constraints that need to be dealt with in efforts to foster the implementation of waste minimization in SSIs are discussed systematically here. We also show how these constraints were tackled within the framework of the DESIRE project. The base material has been generated by the meta review study team, which identified barriers in the course of the demonstration projects, assisted in taking corrective mid-course actions and evaluated the implementation results (Sethi, 1994; Chandak, 1994). To that end, an assessment was made of the management organization, the management commitment, the management systems, team building and technology in each company participating in the DESIRE project. The findings have been organized in seven major groups;

1. Attitudinal constraints;
2. Systemic constraints;
3. Organizational constraints;
4. Technical constraints;
5. Economic constraints;
6. Governmental constraints;
7. Others.

This categorization is, however, not always unequivocal; barriers encountered in a company might be the result of a number of coinciding constraints. The above sequence reflects – to some extent – the sequence in which barriers are often encountered in practice in the course of the implementation of waste minimization in a particular company. This will be elaborated in section 2.9, after the discussion of each of the categories separately in sections 2.2 to 2.8.

In each of the subsequent sections, a division will be made between constraints, catalysts and enabling measures. The *constraints* are the factual barriers that emerged in the preparation and implementation of the DESIRE project. *Catalysis* refer to specific circumstances that were encountered in one (or a few) of the participating companies, which greatly helped in overcoming one (or even a set of interrelated) constraint(s). The *enabling measures*, finally, refer to generic approaches which can be adopted in general in industry to facilitate the identification, evaluation and implementation of waste minimization options.

## 2.2 Attitudinal constraints, catalysts and enabling measures

Attitudes such as 'environment will always cost money', 'waste minimization is impossible in the short term' etc. are quite common in industrial society. Yet such views are seldom, if ever, based on practical experiences or real cost estimates and are therefore perfect examples of attitudinal barriers, which inhibit the entrepreneur from undertaking waste minimization activity. Attitudinal constraints are often not recognised as such in the first place. Further study most often shows that various obstacles, even though formulated in



financial or technical terms, are in fact attitudinal. In the preparation of the DESIRE project, therefore, emphasis was given to the introduction of the waste minimization concept.

The DESIRE project revealed that the attitudinal constraints in Indian SSIs can best be divided as follows:

1. *Indifference towards housekeeping and environmental affairs;*
2. *Resistance to change.*

Each of these will be elaborated and illustrated below.

### **1. Indifference towards housekeeping and environmental affairs**

Good housekeeping is more a matter of culture than technique. Numerous SSIs have been set up as family-run enterprises without professional management systems, and usually lack housekeeping culture. From workers to the chief executive, lapses in housekeeping are taken as part and parcel of industrial operations instead of as an indicator of poor efficiency and mismanagement. The same holds true for environmental problems caused by the industry, which in turn are supported by a mix of general unawareness of environmentally sensitive issues and underrating of environmental affairs in the generally prevailing short-term profit-making business strategies.

### **2. Resistance to change**

Generally, the plant personnel resist any change owing to fear of the unknown and fear of failure. The knowledge of the operator is mostly experience based without any structured training or appreciation of experimentation. Upon deviation from the existing operating practices, the operator will lose the roots of his knowledge and his ability to control the processes in order to safeguard productive output. Such deviation is therefore resisted, which in turn inhibits experimentation with waste minimization practices. This is again fed by the lack of success stories or demonstration projects which could instill confidence of the employees to try out waste minimization. Such resistance to change is the breeding ground for the NMF (Not Me First) syndrome, wherein people would be willing to be the second person to try out an idea provided it has been successfully implemented elsewhere.

## **Catalysts**

In order to ease these attitudinal constraints, the study team decided to try to activate the following catalysts as part of the waste minimization project in each company:

1. *Early success with waste minimization:* since early successes might encourage management as well as operators and supervisors to continue experimentation with waste minimization, the waste minimization assessments in the companies were aimed at the identification of obvious, no- and low-cost waste minimization options in the first place. Such no- and low-cost options often consisted of the elimination of lapses in housekeeping, maintenance and process control, which could easily be identified during the first joint visit of the national and international experts to the company and which had obvious financial pay-offs. These positive experiences then paved the way for more detailed data gathering and analysis and the development of more complex, and often higher cost, waste minimization options.
2. *Employee involvement in waste minimization:* given the need to change operators' and supervisors' attitudes, full attention was given to involving employees right from the start of the waste minimization option generation process. While doing so, it was found that in many cases employees were willing to accept and implement changes if the benefits were properly explained and illustrated.

## **Enabling measures**

With a view to the dissemination of waste minimization practices, the following enabling measures have been proposed in order to deal on an ongoing basis with the attitudinal constraints in Indian SSIs:

1. *Encourage experimentation (especially with no- and low-cost options):* fear of the unknown and fear of failure should be gradually eliminated, which might call for specific, on-the-spot guidance and instructions for experimentation (with modifications of working procedures, alternative raw or auxiliary materials etc.). In order to minimize risks, experimentation should start with no- and low-cost waste minimization practices such as improved housekeeping and process optimization, and gradually be extended on the basis of the lessons learned and experience gained.

2. *Publicize early waste minimization successes*: it is recommended to emphasize both the financial and the environmental benefits of the early waste minimization successes in order to create awareness for waste minimization among the entire workforce and to sustain commitment and involvement from the key decision makers (or owners).

The attitudinal constraints, catalysts and enabling measures have been summarized in figure 2.1

### 2.3 Systemic constraints, catalysts and enabling measures

In the absence of production monitoring data and routine procedures for analysis and evaluation of such data, waste minimization auditing is deemed to end in subjective and tendentious discussions. Data collection and the development of information systems within the company are the obvious remedial actions. The financial benefits for the entrepreneur of not keeping such production records might, however, outweigh the obvious advantages of appropriate data collection and evaluation for the purpose of production process optimization. Although collection of baseline data is an important starting condition for the development of waste minimization activities, it is most often not necessary to do so until obvious lapses in housekeeping and equipment maintenance have been eliminated. Generally speaking, it makes far more sense to repair, for instance, a leak than to monitor the water or steam losses caused by the leak. Since it was anticipated that lack of documentation and reliable records would be a major obstacle towards waste minimization in the DESIRE project, provisions were made for on the spot monitoring of energy, water and materials consumption, productive output, wastes and emissions.

The DESIRE project revealed that the systemic constraints in Indian SSIs can best be grouped as:

1. *Lack of professional management skills*;
2. *Low quality production records*;
3. *Inadequate and ineffective management systems*.

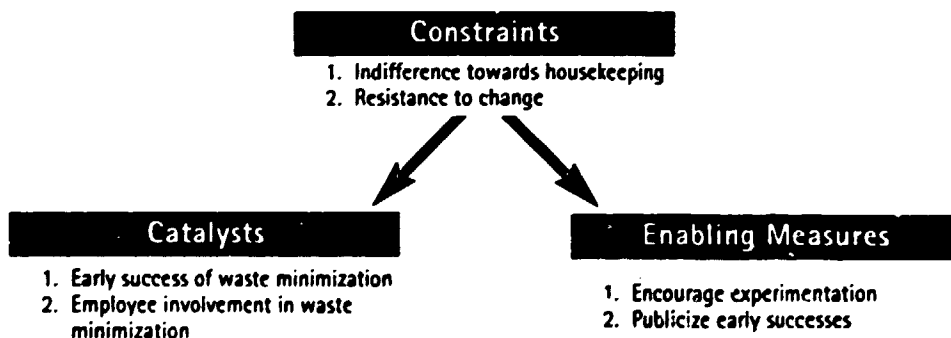
Each of these will be elaborated and illustrated below.

#### 1. Lack of professional management skills

Managerial attitudes are generally poorly developed in SSIs which in turn affects the ability of the company to systematically identify, evaluate and implement any kind of improvement opportunities, including waste minimization. The lack of professional management skills is especially evident in the following areas:

- *Leadership*: SSIs are generally run as family affairs. The owners and decision makers are seldom qualified managers and fail to provide the required leadership and guidance for the further development of the business. This sustains the continuation of the business without medium- or even long-term targets. Consequently, the vision and thinking of the employees is also limited to day-to-day working without any future targets. In addition, the entrepreneurs often start their business from a trader's background and are therefore more sensitive to low resource prices and high product prices than to reduction of the production costs.
- *Supervision*: supervisors in SSIs are usually persons who have been promoted owing to their good performance as workers. They are not trained to

Figure 2.1: Summary of attitudinal constraints, catalysts and enabling measures



perform as supervisors and in turn to instruct, control and guide other workers. The supervision aspect thus suffers from the operators view of the supervisor as being one of their senior colleagues instead of a 'shop floor manager' to whom they are accountable.

- *Job security:* in SSIs, job security is more dependent on the whims and fancies of the employer than on performance of the employee. The employees are therefore more worried about retaining their jobs by doing what pleases the employer and would generally not like to take the risk of failure in a new activity.

## 2. Low-quality production records

Most of the participating units kept hardly any records of water, energy or material consumption, inventories of chemicals, fuels and raw materials or daily floor level log sheets of input, output, down time etc. Environmental records of the quantity and quality of liquid, solid and air emissions were also not maintained. In the absence of record-keeping practices, data analysis and evaluation skills could not develop, which in turn hampered the systematic identification of waste minimization options. The generation of realistic data is already time consuming and effort intensive, but still simple in comparison to the development of skills for data analysis and evaluation. With no direct results coming from data generation, the interest of the project team and commitment of the entrepreneur usually dwindle fast.

## 3. Inadequate and ineffective management systems

In the absence of a well-defined management system, the reporting lines, responsibility and accountability are often assessed on a subjective basis. In response to these subjective performance criteria, the employees will tend to avoid any non-routine work like waste minimization. The imperfection of the management systems is particularly evident in areas like:

- *Professional upgrading of employees:* there is almost total lack of systematic training of employees to upgrade their job skills. The employees are, therefore, unable to comprehend new subjects like waste minimization.
- *Production planning:* production schedules are mostly prepared on a day-to-day basis. This hampers any systematic work, such as baseline data collection or assessment of the impact of implemented measures.

## Catalysts

In the course of the company level waste minimization audits, the study team found that some companies had distinct features which greatly helped them in getting started with waste minimization. These systemic catalysts encompassed:

1. *Proper documentation and planned layout:* Historically the design, procurement and installation of productive equipment took place in a rather haphazard way, following the perceived business opportunities and supplier preferences of the entrepreneur, with little – if any – comparative evaluation of different technical opportunities or planning of the equipment layout. The result was inefficient plant layout and suboptimal dimensioning of various parts of the productive equipment and utilities. It was encouraging, however, to notice that most of the participating units, in particular in the textile industry, had come to realize the shortcomings of such an approach and had improved the preparation and documentation of their latest revamp and capacity expansion projects. This documentation served as excellent starting material for collection and evaluation of the necessary data for the waste minimization assessments.
2. *Proper housekeeping and maintenance provisions:* Although generally imperfect or incomplete, some companies had made good progress in developing housekeeping controls and inspections (on incoming goods inspection, materials utilization etc.). Generally, companies having in-house maintenance and basic fabrication facilities were ahead of companies which had to rely on outside contractors for equipment maintenance and revamping.

## Enabling measures

With a view to the dissemination of waste minimization practices, the following enabling measures are proposed to deal with systemic constraints:

1. *Training of plant level waste minimization team:* It is highly recommended to conduct a training session with the plant level waste minimization team at the start of the waste minimization assessment. The training session should clarify the objective of waste minimization in the first place, which is to reduce the environmental impacts through improvement of the production efficiency. In addition, it should illustrate the importance and benefits of planned production

and the need for collection and evaluation of realistic production records. Finally, attention should be given to illustrating the problem-solving approaches, preferably with an example from within the own company (like lapses in housekeeping or maintenance). The best results are to be expected if key decision makers (and owners) as well as shop floor supervisors participate in such training sessions. In one of the pesticides formulation units, a training session was given by outside trainers as part of the DESIRE project, which basically enabled the waste minimization team to conduct and implement the waste minimization assessment by itself. In some textile dyeing and printing units, the owners themselves instructed the waste minimization team, with little – if any – assistance from outside trainers.

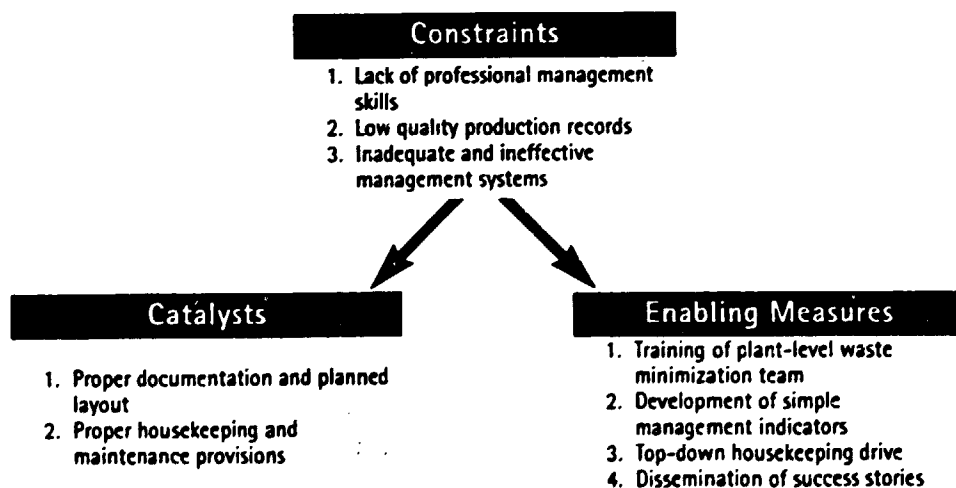
2. *Develop simple management indicators:* In the absence of professional management skills, simple indicators should be developed in order to enable management and supervisors to regain control over the production processes and to minimize wastage of materials, water and energy. Indicators as simple as input material and water and energy consumption per unit of productive output might be sufficient to illustrate the benefits of improved housekeeping and initiate ongoing efforts in this field. The control parameter should fit the basic production processes, and the level of detail should, in principle, meet the level of detail of the existing accounting systems in the company.

3. *Top-down housekeeping drive:* As proven by the experience of some of the companies which had started with the introduction of housekeeping controls, housekeeping will only improve once key decision makers take the lead. They can do so by pinpointing, on a routine basis, lapses in housekeeping (like leaking equipment and pipes, material spills etc.) and following up on the elimination of these lapses. In addition, shop floor managers and supervisors should provide a 'good example': they should not spoil materials and should not intervene in the execution of the production process (for instance by forcing workers to deviate from standard production procedures in order to increase production output with a possible loss of product quality).

4. *Dissemination of success stories:* Waste minimization success stories might help in creating general awareness for waste minimization. The success stories should be well documented with "before waste minimization" (baseline) and "after waste minimization" (accomplishment) financial as well as environmental figures in order to pinpoint the crucial role of accurate information systems for achieving waste minimization. Sectoral as well as generic manuals and workshops can contribute to the dissemination of such success stories.

The systemic constraints, catalysts and enabling measures have been summarized in figure 2.2.

Figure 2.2: Summary of systemic constraints, catalysts and enabling measures



## 2.4 Organizational constraints, catalysts and enabling measures

The organization of the company might also hamper the introduction of proactive environmental management practices. In this context, it is essential to assess how the tasks and responsibilities with regard to production management and environmental issues are divided in the company and to suggest changes which could favour waste minimization. The DESIRE project was not aimed specifically at achieving such major organizational changes in the participating units. Instead, it was decided to set up a project team in each company to initiate and coordinate the waste minimization activities. If proven successful, the companies could then decide upon organizational improvements to sustain the waste minimization success at a later stage. The companies were encouraged to involve shop floor supervisors and technical staff members in the project team, which in turn co-operated with the outside consultants. The level of involvement from the different organizational parts and layers in the company differed however substantially from company to company.

The experiences in the participating companies, illustrate that the organizational constraints can best be categorized under three separate, but strongly interrelated, organizational features of SSIs:

1. *Concentration of decision making powers;*
2. *Emphasis on production;*
3. *Non involvement of employees.*

Each of these will be elaborated and illustrated below.

### 1. Concentration of decision-making powers

Generally, the owner is the chief executive and makes all decisions. Even for low-cost waste minimization measures, approval has to be sought from the owner. The waste minimization team therefore does not feel involved in, nor committed to, waste minimization. This, in turn, is reinforced by a general lack of recognition of the employees by the decision makers; typically employees in SSIs are just supposed to fulfil whatever work is assigned to them. Generally only negative feedback is given to employees in case of non-fulfilment of the assigned jobs. The immense impact of other forms of motivation such as public recognition, awards etc. is not yet realized. The employees, therefore, lack the initiative to take up new and challenging assignments (like waste minimization). This lack of employee initiative, in turn, sustains the concentration of the decision-making powers.

### 2. Emphasis on production

Owing to the overemphasis on production by owners, the time and efforts required for conducting the waste minimization assessment often get relegated to second priority. In some companies, emphasis on production was sustained by the fact that payment of employees was on a production basis; the higher the productive output, the higher the payment of the involved employees, without taking into account that less care was taken (and thus more materials spoiled) in order to achieve this higher productive output.

### 3. Non-involvement of employees

Production personnel do not participate in waste minimization activities until and unless ordered by the chief executive (or owner). Once started, waste minimization team members again face the general lack of recognition. High turnover of technical staff is then to be expected because the technical staff faces excessive workloads and poor remuneration, especially at the junior level. This, in turn, limits the ability of the enterprise to work on waste minimization as the experience gained by one team disappears with the departure of another team member.

### Catalysts

In the course of the DESIRE project, the study team found that some of the participating companies had developed rather effective mechanisms to cope with the above limitations in the company's organization structure. These were:

1. *Family supervision:* Huge differences existed in both the level and the quality of the involvement and supervision of owners and their families in the daily operation of the companies. For companies with technically qualified owners, who lived next to – or even on – the factory premises it proved to be easier to organize the waste minimization efforts effectively. Apparently, the technically qualified owners got more satisfaction from optimizing their production than the non-technically qualified owners who co-operate with chartered engineers or consultants to run the production.
2. *Sharing of information (on costs etc.):* Information-sharing proved crucial in almost all company level assessments. Within the company, sharing of cost data between managers and operators encouraged operators to work more carefully with high-cost materials. On the other hand, sharing of information on perceived causes of equipment failure or off-

specification products among operators and between operators, supervisors and technical staff enabled problem-solving approaches to eliminate waste generation causes. In addition, it was found that to some extent information on cost-effective waste minimization opportunities can be shared among companies. In the textile dyeing and printing industry, the Surat-based Waste Minimization Group served as a platform for the dissemination of waste minimization opportunities among competing companies. In the pesticides formulation industry, the large scale pesticides manufacturers are supporting their commission formulators in implementing process optimization and quality control, which in turn spurs waste minimization in small-scale pesticide formulating companies.

### Enabling measures

On the basis of the experiences in the DESIRE project, the following enabling measures are recommended in order to deal with the organizational constraints in SSIs:

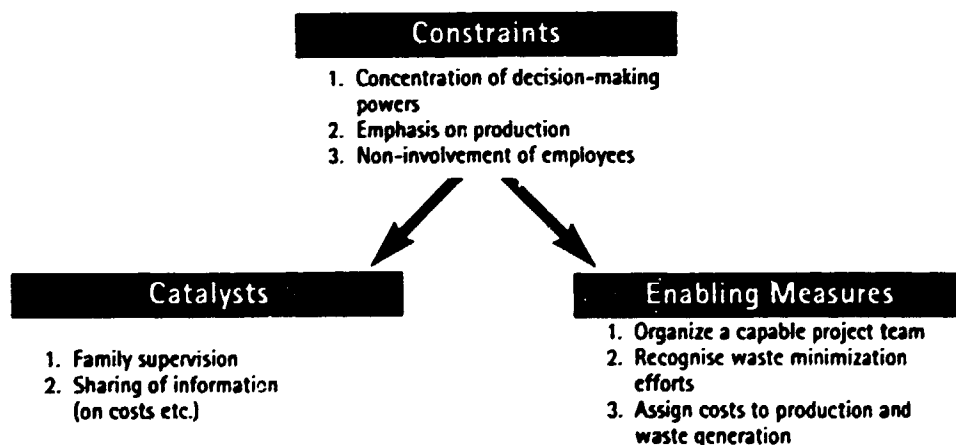
1. *Organize a capable project team:* A capable and well-organized waste minimization team is among the most powerful instruments to develop the waste minimization assessment as well as to eliminate numerous constraints for waste minimization. It should, however, be kept in mind that it might not be easy to establish such an effective team, given the deeply rooted lack of recognition, lack of employee involvement and the concentration of decision-making powers. A balance thus has to be found between the preferred situation with a properly functioning project team being able to develop and implement waste

minimization on its own and the present situation which inhibits delegation of any decision making power and blocks creative problem solving. In this perspective, it deserves recommendation to select a team leader who has the authority to implement at least low- and no-cost waste minimization measures. In addition, efforts should be undertaken to involve one or preferably a few of the most concerned supervisors and operators (shop floor workers) in the waste minimization team.

2. *Recognition for waste minimization efforts:* Once the team has started with the identification and evaluation of waste minimization opportunities, steps should be taken to encourage the team. To this end, various schemes might be put in practice, like public recognition, rewards, publicising the early successes etc.
3. *Assigning costs to production and waste generation:* In order to expand the scope from the management from just production output to more comprehensive control over the efficiency of production, it is necessary to assign costs to the different production factors and waste streams. Comparatively simple calculations of the monetary value of the raw materials, chemicals and products lost with a particular waste stream normally incite managers to take action, as was illustrated in the DESIRE project with calculations on cost of fibre loss (pulp and paper sector) and print paste remnants (textile printing sector).

The organizational constraints, catalysts and enabling measures have been summarized in figure 2.3.

Figure 2.3: Summary of organizational constraints, catalysts and enabling measures



## 2.5 Technical constraints, catalysts and enabling measures

Waste minimization is essentially equal to environment-driven optimization of the use of technology. Consequently, waste minimization requires technical changes to installations, tools, input materials, auxiliaries, processes and equipment. Given this important role of technology in the implementation of waste minimization, technical factors often emerge as constraints to waste minimization. However, upon secondary analysis, technical constraints put forward in the course of the waste minimization assessment often turn out to be resolvable through technology management rather than technology as such. Since it was anticipated that technical obstacles could have a destructive impact on the success of the DESIRE project, provisions were taken to provide proper technical backup for the company-level assessment teams by both a domestic technical institute for each participating industry sector and international industry subsector experts.

The comparative evaluation of the waste minimization options in the DESIRE project (see chapter 4) shows that technical 'improvements' and 'optimizations' were generally the most cost-effective, short-term waste minimization solutions and not the comparatively radical technical 'innovations' (based on new processes and equipment). This illustrates that the technical constraints in SSIs can best be organized as follows:

1. *Limited technical capabilities;*
2. *Limited access to technical information;*
3. *Technology limitations.*

Each of these will be elaborated and illustrated below.

### 1. Limited technical capabilities

For most of the SSIs the ability to produce is based on experience of workers rather than on technical capabilities to monitor, control and improve the production technology. The limitations in the technical capabilities and skills include:

- *Limited or non-availability of trained manpower:* In the absence of in-house or locally-available technical personnel to undertake or guide the waste minimization assessment, the individual companies are constrained to take it up on their own. To ease this lack of technical manpower, the participating companies strongly relied upon the technical expertise of the NPC, which in turn had to expand the envisaged level of technical assistance to each of the companies.

- *Lack of monitoring facilities:* Due to the lack of in-house monitoring facilities required for conducting the waste minimization assessment, the industries have to depend on external agencies (NPC in case of the DESIRE project). Such agencies are few, expensive and located far off. Basic data collection therefore becomes a major limitation in conducting waste minimization.
- *Limited maintenance facilities:* The maintenance department in SSIs is normally equipped with just enough facilities and personnel for routine maintenance. In case of equipment failure, even routine maintenance cannot be safeguarded. Major maintenance jobs like machine overhaul, motor rewinding, boiler cleaning etc. have to be entrusted to external firms which are expensive and time intensive. Since waste minimization often requires such maintenance activities, the dependence on, and costs of, external firms hinder undertaking waste minimization.

### 2. Limited access to technical information

Generally SSIs have limited access to information and success stories on low resource consuming and low waste techniques within the country as well as overseas. Furthermore, there is almost total absence of technical literature. The information available from abroad is neither directly relevant nor tailor-made to the technical status and size of operations of SSIs.

### 3. Technology limitations

The emergence of SSIs has been need-based. There has not been any specific technology development for this sector. Mostly the old discarded technology has been modified. The problems encountered during this modification process are solved by trial and error without analysing the basic chemistry and engineering involved in the process. This has resulted in inefficient, suboptimal equipment and consequently higher waste generation. In addition several technological gaps still exist. Chemical recovery for agro-residue-based pulp and paper industry and low-cost automatic laminar bag filling and sealing for pesticides formulation are examples of such technology gaps identified in the DESIRE project.

### Catalysts

Some of the participating companies in the DESIRE project distinguished themselves from the majority of the SSIs and had a comparatively skilled technical staff

and/or in-house fabrication facilities. The following illustrates these interrelated technical catalysts:

1. *Technically skilled staff:* Given the need to improve the operation and management of the production technology, the companies having technically skilled staff members had less problems in getting started with waste minimization. Normally, these technically skilled staff members had already taken the lead in their company to develop quality assurance policies and tools and/or started to experiment with, for instance, the use of alternative chemicals or raw materials. These staff members could easily absorb the waste minimization concept and had the ability to transfer the general working method to the specific circumstances in their own company.
2. *In-house fabrication facilities:* Given the tradition in SSIs to develop and modify production equipment from old discarded equipment, experience and expertise have been gained in finding smart, but simple, technical fixes for problems encountered in the operation of the previously discarded equipment. Especially those companies that operated in-house fabrication facilities (mechanical, electrical or civil workshops) had such experience and expertise, and could employ this in order to identify appropriate waste minimization solutions (or to modify suggested improvements from the outside experts into such solutions).

### Enabling measures

The technical constraints discussed above are not specific to waste minimization only. These inhibit any innovation in SSIs being in favour of product quality improvement, production expansion, energy conservation etc.. Therefore, most general measures undertaken to improve the technical skills and capabilities for SSIs will also favour waste minimization. These might include technology development, demonstration and diffusion projects, technical training and building an infrastructure for technical support to SSIs. In addition to these generic enabling measures, the following can be recommended to specifically foster waste minimization:

1. *Dissemination of waste minimization techniques and technologies:* Given the prevalence of the Not Me First syndrome, wherein people would be willing to be the second person to try an idea provided it has been successfully implemented elsewhere, dissemination of success stories of waste minimization techniques and technologies could be a very powerful

instrument to abate existing technical constraints. The publication of technical waste minimization manuals as well as the organization of workshops and seminars are valuable starting points. However, it should be kept in mind that numerous SSIs are difficult to reach since by themselves they do not read technical literature nor consult technical service institutes. Therefore, intermediary organizations like small industries service institutes, professional organizations, industry associations and probably even equipment suppliers should become involved in delivering the successful waste minimization techniques and technologies to the companies.

2. *Need-based support for environment-driven R&D:* There are obvious areas in which state of the art technology is not yet able to prevent environmental problems at typical production scales for SSIs. In order to eliminate these technology and technique gaps, R&D support could be useful. This support however has to meet the needs of SSIs (to fit to the existing technical status, size and investment capabilities of SSIs) and integrate minimization of the environmental burden as one of the development objectives in the technical research.

Figure 2.4 contains a summary of the technical constraints, catalysts and enabling measures discussed above.

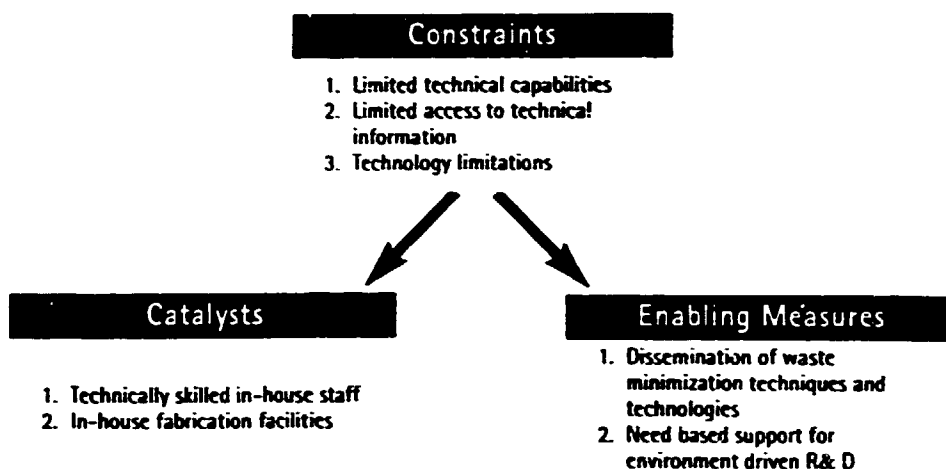
## 2.6 Economic constraints, catalysts and enabling measures

Although the DESIRE project proves the validity of the waste minimization adage 'from waste to profits', economic constraints can still hamper the development and implementation of waste minimization in companies. This is essentially so because resources (staff time, monitoring efforts etc.) have to be invested up front in the waste minimization assessment, without knowing exactly what financial benefits (input cost reduction, production expansion, product quality improvements etc.) can be gained from doing so. The DESIRE team came across four types of economic constraints:

1. *Prevalence of production quantum over production costs;*
2. *Resource pricing and availability;*
3. *Ad hoc investment policy;*
4. *Capital availability and costs.*



Figure 2.4: Summary of technical constraints, catalysts and enabling measures



The economic constraints referred to in this section are to be encountered in different stages of the introduction of waste minimization. The prevalence of production quantum over production costs and resource pricing and availability carry great weight when trying to obtain management commitment and involvement in the execution of a waste minimization assessment. Resource pricing and availability continue to play a role in evaluating the generated waste minimization opportunities, along with ad hoc investment policies. In an even later stage, when decisions have to be made about investments in waste minimization solutions, capital availability and costs as well as ad hoc investment policies can act as economic constraints. Each of the economic constraints will be elaborated and illustrated below.

### 1. Prevalence of production quantum over production costs

The prevailing fiscal incentives, viz. concessions in excise duty, sales tax etc., are mostly related to quantum of production with little or no relevance to cost of production. This coincides with the perception of fixed production costs arising out of the trader's attitude of most of the owners of SSIs (see also section 2.2). The tendency of entrepreneurs is therefore to concentrate on maximisation of production to derive maximum financial benefit. Cost reduction exercises such as waste minimization get relegated to secondary and tertiary levels of importance.

### 2. Resource pricing and availability

The prevailing low prices and abundant availability of

natural resources such as agro-residues, water etc. in most areas dampen the impetus for identifying and implementing waste minimization measures. It should however be noticed that in heavily industrialized zones, resource scarcity has become a major concern for industrial entrepreneurs. In the DESIRE project, this played a role in the textile dyeing and printing industry in Surat, which is in urgent need of 'soft' water.

### 3. Ad hoc investment policy

The inadequate and ineffective management systems (see section 2.3) sustain ad hoc investment policies in SSIs. This ad hoc nature of investments disfavours waste minimization in several interrelated ways:

- *Limiting economic analysis to obvious direct costs and benefits:* The economics of all investments (including waste minimization measures) are computed mainly on the basis of direct financial returns and short term financial gains. Therefore, only increases in production capacity, reductions in the consumption of raw materials and fuels and obvious reductions in production costs (such as reduction of workforce needed) are accounted for. The benefits accruing from reduced pollution control costs and electricity savings are often not accounted for on a routine basis, because in many cases no such costs are currently incurred. As savings on these environmental costs are often a major part of the economic benefit of waste minimization measures, their exclusion disfavours acceptance of waste minimization.

- *Ad hoc investment criteria:* The small-scale entrepreneur is usually short of capital. The most attractive measures requiring higher investment do not get the priority. Instead, the measures that get selected for implementation are the least capital intensive. The impact of such implementation is not as attractive as one would expect it to be.
- *Inadequate investment planning:* Investments, including those for adopting waste minimization, are often made without proper planning, which may result in partial implementation. The expected results are thus not achieved, bringing in dissatisfaction and loss of faith of decision makers.

#### 4. Capital availability and costs

The financial institutions have not evinced interest in financing cost-intensive waste minimization measures having longer pay back periods (over one year). Even if financing were available, the interest rates are high (market rates vary from 15 to 20 per cent), rendering major waste minimization investments unviable.

#### Catalysts

The extent to which each of the above economic constraints actually played a role in each company depended to a large extent on the financial position of the company at the start of the project and the ability of the waste minimization team to identify financially attractive options. In the company selection and in the assistance to the companies, attention has been given to exploit each of these economic catalysts:

1. *Company financially-sound:* Since it is evident that financially sound companies are less vulnerable to the economic constraints, the perceived financial soundness of the companies has been used as one of the criteria for the company selection. Accordingly, in each sector at least two companies participated in which capital availability for implementation of waste minimization would not be a major problem given the proven economic feasibility of the proposed waste minimization measures.
2. *Financially-attractive options:* Since it had been recognised in the preparation of the project that the implementation of financially-attractive waste minimization options could be a strong catalyst for waste minimization, the assistance to the companies has been focused on the identification of waste minimization options requiring low to medium investments and having obvious financial returns. The implementation of such low- and no-cost,

highly cost-effective waste minimization options is thought to pave the way for the implementation of selected higher cost options in the near future.

#### Enabling measures

The experiences in the DESIRE project lead to the identification of the following measures to enable companies to deal with the economic constraints for waste minimization:

1. *Proper cost allocation and planned investments:* Awareness of costs due to wastes seems to be a crucial starting point for any company level waste minimization effort. To be able to illustrate the potential for savings from waste minimization, one needs to prepare an estimate of the costs of various components in a waste stream (e.g. energy, raw materials, water, product). Once different components and their cost have been allocated, it becomes easier to assign cost to a waste stream. Estimating the savings arising out of minimising or eliminating the waste stream becomes simpler. Such an exercise also helps in making the entrepreneur realize how much he is losing through the drain. In addition, it may be useful to merge waste minimization in the overall investment plan, because the additional costs for waste minimization might be much lower once waste minimization is included in an overhaul or capacity expansion plan than when implemented on its own.
2. *Long term industrial policies:* The Government should avoid making frequent changes in the industrial policies, because such changes sustain short-sighted investment planning in SSIs. Declaration of long term industrial policies would help the industries in merging waste minimization into the investment planning and in taking suitable steps to be more and more competitive without artificial fiscal protection.
3. *Financial incentives:* Special financial schemes might have a huge impact on the capital cost and availability of SSIs for waste minimization investments. To foster the implementation of high-cost waste minimization options, financial schemes could be developed by government or donor agencies which give priority to waste minimization proposals over end-of-pipe proposals. To suit SSIs, such schemes should be procedurally simple and easily accessible. In addition, fiscal incentives can be created for waste minimization. These might include automatic capacity enhancement, preferential purchase in the government sector, a 100 per cent

depreciation allowance on investments in waste minimization etc.

Figure 2.5 depicts the interrelations between the economic constraints, catalysts and enabling measures.

## 2.7 Governmental constraints, catalysts and enabling measures

Governmental policies affect company decision-making, and might thus either hamper or incite companies to adopt waste minimization. With a view to fostering waste minimization, industrial and environmental policies are expected to be most effective. In each of these policy areas, legislative initiatives are developed, which require training and institutional capacity building – both within the industrial community within various governmental organizations – in order to be effectively implemented and enforced. Although neither industrial nor environmental policies have been assessed in full detail as part of the DESIRE project, a preliminary inventory of governmental constraints and incentives has been made on the basis of the experiences within the companies. The following summarizes the major findings, which to some extent overlap with the results discussed above on each of the themes within the companies.

### 1. Industrial policies

Frequently changing industrial policy is not conducive to waste minimization efforts. In the course of the DESIRE project, for example, a reduction was announced of the excise duty exemption from agro-residue-based paper, which upset the economics of this sector completely. With such uncertainties, industries are

not willing to implement long- or even medium-term waste minimization measures. In addition, incentive schemes like concessional corporate tax, a 100 per cent depreciation allowance for pollution control measures etc. are not yet available for waste minimization.

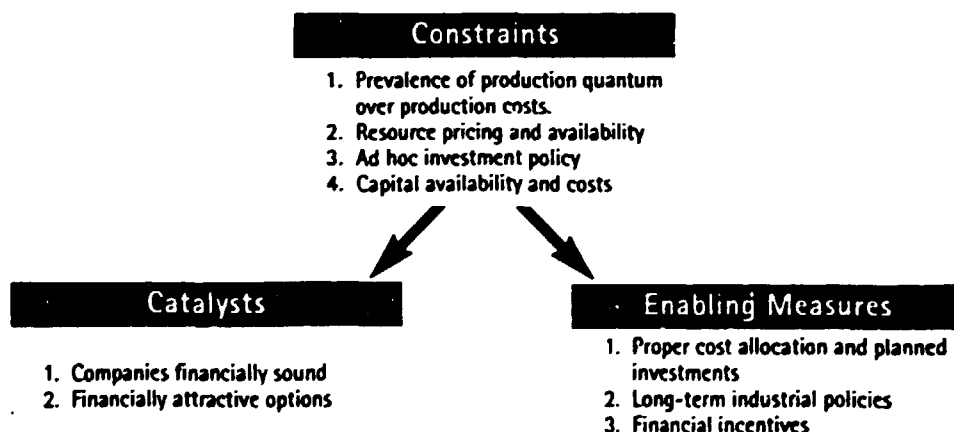
### 2. Environmental policies

Regulatory authorities still emphasize exclusively achieving stipulated environmental discharge standards. No weight is given to reduction of the generation of waste. The entrepreneurs, therefore, prefer using conventional end-of-pipe control practices which satisfy the regulatory authorities rather than adopting waste minimization practices which are open to question by the authorities. Another area not yet covered by environmental regulations is utilization of ground water, which is a major industrial resource for numerous industry sectors (such as textile dyeing and printing and pulp and paper manufacturing). The price of ground water is based on the pumping cost and a nominal tax. This is far too low to justify financial returns even from low-cost water conservation measures.

### Catalysts

Given the limited pressure from governmental authorities on industries to reduce their environmental loadings, it was very promising to notice that a number of the participating companies had already taken self-responsibility and showed serious commitment to improve the environmental performance of their operations. The reasons for such self-responsibility differed from company to company. In the participating textile dyeing and printing companies, the self-responsibility was most profound and based on concerns

Figure 2.5: Summary of economic constraints, catalysts and enabling measures



for future supply of soft water for the sector and the growing concerns among foreign consumers about possible residues of health-threatening chemicals in clothing. In pesticides formulation, the environmental concern seems to be a positive spin-off from occupational health and safety concerns. In the pulp and paper industry, the location of the industry played a major role, with the mills located in residential areas showing more commitment to environmental improvement than those located outside residential areas.

### Enabling measures

In the preceding sections some guidance has been given on how to develop governmental policies favouring waste minimization in SSIs. Included were training policies to improve managerial skills of SSIs (see section 2.3), dissemination of waste minimization techniques and technologies (see section 2.5), and long-term industrial policies and financial incentives (see section 2.6). In addition, the following measures could be adopted by the Government to foster waste minimization:

1. *Area-wide, voluntary waste minimization groups:* The Government could set the stage for area-wide voluntary waste minimization groups by providing funds for the expenses to run such groups and creating conditions to exploit in their achievements. The expenses include for instance; the cost of publication of newsletters and other documentation, contribution to the costs of trial implementation of selected waste minimization options, the costs of technical support, the cost of study tours etc. In order to avoid undertaking similar initiatives by different waste minimization groups in different parts of the country,

there exists the need for a national coordination and information exchange mechanism, which in turn could be used by other agencies like industry associations, small industry service institutes, professional organizations and schools, banking and financing institutes and pollution control boards.

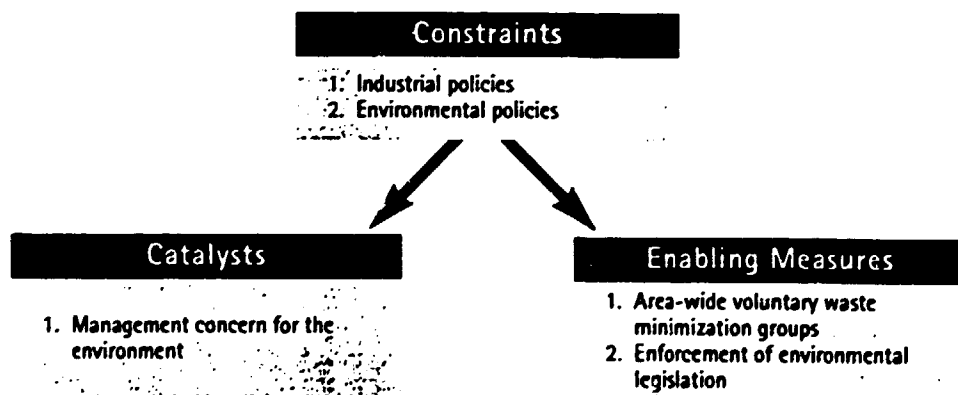
2. *Enforcement of environmental legislation:* Since numerous SSIs do not yet feel the need to undertake action to protect the environment or bear any pollution control cost, there is a serious need to improve the enforcement of environmental legislation. Although numerous suggestions can be made to improve environmental legislation in order to make it more waste minimization oriented, it is felt that enforcement of existing environmental legislation will be more effective in fostering waste minimization on the short term. Unless enforcement is taken seriously, entrepreneurs will not perceive the need to include environmental concerns in their business activities.

Figure 2.6 contains a summary of the interrelations between governmental constraints, catalysts and enabling measures.

### 2.8 Other factors

In the preceding sections, constraints within the industry as well as coming from Government activity have been dealt with on a topical basis. Next to these, a few other constraints occurred in the DESIRE project, which are basically beyond the scope of influence of both industry and Government. These are:

Figure 2.6: Summary of governmental constraints, catalysts and enabling measures



1. *Seasonal variations*: Some of the SSIs are susceptible to seasonal variations. For example, agro-residue-based pulp and paper mills are dependent on the crop for the supply of raw materials which varies from season to season. The mills thus typically change the raw materials upon seasonal availability (rice straw, wheat straw, bagasse, elephant grass), and consequently do not have the opportunity to optimize the processes and choice of equipment to one of these agro-residues. Similarly, the pesticides formulation industry has to regulate its production with respect to the market demand which in turn tends to be governed by monsoons, climate etc.

2. *Lack of public pressure*: Pressure from non-governmental organizations and the public in general is necessary for proper environmental management by industry and for proper enforcement of environmental legislation by governmental agencies. In the absence of such pressure, entrepreneurs tend to adopt a lackadaisical approach.

## 2.9 Concluding remarks

A series of constraints can arise when introducing waste minimization in SSIs. In this chapter we have discussed such constraints and elaborated on catalysts and enabling measures to deal with these constraints. A division in seven categories has been used:

1. Attitudinal;
2. Systemic;
3. Organizational;
4. Technical;
5. Economic;
6. Governmental;
7. Others.

In its own way, each of the types of constraints can delay or even block the waste minimization process. It is therefore essential to set up waste minimization policies that can tackle the broadest possible spectrum of potential constraints. The experience of the DESIRE project shows that intensive guidance and company-specific supervision by outside trainers cum consultants can eliminate a number of these constraints and thus foster waste minimization.

There appears to be a set sequence in which the five topical groups of constraints normally appear when introducing waste minimization in companies. The first constraints facing both companies and external agencies are normally attitudinal. These become evident in various

misunderstandings as to the opportunities for waste minimization and the financial as well as environmental benefits to be gained by the implementation of waste minimization. This means that when encouraging waste minimization in companies, a great deal of attention must be devoted to these attitudinal constraints. Once these are broken down – at least to some extent – and the management has decided to start a waste minimization assessment, it is common to encounter systemic constraints (especially non-availability of information for conducting the assessment) and organizational constraints (especially towards the establishment of a properly functioning waste minimization team in the company). In a subsequent stage, waste minimization opportunities, which might face technical constraints have to be generated and evaluated. In the last stage – the actual implementation of waste minimization solutions – economic constraints might be most profound.

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# Audit methodology

## 3.1 Introduction

It is almost impossible to disseminate waste minimization results on an option-by-option basis, as waste minimization options have to suit the processes, technologies and materials used, product specifications to be met and development stage of the management system. A waste minimization "solution" for one company may therefore not be the best waste minimization "opportunity" for another, highly comparable company in the same sector. The dissemination activities thus have to focus on the audit methodology that enabled the companies to identify the tailor-made waste minimization solutions, instead of on the solutions found. By doing so, the audit methodology is used as the vehicle for the dissemination of waste minimization achievements and experiences.

Waste minimization audits are often characterized as systematic planned procedures with the objective of identifying ways to eliminate – or at least reduce – the generation of waste and emissions. Furthermore, an audit should contribute to the initiation of on-going waste minimization activities, catalysing the corporate effort in achieving continuous environmental improvements in its operations (Van Berkel, 1995). A comparative evaluation of audit methodologies used in various waste minimization projects, in different countries as well as in different projects in the same country (De Hoo, 1991; USEPA, 1992; UNEP/UNIDO, 1991; MOWM, 1991), revealed differences regarding the following (Van Berkel, 1994):

- Organization of the audit *process* in the company: This is reflected in the short lists of audit tasks which in turn are organized in different phases for the audit process.
- Development of alternative, waste minimization *options*: This is reflected in different sets of standardized prevention techniques used to facilitate option generation.
- External *guidance* to companies: Some audit

methodologies allow for a self-assessment by motivated companies, whereas others require substantial outside technical or managerial assistance and guidance.

The explanation of the waste minimization concept in section 1.2 already specifies the general prevention techniques to be considered in the DESIRE audit methodology. The external guidance provided in the frame of the DESIRE project is already described in the workplan (section 1.4). This chapter therefore focuses on the organization of the audit process in the DESIRE project.

The development of the audit methodology tailored to the needs and capabilities of Indian SSIs was a crucial part of the DESIRE project (second aim as specified in section 1.3). At the start of the DESIRE project, an audit manual was drafted by the technical study team. This draft was almost completely derived from international examples, in particular the PRISMA/PREPARE "Manual for the Prevention of Waste and Emissions (De Hoo, 1991) and the UNEP/UNIDO "Audit and Reduction Manual for Industrial Waste and Emissions" (UNEP/UNIDO, 1991). The preliminary experiences with the application of this draft manual in the agro-residue-based pulp and paper industry proved that the manual did not fit some predominant features of SSIs, especially:

- Limited technical capabilities 'understaffed';
- Almost complete absence of reliable production and environmental records;
- Limited written communication skills;
- Lack of professional project organization and management skills.

It was therefore decided to start "from scratch" and develop a new audit methodology tailored to the needs and capabilities of SSIs. To this end, inputs from the technical teams, the meta review study team, CII and the international experts were gathered during a brainstorm and transferred into a DESIRE audit methodology. The experiences in the three sectors were

then used to further develop and test a general waste minimization guide (NPC, 1994) and three sector specific technical waste minimization manuals (Gupta, 1995; Kuttiappan, 1995; Pervez, 1995).

This chapter summarizes the results of the development and practical application of the DESIRE audit methodology. Section 3.2 describes the generic guidelines for waste minimization prepared as part of the project lines. Section 3.3 then continues with a summary of the coverage of the technical manuals for the three industry sectors covered in the project. The practical experiences of working with the audit methodology are evaluated in section 3.4. The chapter concludes with a discussion of the dissemination opportunities (section 3.5) and concluding remarks (section 3.6).

### 3.2 General guide

Under the project a generic guideline for minimization guide has been developed for SSIs. The guidelines were conceptualized as a first and attractive introduction to the waste minimization concept, its potential and conditions for its implementation at the factory level. They cover, inter alia, a short description of the systematic working method. In this section, we will first address the general outline of the guidelines and then continue with a more detailed description of the audit methodology.

### Objective and outline

The generic guidelines addresses entrepreneurs of SSIs in the first place. Reading through the guidelines should enthruse them for waste minimization and develop their desire to experiment with waste minimization in their own operations. To this end, the financial potential of waste minimization has been stressed in the first place and details about the audit methodology only in the second place. In addition, practical examples have been included from a number of different sectors in order to prove to the entrepreneur that he won't be the first one experimenting with waste minimization.

To achieve this overall objective, the following logical sequence of aims has been elaborated in the DESIRE guidelines:

1. Attract attention for waste minimization;
2. Establish the need for waste minimization;
3. Suggest waste minimization as the solution;
4. Provide a framework for the implementation of waste minimization;
5. Identify additional assistance.

This has been elaborated into a fifty-page guideline for waste minimization, with numerous examples and illustrations. The guidelines have been kept brief in order to allow for complete reading at one stretch (about 1 hour). The content is summarized in box 3.1.

#### Box 3.1: Summary of the content of the generic guidelines for waste minimization (NPC, 1994)

##### FROM WASTE TO PROFITS: GUIDELINES FOR WASTE MINIMIZATION

###### Chapter 1: Money in your drain?

Attractive introduction based on three industry case-studies, illustrating that these companies were not aware how much money was lost with wastes and emissions and how these could be converted in extra profits.

###### Chapter 2: Or even more!

Explanation and illustration of the other benefits obtainable with waste minimization, like improvement of the work environment, quality improvement, image, compliance and new market opportunities.

###### Chapter 3: Waste minimization gets it!

Explanation of the waste minimization concept and the generally applicable approaches, with industrial examples. In addition, the essential conditions for waste minimization are summarized; management commitment, operator involvement and an organized approach.

###### Chapter 4: Let's do it!

The step-by-step summary of the essentials of waste minimization. The explanation of the audit methodology runs parallel with a case history of its application in the pulp and paper industry.

###### Chapter 5: Just in case

Listing of useful documentation and contacts for additional assistance.

## DESIRE audit methodology

The DESIRE audit methodology divides the waste minimization audit into six stages. The objective of each of these is as follows:

1. *Getting started*: Planning and organization of the waste minimization audit, including the establishment of a project team and the selection of the audit focus.
2. *Analysing process steps*: Evaluation of the unit operations relevant to the selected audit focus in order to quantify waste generation, its costs and its causes.
3. *Generating waste minimization opportunities*: Development and preliminary selection of waste minimization opportunities.

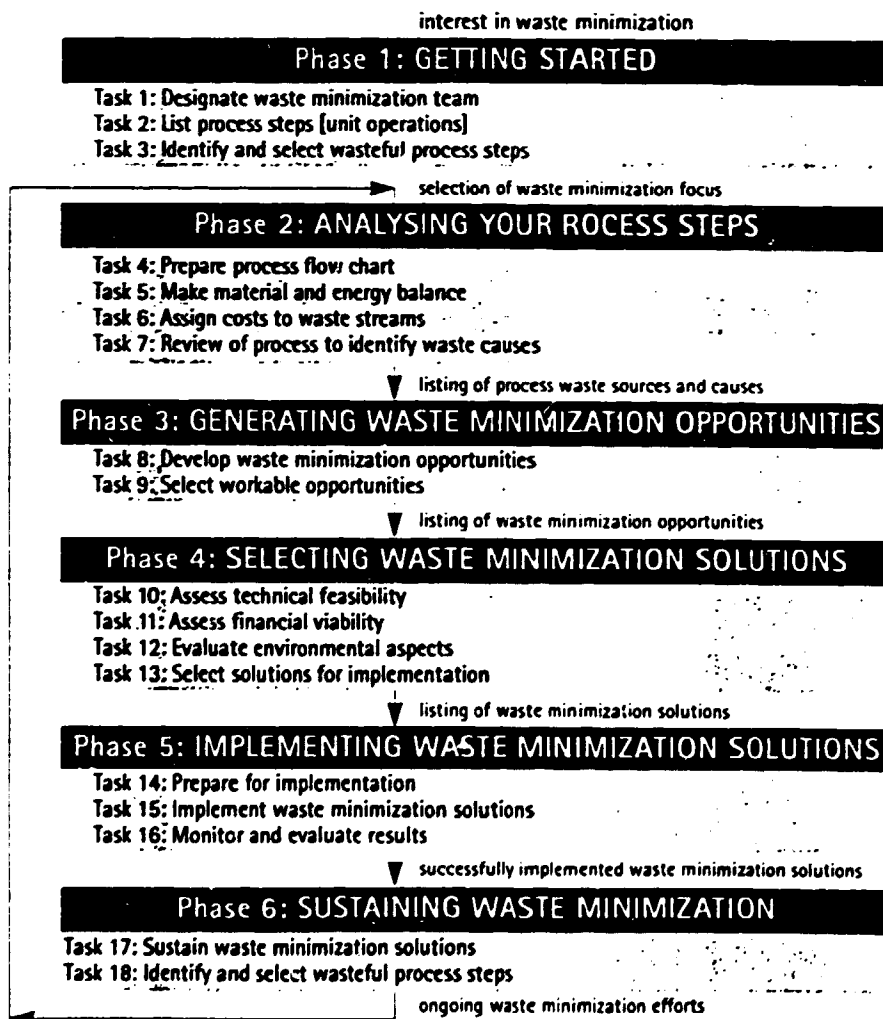
4. *Selecting waste minimization solutions*: Evaluation of the technical and financial feasibility and environmental desirability of waste minimization opportunities in order to select feasible waste minimization solutions.

5. *Implementing waste minimization solutions*: Actual implementation of the feasible waste minimization solutions and monitoring of the results achieved by their implementation.

6. *Sustaining waste minimization*: Perpetuating continuous search for waste minimization opportunities.

A flow chart of this manual with a specification of the tasks to be executed in each phase is included in figure 3.1. Below is a short explanation of each of these tasks.

Figure 3.1: Flow sheet for the DESIRE auditing procedure (NPC, 1994)





## 1. Getting started

In order to prepare for the waste minimization audit, the following tasks need to be executed:

1. *Designate waste minimization team:* The team should be made up of representatives from the groups in the company that will have a major interest in waste minimization. Size and composition of the team should fit to the company's organizational structure. The team should be capable of identifying potential areas, developing solutions and implementing them. To this end, input from both in-house and external experts might be needed.
2. *List process steps (unit operations):* All process steps should be specified, including utilities, storage and waste treatment and disposal facilities, in order to get a proper overview of all manufacturing processes. The team should specifically highlight major and obvious waste generating areas and, if possible, identify the reasons for waste generation. In addition, housekeeping and process control practices should be broadly assessed. Special attention should be paid to periodic activities e.g. washing and regeneration (of catalysts, absorbents etc.) as these are often highly wasteful but still overlooked.
3. *Identify and select wasteful process steps:* This activity might be considered a preliminary prioritization activity. Without going into details, the team should broadly assess all process steps in terms of quantum of waste, severity of impact on the environment, expected waste minimization opportunities, estimated benefits (cost savings) etc. Such preliminary assessment helps in focusing on one or a few process steps (audit focuses) for detailed analysis.

## 2. Analysing process steps

This step covers the detailed data collection and evaluation for the selected processes. This information will enable the generation and evaluation of waste minimization opportunities in the next phases. To this end the following tasks need to be addressed:

4. *Prepare process flow chart:* A schematic representation of the selected process steps is made, with the purpose of identifying all process steps and the sources of wastes and emissions. The flow chart should list and – to some extent – characterize the input and output streams per process step. Given the historic development of the production processes, it is not always easy to establish a correct process flow

diagram. This is however crucial for the smooth development of the waste minimization audit.

5. *Make material and energy balance:* These balances are needed to quantify the process flow diagram and the occurring losses (wastes). Later on, balances can be used to monitor progress of the implementation of waste minimization. Normally, only a preliminary balance can be derived, given the lack of records and the lack of data on composition of input and output material streams and complex recycle streams. It may be worthwhile to draw component balances for important resources, e.g. water and fibre balance in paper industry or print paste balance in the textile finishing industry.
6. *Assign costs to waste streams:* In order to assess the profit potential of waste streams, the monetary loss incurred by a waste stream should be evaluated. A preliminary estimate can be made with a calculation of the cost of raw material and intermediate product lost with the waste stream (like fibre loss in the pulp and paper industry). A more detailed analysis might reveal additional costs, including the cost of raw materials in waste, the manufacturing cost of material in waste, cost of product in waste, cost of treatment of waste, cost of waste disposal, waste tax etc.
7. *Review of process to identify waste causes:* A review of the processes should locate and highlight the causes of waste generation (cause analysis). A wide variety of possible causes should be considered, including for instance poor housekeeping, operational and maintenance negligence, poor raw material quality, poor layout, bad technology, inadequately trained personnel and employee demotivation.

## 3. Generating waste minimization opportunities

Having identified and assigned causes to waste generation, the audit team can move on to determining waste minimization opportunities which eliminate these causes. The following tasks need to be undertaken to this end:

8. *Developing waste minimization opportunities:* The team, ready with data, starts looking for possible methods for eliminating waste causes, which in turn minimize waste generation. Finding such options, depends on knowledge and creativity of the team members, much of which comes from their education and work experience. Techniques like brain-storming, group discussions etc. might be applied to boost option generation.

9. *Select workable opportunities:* The waste minimization opportunities are now screened in order to weed out those which are impractical. This weeding-out process should be simple, fast and straightforward and may often be only qualitative. The remaining opportunities are then subjected to more detailed feasibility studies.

#### 4. Selecting waste minimization solutions

The feasibility of the workable waste minimization opportunities is to be evaluated in order to select the most practical set of waste minimization solutions. The following need to be undertaken to this end:

10. *Assess technical feasibility:* The technical evaluation determines whether a proposed waste minimization opportunity will work for the specific application. To this end, impact of the proposed waste minimization on process, product, production rate etc. has to be evaluated. In addition, an inventory has to be made of the necessary technical changes for the implementation of the waste minimization opportunity.

11. *Assess financial viability:* Financial viability will often be the key parameter in the evaluation of waste minimization opportunities. Priority should be given to the evaluation of the low-cost options, which often require only simple analysis like pay back calculations. A proper evaluation of higher cost options should include the full array of potential savings (including, but not limited to, savings on raw materials and energy, increased production and lower operation and maintenance cost) and might require advanced financial methods (like net present value or internal rate of return).

12. *Evaluate environmental aspects:* In most cases the environmental advantage of waste minimization opportunities is obvious. However for complex options, involving changes of raw materials or process chemistry, care should be taken to assess whether or not a net reduction of toxicity and quantity of waste and emissions occurs.

13. *Select solutions for implementation:* The results of the technical, financial and environmental evaluation have to be combined in order to select the most practical and viable solutions. Proper documentation of the selected solutions will be highly useful in obtaining approval and funds for the actual implementation of these solutions.

#### 5. Implementing waste minimization solutions

The selected waste minimization solutions now have to be implemented. A significant number of solutions might be implemented as soon as they are identified (i.e. repairing of leaks and enforcement of working instructions), while others would require a systematic plan of implementation. To this end, the following tasks should be undertaken:

14. *Prepare for implementation:* This includes arranging finances, establishing task forces, detailed technical preparation and planning of the implementation. Good liaison, awareness and information dissemination should assist in obtaining the involvement of key departments and persons.

15. *Implement waste minimization solutions:* Implementing waste minimization solutions is similar to any other industrial modification. In order to optimize the implementation results, the simultaneous training of manpower should not be missed out.

16. *Monitor and evaluate results:* A performance evaluation is needed to assess causes for deviation of the results obtained from the results expected as well as to inform management and to sustain its commitment for waste minimization.

#### 6. Sustaining waste minimization

It might seem in the first place that waste minimization is completed upon the implementation of the feasible waste minimization solutions. However, the team still faces the major challenge of sustaining waste minimization in order to further reduce wastes and improve profits in the future. This basically consists of the two activities:

17. *Sustain waste minimization solutions:* Especially for housekeeping and process optimization, employees tend to return to the wasteful, old practices if not continuously motivated to sustain the improved practices. Information is therefore crucial in order to monitor ongoing achievements. Reward and recognition schemes could safeguard the ongoing involvement of the employees.

18. *Identify and select wasteful process steps:* Having improved the environmental performance of selected wasteful processes, a new selection should be made as the focus for the next waste minimization audit. The newly selected processes

should then be subjected to the audit procedure (start at step 2: "Analysing production process steps").

### 3.3 Technical manuals

The generic guidelines for waste minimization focus on industrial entrepreneurs in order to convince them of the opportunities and benefits of waste minimization. The guidelines contain only a brief and general introduction to the techniques of waste minimization auditing. It is envisioned that these entrepreneurs will then pass on the job of implementation of waste minimization to their technical staff. In order to serve this technical staff in the execution of the waste minimization audit, a series of sector-specific technical manuals has been developed.

#### Objective and outline

The sector-specific waste minimization manuals address primarily technical experts in the respective industry sector. Reading through the manual, they should be able to find enough information on suggested waste minimization opportunities and auditing tools to conduct a waste minimization audit in their industry. To this end, example waste minimization opportunities are broadly evaluated and the audit methodology has been tailored to the industry sector. In addition, examples of company-level waste minimization audits are included.

To achieve the above general objective, the following logical sequence of aims has been elaborated in each of the technical manuals:

1. Establish the *potential* for waste minimization;
2. Suggest waste minimization as the *solution*;
3. Provide a set of *practical approaches*;
4. Provide a *framework for the implementation* of waste minimization;
5. Identify *additional assistance*.

This has been elaborated into a technical manual of about 100 pages for the agro-residue-based pulp and paper industry, textile dyeing and printing industry and pesticides formulation industry. Each manual contains numerous examples and technical details. The content is summarized in Box 3.2. Table 3.1 has been compiled to summarize the coverage of each of the technical manuals.

### 3.4 Practical experiences

Since the audit guidelines and manuals have been developed based on practical experience of the companies, no real test of these auditing tools has taken place as part of the DESIRE project. It is, however, possible to relate the practical experiences in the participating companies to the proposed audit methodology. The results of doing so have been

Box 3.2: Summary of the content of the sector-specific technical waste minimization manuals

#### FROM WASTE TO PROFITS: SECTOR-SPECIFIC MANUALS FOR WASTE MINIMIZATION

- |                                   |  |
|-----------------------------------|--|
| Chapter 1:                        | Industry profile<br>Short introduction to processes, techniques, financial and environmental problems in the industry sector.  |
| Chapter 2:                        | Waste minimization: principle, need and potential<br>Explanation of the coverage of waste minimization (generally applicable techniques), with applications from the respective industrial sector. An estimate is given for the financial and environmental benefits to be gained from adopting waste minimization in an average unit in the respective industry sector. |
| Chapter 3:                        | Waste minimization opportunities<br>Comprehensive listing of suggested waste minimization opportunities, organized per process area (unit operation) in the respective industrial sector. Each opportunity is broadly assessed on financial, technical aspects and environmental benefit.  |
| Chapter 4:                        | Let's do it<br>Description of the waste minimization audit methodology (see figure 3.1), tailored to the opportunities and constraints of the industrial sector. Some worksheets have been added in order to streamline data collection and evaluation for the industrial sector.  |
| Chapter 5:                        | Barriers to waste minimization and enabling measures<br>A summary of the most important barriers that might be encountered in the industrial sector and tailor-made enabling measures to these industry specific constraints.  |
| case-studies                      | The results and experiences of the waste minimization audit in two companies participating in the DESIRE project are included as annexes to the manual.  |
| Sources of additional information | Listing of useful documentation and contacts for additional assistance.  |

Table 3.1: Coverage of the technical waste minimization manuals at a glance (Chandak et al, 1995a, 1995b, 1995c)

Coverage	agro-residue-based pulp and paper industry	Pesticides formulation industry	Textile dyeing and printing industry
Process areas	<ul style="list-style-type: none"> <li>Raw material preparation</li> <li>Pulp mill</li> <li>Stock preparation</li> <li>Paper machine</li> <li>Utilities</li> </ul>	<ul style="list-style-type: none"> <li>Granules formulation</li> <li>Dust formulation</li> <li>Liquid formulation</li> </ul>	<ul style="list-style-type: none"> <li>Cloth preparation (scouring, bleaching)</li> <li>Cloth dyeing</li> <li>Cloth printing</li> <li>Cloth finishing (washing, ageing, softening, heat setting)</li> <li>Colour and paste preparation</li> <li>Utilities</li> </ul>
Environmental issues	<ul style="list-style-type: none"> <li>Waste water discharges</li> <li>Fibre loss</li> <li>Energy consumption</li> <li>Water consumption</li> <li>Chemical consumption</li> </ul>	<ul style="list-style-type: none"> <li>Toxic fumes</li> <li>Dust emissions</li> <li>Cleaning waste</li> <li>Leftovers in drums etc.</li> <li>Off specification products</li> </ul>	<ul style="list-style-type: none"> <li>Waste water discharges</li> <li>Energy consumption</li> <li>Water consumption</li> <li>Chemicals selections and consumption</li> </ul>
Waste minimization potential (environmental)	<ul style="list-style-type: none"> <li>Potential reductions per ton paper production:</li> <li>fibre: 40-100 kg</li> <li>caustic: 10-15 kg</li> <li>additives: 1-2 kg</li> <li>steam: 0.5-1.5 ton</li> <li>electricity: 60-120 kWh</li> <li>water consumption: 60-120 m<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>70-80 % reduction of losses of active ingredients</li> <li>60 % reduction of losses of formulation compounds (soapstone, granules, solvents)</li> </ul>	<ul style="list-style-type: none"> <li>15-20% reduction in Chemical Oxygen Demand (COD)</li> <li>30-40% reduction in water use</li> <li>10-20% reduction in steam consumption</li> <li>5-10% reduction in electricity use</li> </ul>
Waste minimization potential (financial)	<ul style="list-style-type: none"> <li>Savings on materials, energy and water: Rs 700-1800 /ton paper production</li> <li>Savings on effluent treatment cost: Rs 500 /ton paper production</li> <li>Capacity expansion generally possible but not well quantified</li> </ul>	<ul style="list-style-type: none"> <li>RS 60,000-90,000 /yr. savings on raw materials per formulation unit</li> <li>Capacity expansion generally possible but not quantified</li> </ul>	<ul style="list-style-type: none"> <li>Savings on material, energy and water: Rs 700,000 to 1,500,000/year</li> </ul>

note: 30 Rs = 1 \$

summarized in table 3.2 (see pp. 32-33). This table lists the impediments encountered along with supervisory tasks and suggested methodological improvements.

From table 3.2 it can be concluded that although the DESIRE audit methodology fits quite well the opportunities and capabilities of SSIs, a number of impediments are to be expected if companies have to implement the audit methodology on their own. These impediments do not, however, originate in the audit methodology itself but rather in the limited development of project organization and management skills of the companies (as discussed in chapter 2). Outside experts (consultants and training or industry service institutes) can

easily facilitate the proper development of the waste minimization audit in a particular company. To this end, the outside expert basically has to see to the reasonable execution of each of the tasks specified in the audit methodology by the company audit team. Such a programmatic role does not require much technical expertise from the outside expert; it requires rather the ability to motivate and enable the company level audit team to execute the audit by itself (Van Berkel, 1994). In this role, the outside expert resists the temptation to overtake the audit tasks from the company audit team because a waste minimization audit executed by outside experts is not likely to be as effective in terms of involving staff and operators and assuring the implementation of waste minimization.

Table 3.2: Practical experiences with the DESIRE audit methodology

Audit tasks Bottlenecks encountered Supervisory tasks Suggested improvements

**STEP 1: GETTING STARTED**

1. Designate waste minimization team	1. Industries are not used to systematic project work.	1. Assist in team building; instruction in data evaluation and problem solving approaches.	
2. List process steps	2. Lack of good housekeeping attitudes hampers identification of obvious lapses in process control, maintenance, etc.	2. Pinpoint obvious lapses in housekeeping; check completeness of preliminary inventory of processes and associated in- and outputs.	Inclusion of checklists with frequently occurring poor housekeeping practices and generally applicable low- and no-cost waste minimization opportunities.
3. Identify and select wasteful process steps	3. Tendency exists to overlook excessive use of 'cheap' resources (water etc.).	3. Support priority setting; advocate implementation of obvious no- and low-cost opportunities.	

**STEP 2: ANALYSING YOUR PROCESS STEPS**

4. Prepare process flow chart	4. Unplanned development and extension of facilities hampers preparation of correct flow chart.	4. On the spot verification of flow charts.	
5. Make material and energy balance	5. Non availability of sufficiently detailed data; lack of monitoring equipment.	5. Assist in data collection and evaluation; supply necessary equipment.	Improve explanation of logical option generation cycle; provide checklist with possible waste
6. Assign costs to waste streams	6. Resistance to include environmental costs.	6. Emphasize monetary losses in the first place (raw materials, product and manufacturing cost).	generation causes (task No.7) that fits to the available set of generally applicable waste minimization techniques (fig. 1.1 and task No.8).
7. Review of process to identify waste causes	7. Lack of skill and experiences to evaluate processes.	7. Participate in process evaluation; question process details with operators and supervisors.	

**STEP 3: GENERATING WASTE MINIMIZATION OPPORTUNITIES**

8. Develop waste minimization opportunities	8. Difficult to create enabling environment for workers and technicians to contribute to creative problem solving.	8. Participate in option generation session; challenge workers and technicians to share experiences; systematic evaluation of all waste generation causes.	Relate generally applicable waste minimization techniques to standardized waste generation causes (see also step 2).
9. Select workable opportunities	9. None.	9. Check whether acceptable criteria and arguments are used.	

cont

Audit tasks	Bottlenecks encountered	Supervisory tasks	Suggested improvements
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STEP 4: SELECT THE BEST ALTERNATIVE OPPORTUNITIES			
10. Assess technical feasibility	10. Non-availability of engineering details to elaborate equipment-related options.	10. Support the technical evaluation; identify technical know-how and suppliers.	
11. Assess financial viability	11. Tendency to limit analysis to short-term, direct gains (underestimation of benefits)	11. Contribute to reasonable quantification of less-obvious financial benefits.	None
12. Evaluate environmental aspects	12. None.	12. Broadly verify figures.	
13. Select solutions for implementation	13. Tendency to prioritize low-cost options, regardless of inferior technical or financial performance.	13. Check consistency of selection with outcome of feasibility studies.	

STEP 5: IMPLEMENT WASTE MINIMIZATION SOLUTIONS			
14. Prepare for implementation	14. Most solutions required minimal investments enabling almost immediate implementation.	14. Assist in seeking support and funds for implementation.	
15. Implement waste minimization solutions	15. Instruction of personnel not always seriously addressed.	15. Pinpoint and illustrate the need for proper instruction of employees.	Include suggestions for performance indicators for monitoring waste minimization progress.
16. Monitor and evaluate results	16. Lack of simple performance indicators.	16. Suggest appropriate, easy-to-monitor performance indicators.	

STEP 6: MAINTAIN WASTE MINIMIZATION			
17. Sustain waste minimization solutions	17. No experience gained in the DESIRE project.	17. Advise on appropriate reward or recognition systems.	Include suggestions for simple but effective employee reward and recognition opportunities.
18. Identify and select wasteful steps	18. No experience gained in the DESIRE project.	18. Assist in selection of audit focus for second waste minimization audit.	

Table 3.2 suggests specific additional guidance that could be provided in the DESIRE audit manual in order to ease its implementation. These are in particular:

- *Checklist to identify obvious lapses in housekeeping, process control and maintenance* and to generate obvious, no- and low-cost solutions to eliminate these lapses (step 1 getting started);
- More detailed explanation of the logic behind option generation: at present the logical link between cause evaluation (task No. 7: "Review processes in order to identify the waste generation causes") and option generation (task No. 8: "Development of waste minimization opportunities") is not yet explained. It is felt that option generation could benefit from explicit attention for this logical link; therefore waste generation causes and generally applicable waste minimization techniques (see figure 1.1) have to be classified in logical groups of problems (waste generation causes, for task No. 7) and solutions (waste minimization techniques, for task No. 8);
- Suggestions for *performance indicators*: this should include possible performance indicators along with suggested applications (type of options to which these might be applied) and monitoring provisions (step 5: "Implementing waste minimization solutions");
- Suggestions for *employee reward and/or recognition schemes* in order to sustain employee involvement for the ongoing implementation of waste minimization solutions (step 6 "Sustaining waste minimization").

### 3.5 Dissemination experiences

The waste minimization guidelines and manuals have been made in order to foster the dissemination of the results and experiences of the DESIRE project, which in turn was the fifth aim of the project (see section 1.3). To initiate these dissemination activities, a series of three sector specific workshops as well as a national seminar have been organized. In addition, the present final report along with the DESIRE audit manual and associated video will help sustain the initial dissemination efforts.

#### Sector specific workshops

The sector specific workshops aimed at participation from SSIs and had three separate but interrelated objectives:

- To create *awareness* of the waste minimization concept and its opportunities in the respective sector;
- To *inform* about the waste minimization results achieved in the demonstration units and the barriers encountered while doing so;
- To present a waste minimization *audit methodology* by which other units might achieve similar results.

The pulp and paper workshop was held in New Delhi on 28 November 1994 and attracted about 30 participants. The textile dyeing and printing workshop was held in Surat on 1 December 1994 and attracted about 140 participants. The pesticides formulation workshop was held in Ahmedabad on 3 December, 1994 and attracted about 35 participants.

The programme for the sector-specific workshops consisted of:

- Opening ceremony (including welcome addresses by industrial authorities and DESIRE study team);
- Presentation of the DESIRE project (by technical study team);
- Presentation of the DESIRE audit methodology with applications from the respective industry sector (by technical study team);
- Overview of sectoral results (by technical study team);
- Presentation of company-level results and experiences (by representatives of the participating companies);
- Summary of constraints, catalysts and enabling measures (by meta review study team);
- Summary of lessons learned (by international expert);
- Closing session (with participants' feedback).

The workshops generally served their threefold purpose of creating awareness for waste minimization, informing about results and presenting the waste minimization audit methodology. The presentations of the results by the companies were most powerful in convincing other units to get started with waste minimization. Throughout the workshops, emphasis was given to the practical

solutions implemented by the companies. This might have had the drawback that the participants experienced the workshops as an endorsement to implement the *same solutions* instead of as an endorsement to apply the *same audit methodology* to identify solutions tailored to the specifications of their own units.

The sectoral workshops clearly underscored the success of the DESIRE project, particularly in the pulp and paper industry and, even more so, in the textile dyeing and printing industry. In the beginning, only three textile dyeing and printing units from Surat could participate (Paradise Prints, Garden Express Printing and Bhavin Textiles). In the early phases of the project implementation, another unit joined (Luthra Dyeing and Printing). Upon the finalization of DESIRE, several options developed as part of DESIRE (like dye bath reuse, print paste collection and reuse, gas-fired systems etc.) were already implemented in some 15 to 25 units in Surat.

### National seminar

A national seminar was held from on 6 to 7 December 1994 in New Delhi by the Confederation of Indian Industries (CII), in cooperation with the Friedrich Erbert Stiftung (FES), UNIDO and the NPC. The two day programme was designed in order to:

- Create *awareness* on the waste minimization opportunities, benefits and constraints among industrial and governmental leaders;
- Contribute to the discussion on, and development of, *appropriate policies* for the dissemination of waste minimization among SSIs in India.

Around 80 persons attended the programme.

The programme consisted of:

- **Welcome session:** opening addresses by officials from industrial and environmental authorities and presentation of sectoral waste minimization awards to Paradise Prints (textile dyeing and printing), Super Industries (pesticides formulation) and Ashoka Pulp and Paper;
- **Introductionary session:** presentation of background, genesis and activities of the DESIRE project (by NPC and UNIDO);
- **Summary session:** sectoral overviews of the waste minimization achievements in the participating companies (by technical team);

- **Company examples:** presentations of company level results and experiences (by industrial leaders of the award winning companies);
- **Evaluation session:** presentation of lessons learned and barriers encountered in the company level waste minimization audits (by meta review study team and international expert);
- **Policy session:** views on the project achievements from MOEF, Central Pollution Control Board and CII;
- **International session:** presentation of waste minimization initiatives in China, the Netherlands, Pakistan, and Sri Lanka (by international experts);
- **Valediction:** summary of the seminar topics.

The seminar was effective in achieving the first objective. The pros and cons of waste minimization were discussed by the participants and the seminar attracted a lot of attention in the media (Indian economic newspapers etc.). However, it is felt that the seminar didn't contribute significantly to the second objective, for a number of reasons:

- **Confusion** about the waste minimization *concept* as practised in the DESIRE project, because the policy sessions slipped into other subsets of environmental policies (like waste utilization, unleaded fuel etc.) and other target groups (international waste management corporations, power plants etc.);
- **Lack of a policy proposal** for a waste minimization fostering strategy.

It is felt that a larger step forward could probably have been made by presenting a vision of what a waste minimization fostering policy should look like (as in chapter 5 of this report) and by using the seminar as a discussion platform for getting feed back on the strategy and obtaining commitment to improving and implementing this strategy.

### Recommendation

Although the DESIRE project has highlighted a number of examples of companies that have benefited from the application of waste minimization concepts, approaches and methods, international experience (from, for instance, Austria, Denmark, the Netherlands, the United States of America etc.) shows that this will not automatically incite other companies to start a waste



minimization audit for their own operations. A properly planned and designed communication and dissemination strategy is needed in order to achieve a maximum multiplier effect from the DESIRE project. The following general recommendations can be given for the development of such a dissemination strategy:

*1. Use example options and indicators to get started*

The practical results achieved in the demonstration units clearly illustrate the possible benefits of waste minimization. Although the options implemented in the demonstration units were the best practical solutions to the waste generation problems in these demonstration units, these options are normally not the best practical solutions for all companies in the respective industry sector. Options should therefore be presented as examples in order to boost option generation by plant representatives in other units in the same industry sector. In addition, one might avoid the common reaction of other units ("they could do so, but I'm already more efficient than they are") by developing indicators for the range of savings and environmental benefits that can be achieved by waste minimization per unit of production. The industry specific manuals already contain such indicators. In support of the manuals, there could be a need for easily accessible, basic information in flyers, for instance.

*2. Employ a general audit methodology to identify tailor-made solutions*

The general audit methodology (as outlined in the DESIRE guidelines and technical manuals) should be used as the vehicle for the dissemination of results. The company-level achievements in each sector might be presented as evidence that the systematic implementation of the waste minimization audit will bring benefits to each company willing to invest some human resources in the implementation of the waste minimization audit.

*3. Foster cooperation for environment-driven technological development*

It cannot be expected that all waste generation causes can be eliminated by existing equipment and technology. Therefore, cooperation between companies facing the same waste generation problems might incite technical institutes as well as equipment suppliers to develop appropriate technical provisions for waste minimization in the respective industry sector. The development of waste minimization circles is therefore a promising approach.

### 3.6 Concluding remarks

The DESIRE project proved the need for a waste minimization audit procedure tailored to the needs and capabilities of small-scale industries. To this end, international waste minimization methodologies have been merged with the practical experiences of the companies participating in the DESIRE project in order to arrive at a new audit methodology. This in turn has been elaborated into both generic waste minimization guidelines, aimed at obtaining interest in, and commitment to, waste minimization from industrialists and sectoral technical waste minimization manuals aimed at assisting technical staff in SSIs to identify, evaluate and implement waste minimization. The practical experiences in the participating companies show that this general audit methodology enables companies to identify and implement tailor-made waste minimization solutions. Whether or not the audit methodology will enable SSIs to conduct waste minimization audits on their own is not yet known. Most likely, SSIs will still need limited guidance and assistance from outside experts, given the lack of project organization and management skills. With the help of the DESIRE audit methodology, the input of outside experts can be limited to a programmatic role, in which they supervise the completion of each of the tasks specified in the audit methodology, with little need of technical expertise.

Within the DESIRE project, a start has been made with the dissemination of waste minimization results and experiences. To this end, a national seminar as well as three sector-specific workshops have taken place. These showed that the presentations of the case-studies by the respective industrialists were most powerful in convincing outsiders of the opportunities and benefits of waste minimization.

The DESIRE audit methodology can be used as the vehicle for the dissemination of waste minimization. To this end, a properly planned and designed communication and dissemination strategy is needed. Chapter 5 (particularly section 5.3) contains more detailed thoughts on the further dissemination of the waste minimization successes.

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# Financial and environmental dividends in companies

## 4.1 Introduction

This chapter contains the comparative analysis and evaluation of the results – the concrete waste minimization measures identified and implemented – that have been achieved in the three industrial sectors covered by the DESIRE project. The results will be reviewed against the hypotheses put forward at the start of the project. These were:

- There are *many opportunities* for waste minimization in SSIs. These can be detected by making an integral analysis of the company, including – but not limited to – its production processes, input materials, waste streams and emissions.
- Many of these waste minimization opportunities can be implemented by SSIs within the *short term* (within 1 to 3 years).
- Waste minimization goes *beyond technical modifications*; it can also be achieved by improvement of operating practices, changes of input materials and recycling practices.
- The implementation of waste minimization will *benefit the company*; these benefits will include monetary savings as well as less tangible benefits such as improvement of working conditions, improvement of product quality and improvement of the local environment around the facility.

These hypotheses will be dealt with in this chapter. To this end all waste minimization measures identified in the participating companies are categorized, with regard to:

1. *Waste minimization technique*: following the subdivision discussed in section 1.2 (good housekeeping, input material change, better process control, equipment modification, technology change, on-site reuse, useful by-product and product modification);

2. *Implementation status*: a division is made between measures implemented in the course of the DESIRE project ('implemented'), measures being under implementation at the end of the project ('started'), measures planned for implementation ('planned') and measures proven technically or financially-unfeasible ('rejected');

3. *Investment*: measures are classified according to the required investment level, being low (less than Rs. 30,000 (\$1,000)), medium (Rs. 30,000 – Rs. 90,000 (\$1,000 – \$3,000)) or high (more than Rs. 90,000 (more than \$3,000 ));

4. *Financial feasibility*: to this end the measures are classified according to the pay back period, being either low (less than 1 year), medium (between 1 and 3 years) or high (over 3 years);

5. *Environmental impact*: the options have been classified with regard to the nature of the environmental impact, being minimization of air emissions, minimization of waste water discharges or reduction of solid waste, as well as with regard to the quantity of waste reduction, being either low, medium or high. The categorization of the size of the environmental improvement is explained in table 4.1. Actual measurements could be made of reductions in solid waste generation and waste water discharges; these environmental impact categories are therefore given in weight. For air emissions, reductions had to be estimated and calculated; therefore the environmental impact categories are given as a percentage.

The results will be evaluated on a sectoral basis, starting with the agro-residue-based pulp and paper industry (section 4.2), pesticides formulation industry (section 4.3) and textile dyeing and printing industry (section 4.4). For each industrial sector a short description of typical waste minimization approaches in the sector, a summary of the company-level achievements for each participating company and a summary of the sector-level achievement will be given. The chapter concludes

**Table 4.1: Classification scheme for environmental impact of waste minimization measures**

Type of environmental improvement	Category		
	low	medium	high
<b>AIR POLLUTION:</b>			
Reduction in suspended particulate matter (SPM)	< 10 %	10 - 20 %	> 20 %
<b>WATER POLLUTION:</b>			
Reduction in kg/day of:			
• Chemical oxygen demand (COD)	< 100	100 - 300	> 300
• Total solids (TS)	< 120	120 - 350	> 350
<b>SOLID WASTE:</b>			
Reduction in kg/day of:			
• Non toxic waste	< 100	> 100	> 1000
• Toxic waste	< 0	> 0	> 0

with a general evaluation, consisting of the lessons learned regarding the features of the waste minimization potential in SSIs.

### 4.2 Pulp and paper industry

The production of paper based on agro-residues such as rice straw, wheat straw, bagasse and sarkanda causes severe pollution to the environment. Most visible are the waste water discharges containing 'black liquor' (concentrated liquor removed from the pulp after digestion containing remnants of pulping chemicals dissolved (hemi)-cellulose, lignin, dust and silica) and fibre loss. In addition, the industry is highly energy and water intensive. Air emissions include dust from raw material preparation and stack emissions from the boiler house.

Pulp and paper manufacturing consists of the following process areas:

- **Raw material preparation:** cutting and cleaning of the raw materials (agro-residues, rags and waste paper) in order to remove impurities (non-fibre components, sand and dust) and to improve the pulping characteristics of the raw material;
- **Pulp-making section:** production (cooking and digestion of raw materials), washing and bleaching of the pulp in order to produce a clean pulp;
- **Stock preparation section:** preparing the pulp for feeding to the paper machine, by means of refining, cleaning and dewatering of the pulp, mixing different pulp qualities and adding additives;
- **Paper-making section:** production of the paper from

the pulp on the paper machine, including drying of the paper and cutting of the paper;

- **Utilities:** boiler house, power generation and waste water treatment.

Waste minimization can be applied to each of these process areas, as illustrated in table 4.2.

The following industries were selected for participation in the DESIRE project:

1. M/s. Ashoka Pulp & Paper, Delhi;
2. M/s. Bindlas Duplex Pvt. Ltd., Muzzaffarnagar, U.P.;
3. M/s. Raval Paper Mills, Raibareilly, U.P.;
4. M/s. Sangal Papers, Mawana, U.P.;
5. M/s. Three Star Paper Mills, Dadri, U.P.

M/s. Sangal Papers did not participate in the project despite initial confirmation because the management did not remain committed and had other priorities. The unit was, therefore left out. M/s. Three Star Paper Mills, though initially agreed, changed their mind as they wanted to switch over from waste paper based to bagasse based paper making, and the required plant modification kept them out of the project for almost 8 months. Subsequently, they were attracted again, mainly because of the visible successes in other units; Three Star Paper Mills therefore became a late participant. The key findings at each of the participating units are summarized in annexes I to IV to this report.

The company level summaries contained in annexes I to IV show that the DESIRE project has been

Table 4.2: Illustrative waste minimization measures for agro-residue-based pulp and paper production (Chandak et al, 1995a)

Waste minimization technique	Illustrative examples with associated benefits
1. Good house-keeping	<ul style="list-style-type: none"> <li>• Closing water taps not in use in order to conserve water.</li> <li>• Proper inspection and maintenance of steam pipes, traps and valves in order to minimize steam losses and conserve energy.</li> </ul>
2. Input material change	<ul style="list-style-type: none"> <li>• Dedusting of raw agro-residue to reduce effluent load generation (6-8 % S reduction and 5-10 % COD reduction) and steam and chemical consumption by 7-10 % to increase pulping capacity and to improve pulp quality. The investment of about Rs. 400,000 for a 40 TPD plant is paid back in less than one year.</li> </ul>
3. Better process control	<ul style="list-style-type: none"> <li>• Optimization of cooking process (steam pressures, time and chemical dosing) in order to improve pulp yield and pulp quality. Pay back of the investment of Rs. 100,000-150,000 is difficult to quantify in advance.</li> </ul>
4. Equipment modification	<ul style="list-style-type: none"> <li>• Fibre recovery from centri-cleaners by fibres savers with high pressure pumps reduces TS and COD load by 2 %. The investment of Rs. 20,000-30,000 generates annual savings in the range of Rs. 200,000-400,000.</li> <li>• Better insulation of digester with appropriate insulating materials leads to reduced cooking steam requirement. The investment of Rs. 100,000-150,000 is paid back in less than one year.</li> </ul>
5. Technology change	<ul style="list-style-type: none"> <li>• Use of twin wire belt press for pulp dewatering enables a 60-70 % effluent volume reduction in pulp washing and recycling of thick black liquor for making use of residual cooking chemicals. The investment of Rs. 1,000,000-1,500,000 has an anticipated payback within two years.</li> <li>• Double felting in paper machine eliminates kerosene oil for avoiding press picking and allows for an increase of the machine speed. The investment of Rs. 350,000-400,000 is paid back in less than one year.</li> </ul>
6. Useful by-products	<ul style="list-style-type: none"> <li>• The use of screening rejects for unbleached paper making reduces solid waste while simultaneously saving on cooking chemicals. Without any investment, Rs. 100,000-200,000 can be gained.</li> </ul>
7. On-site recycling	<ul style="list-style-type: none"> <li>• Coult. Decker filtrate can be recycled in paper washing, thus reducing total solids and COD load by 2-2.5 %. The investment of Rs. 50,000-100,000 is paid pack in less than one year.</li> <li>• Installation of broke pulper for reduction in chemical costs for re-pulping broke paper and recovering fillers and other chemicals. Investment of Rs. 500,000-1,000,000 might be paid pack in two to four years.</li> </ul>
8. Product reformulation	<ul style="list-style-type: none"> <li>• Switch from bleached to unbleached paper production.</li> </ul>

extremely effective in achieving both environmental improvement and financial benefits for the participating agro-residue-based pulp and paper mills. Significant differences are apparent when the achievements per unit are compared. The total number of options ranges from 31 to 65 per mill, between 32 and 48 per cent of these options has been implemented within the course of the DESIRE project. The share of low cost options (requiring less than \$1,000 investment) is significant: between 30 and 58 per cent of all options for each company. In order to visualize the differences between the participating mills, table 4.3 has been compiled.

In the four mills, a total of 197 waste minimization options has been identified and evaluated. The nature and complexity of the options ranges from comparatively simple improvements of housekeeping practices and repair of leaks to relatively radical technology changes (like two-stage vacuum washer, high velocity hoods etc.). Figure 4.1 reveals some of these differences, since it contains the subdivision of all options according to the waste minimization technique employed. Four waste minimization techniques have about an equal share in the total number of options, respectively technology changes (21 per cent), better process control (20 per cent), good

Table 4.3: Summary of sectorial results in agro-residue-based pulp and paper industry

Company	No. of options	Implementation status	Option evaluation			Total impact	
			Payback period	Environmental impact	Financials	Environment	
1. Ashoka Pulp & Paper	50				Investments: \$95,000 Savings: \$160,000/yr Payback: < 7 months Savings of \$47,000 in treatment cost	30% COD reduction	
2. Bindias Duplex	51				Investment: \$104,000 Savings: \$330,000/yr Payback: < 4 months Savings of \$43,000 in treatment cost	28% COD reduction	
3. Raval Paper Mills	65				Investment: \$150,000 Savings: \$182,000/yr Payback: < 10 months Savings of \$55,000 in treatment cost	34% COD reduction	
4. Three Star Paper Mills	31				Agro-residue based pulp production not yet stabilised	Agro-residue based pulp production not yet stabilised	
<b>SECTORAL SUMMARY</b>	197				I = \$ 347,000 S = \$ 672,000 P = 6 months	Estimated total reduction per ton of paper production at four mills: 32% effluent volume 31% COD load 40% TS load	

housekeeping (20 per cent) and on-site recycling (17 per cent).

These waste minimization options apply to different parts of the pulp and paper mills. Figure 4.2 shows the division of the options over the most important sections in the pulp and paper mills. Most options apply to pulp making (33 per cent) and paper making (32 per cent). The remaining options address environmental concerns arising from raw material preparation, stock preparation and utilities.

The waste minimization efforts in the agro-based pulp

and paper sector concentrated on water-related environmental concerns; 78 per cent of the options aimed at minimization of the waste water discharges (see figure 4.3). Most of these options have related environmental benefits, such as better raw material, chemicals, water and energy utilization. The second largest share belongs to the options aiming at minimization of air pollution (19 per cent); generally speaking these reductions of air emissions are achieved through minimization of the steam requirements throughout the mill, via for instance insulation, improved equipment design and lay out and better operating practices.

Figure 4.1: Division of the waste minimization options according to waste minimization technique (paper industry: 197 options)

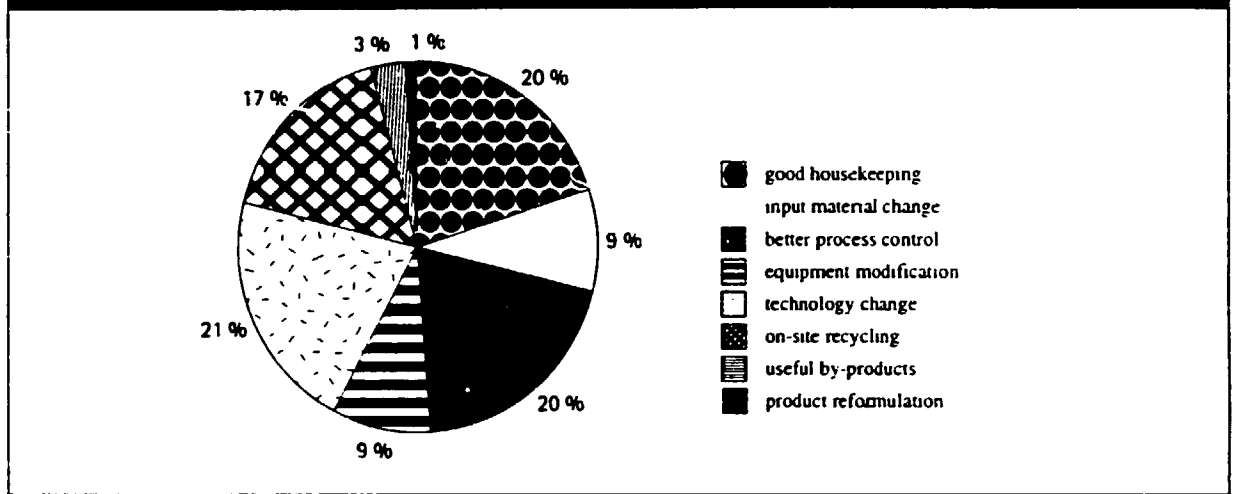
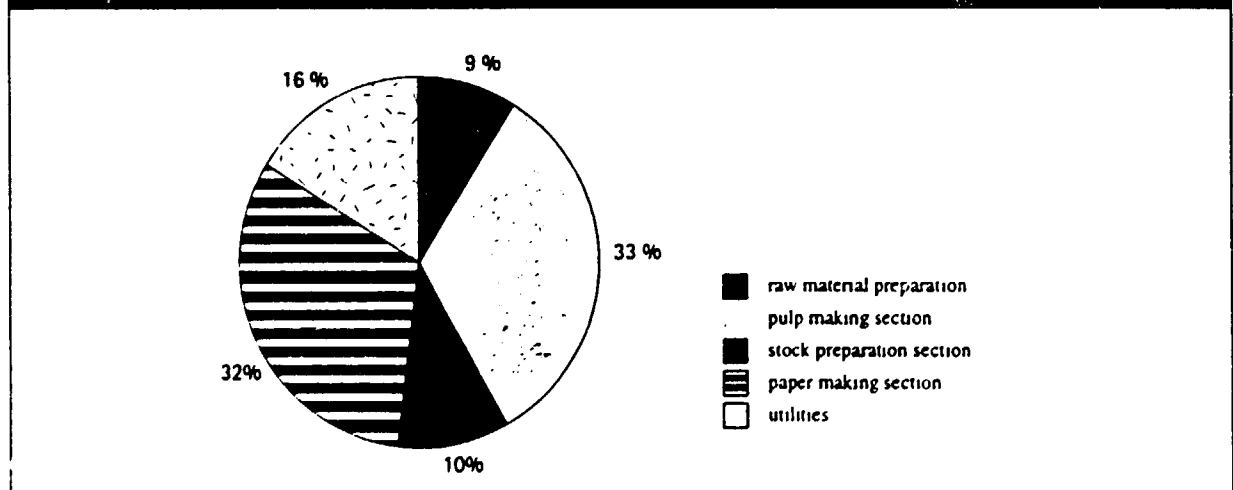


Figure 4.2: Section-wise division of waste minimization options (paper industry: 197 options)



The implementation status of all options is finally depicted in figure 4.4. A significant share of the options (42 per cent) could be implemented within the 15-month time-frame of the DESIRE project. In addition, a start has been made with the implementation of another 19 per cent of the options. A comparatively small share of the options (11 per cent), was proved to be feasible, but implementation was not yet started for various reasons (like non-availability of capital, the need to plan for plant shut down in order to implement the option etc.). Finally, for the remaining 28 per cent of the options, either more detailed technical and financial viability study needs to be carried out or the management has yet to take them up and include in the implementation programme. It can thus be concluded

that most options were very practical; as many as 72 per cent of all options identified proved to be feasible upon detailed evaluation.

The overall financial impact could not be evaluated properly at one of the mills, due to change from waste paper based to agro-residue-based paper production (at Three Star Paper Mill). The other three mills invested \$349,000 in the first batch of 72 feasible waste minimization options. These options generate net annual savings worth \$672,000. An additional financial benefit of \$145,000 is caused by the reduction of the effluent treatment costs. This in turn means that, even without savings on end-of-pipe treatment costs, the investments generated by the DESIRE project in the

Figure 4.3: Division of waste minimization options according to environmental impact (paper industry: 197 options)

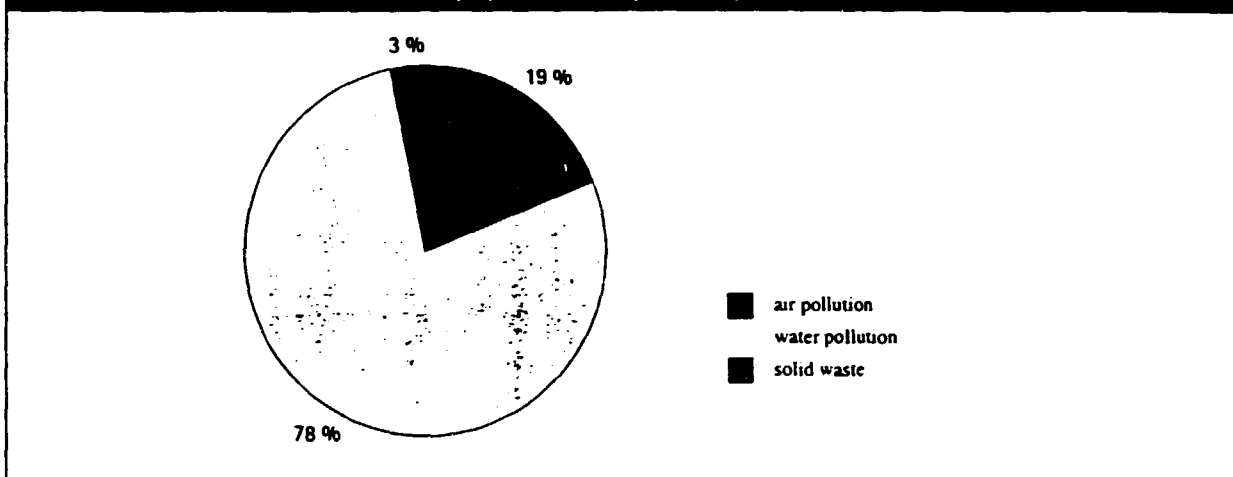
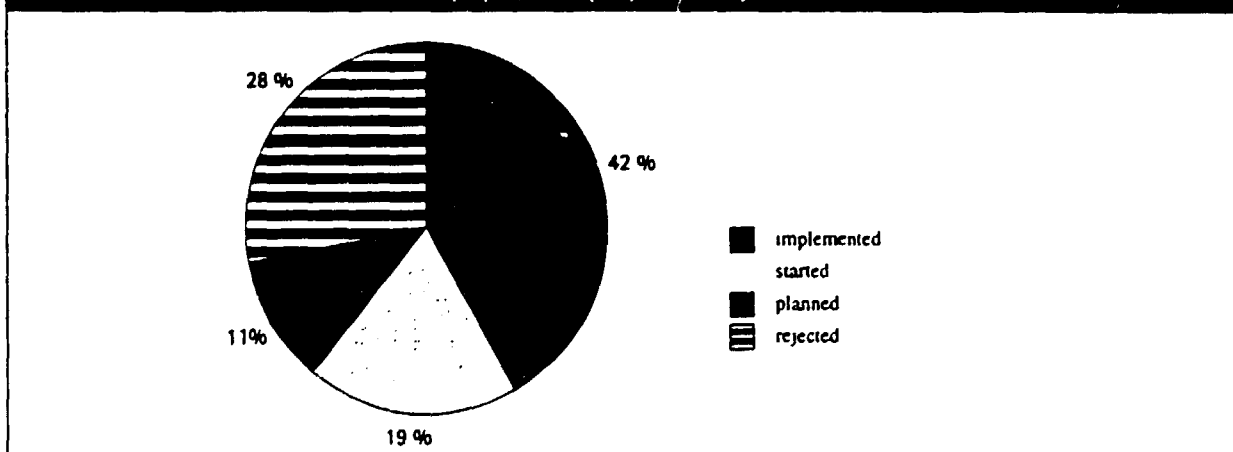


Figure 4.4. Implementation status of the waste minimization options (paper industry: 197 options)





agro-residue-based pulp and paper industry had an overall pay backtime of six months.

### 4.3 Pesticides formulation industry

Pesticides formulation converts highly concentrated pesticide active ingredients into convenient-to-use products at application concentrations packaged for the end user. The processes used to formulate pesticides are basically blending operations where the active ingredients are mixed with inert materials (fillers (pulverized soapstone, clay), solvents etc.). Generally, chemical reactions do not occur in pesticides formulation, as opposed to the chemical complexity of the production of the active pesticides.

The manufacturing process thus primarily consists of batch type mixing in solid-solid, solid-liquid and liquid-liquid phases. Therefore, there are no process waste streams. Waste arises principally from spillage, fugitive emissions and equipment cleaning between the formulation of different types of products in the same equipment. Waste generation ratios are therefore normally small compared to the overall material flows in the facility, which leaves little space for cost-recovering waste minimization options. However, given the high toxicity of the waste materials – especially those waste materials possibly contaminated with active pesticides – efforts to minimize waste generation do have a significant positive environmental impact, both within the factory (working conditions) and outside the factory (especially in the immediate vicinity of the plants).

Four types of products are at present made in large volumes by small-scale pesticide formulators:

- *Granule based formulations:* 10 per cent phorate granules is by far the single largest granule based formulation. Phorate is sprayed on clay granules. The granules are then coated with a solvent based coating before being weighed and packed.
- *Dust formulations:* products include BHC (5-50 per cent), fenvalerate (0.4 per cent), malathion (5 per cent), methyl parathion (2 per cent), quinalphos (1.5 per cent) and thiram (75 per cent) and are typically applied as dusting powders by the farmers. The main raw materials are soap-stone or china clay (filler), respective liquid or solid active pesticide and adjuvants. After crushing and pulverising, the active pesticide is sprayed on (in case of liquid technical) or mixed with (in case of solid technical) the pulverized filler.

- *Wettable powder formulations:* products include BHC (50 per cent), butachlor (5 per cent), carbendazim (50 per cent) and isoproturon (50 per cent), and are typically dispersed in water before being applied by the farmer. Raw materials as well as process steps are essentially the same as in the production of dusts.

- *Liquid formulations (emulsion concentrates):* products include butachlor (50 per cent), cypermethrin (10-25 per cent), chlorpyrifos (20 per cent), DDVP (76 per cent), dimethoate (30 per cent), dichlorophos (70 per cent), endosulfan (35 per cent), fenvalerate (20 per cent), lindane, methyl parathion (50 per cent), monocrotophos (36 per cent) and quinalphos (25 per cent). The products have to be diluted by the farmer before being sprayed on the crops. The raw materials for the formulation of liquids are active pesticide (liquid or solid), solvents and adjuvants. The process consists of mixing and dispersing active pesticide and adjuvants in solvents. Before being filled, the product is normally filtered.

Waste minimization can be applied to each of these types of formulation plants. For each waste minimization technique (as distinguished in table 1.1) some illustrative examples are given for the pesticides formulation industry (see table 4.4). Some of these are normally easy to implement (like good housekeeping and better process control), while implementation of others might go beyond the capabilities of a single small-scale pesticide formulator (like changes to new types of formulations and new types of active pesticides).

The following industries were selected for participation in the DESIRE project:

1. M/s. Baroda Minerals & Grinding Industries Ltd. Ahmedabad;
2. M/s. Indichem, Ahmedabad;
3. M/s. Northern Minerals Ltd. Gurgaon;
4. M/s. Super Industries, Ahmedabad;
5. Vimal Pesticides Ltd., Ahmedabad.

M/s. Indichem had severe financial problems and, therefore, did not join the project initially. However, after seeing the success of the other units, the unit started taking initiative towards the end of the project. Although some assistance was provided to this company, it has been kept out of the sectoral summary. The most important findings for each of the companies are given in annexes V to VIII.

Table 4.4: Illustrative waste minimization measures for pesticides formulation (Chandak et al, 1995b)

Waste minimization technique	Illustrative examples with associated benefits
1. Good housekeeping	<ul style="list-style-type: none"> <li>Use of industrial vacuum cleaner instead of manually sweeping the floor results in recovery of spilled soapstone granules etc. significant reduction of fugitive emissions and improvement of the working environment.</li> </ul>
2. Input material change	<ul style="list-style-type: none"> <li>Use of high quality raw materials (such as granules with sufficient absorption capacity, pure grade solvents, etc.)</li> <li>Substitution of toxic adjuvants by less toxic adjuvants (for instance dispersing agents, solvents).</li> </ul>
3. Better process control	<ul style="list-style-type: none"> <li>Quality check on all incoming materials (and their packages)</li> <li>Proper implementation of procedures for loading and unloading of blenders and other equipment.</li> </ul>
4. Equipment modification	<ul style="list-style-type: none"> <li>Installation of rotary air lock valve to cut-off pressurized air entering dust blenders, to avoid excessive fugitive dust emissions during blending.</li> <li>Introduction of manual trolleys for weighing and charging soapstone powder to blenders.</li> </ul>
5. Technology change	<ul style="list-style-type: none"> <li>Installation of fluid coupling assembly to avoid unloading of (dust) blender after power failure; avoids waste generation and workers' exposure and might increase productivity by about 10 %.</li> <li>Installation of automatic volumetric filling and packing machine for small volume packages reduces workers' exposure to toxic fumes, reduces excess filling and increases production rate.</li> </ul>
6. Useful by-products	<ul style="list-style-type: none"> <li>Off-site reuse of technical packages (drums) by supplier of active pesticides.</li> </ul>
7. On-site recycling	<ul style="list-style-type: none"> <li>Rinsing technical packages with a suitable solvent; rinse solvent might be stored and reused as part of the recipe in the next batch of the same product.</li> </ul>
8. Product reformulation	<ul style="list-style-type: none"> <li>Introduction of new types of formulations which minimize users' exposure and ecological risks during application (like dispersion concentrates (water based), water dispersible granules and controlled release applications).</li> <li>Introduction of formulations based on less toxic and more specific active ingredients (like growth inhibitors etc.).</li> </ul>

The summaries of the company-level final results illustrate that the DESIRE project has enabled each participating pesticide formulating industry to implement several waste minimization options. In the four plants, a total of 224 waste minimization options has been identified and evaluated. Of these 133 should be considered as feasible and could be implemented or are in the process of (planning for) implementation, while the remaining 91 have been rejected by the companies. The implementation of the feasible options requires only small investments (97 per cent of the options required less than \$1,000 investment) and results in significant, but difficult to quantify, reductions of fugitive emissions of dust and toxic materials. The analysis of the achievements per unit shows remarkable differences. The total number of options ranges for instance from 47 to 64 per unit, between 25 and 39 per cent of these options

have been implemented within the course of the DESIRE project. In order to visualize the differences between the participating industries, table 4.5 has been compiled.

As had been expected in the pesticides formulation sector, most of the feasible waste minimization options fell under the categories of good housekeeping (38 per cent), on-site recycling (30 per cent) and equipment modification (20 per cent) as illustrated in Figure 4.5. These are comparatively simple improvements which the industries are apparently able to implement with limited outside technical assistance. More radical environmental improvements, like product reformulations and technology changes, seem to go beyond the capabilities of small-scale pesticides formulating industries, given their absence among the feasible options identified in the pesticides sector study of the DESIRE project.

Table 4.5: Summary of sectoral results in pesticides formulation industry

Company	No. of options	Implementation status	Option Evaluation Payback period	Environmental impact	Total impacts Financial	Environmental
1. Baroda Minerals & Grinding Industries	27				Investment: \$700 Savings: \$1,500/yr Payback: 6 months	Not quantifiable
2. Northern Minerals	57				Investment: \$4,150 Savings: \$2,650/yr Payback: 19 months	Not quantifiable
3. Super Industries	56				Investment: \$13,350 Savings: \$8,350/yr Payback: 20 months	Not quantifiable
4. Vimal Pesticides	64				Investment: \$5,350 Savings: \$8,350 Payback: 8 months	Not quantifiable
SECTORAL SUMMARY	224				Investment: \$23,550 Savings: \$20,850 Payback: 14 months	Not quantifiable

■ implemented  
▨ started  
▧ planned  
□ rejected

■ unquantifiable  
▨ low  
▧ medium  
□ high

■ low  
▨ medium  
▧ high

(\*) covers only the options considered 'feasible'

These waste minimization options apply to different parts of the participating pesticides formulating companies. Figure 4.6 shows the division of the feasible options among the most important types of formulations in the pesticides formulation industry. Apparently more feasible options could be found for the formulation of granules and dust than for the formulation of liquids. It is felt, however, that these differences are not significant, especially taking the following into account:

- The number of production lines per type of formulation varied significantly: this sector study

included in total 3 production lines for granules, 8 production lines for liquids and 6 production lines for dust/wettable powder;

- The size and complexity of these production lines varied significantly; the variety of batch size for the liquid plants ranged for instance from 1,000 to 5,000 litres;
- The capacity utilization per production line varied significantly; some production lines operated 24 hours per day throughout the entire season, while other production lines only operated in periods of

Figure 4.5: Division of the waste minimization options according to waste minimization technique (pesticides industry: 133 feasible options)

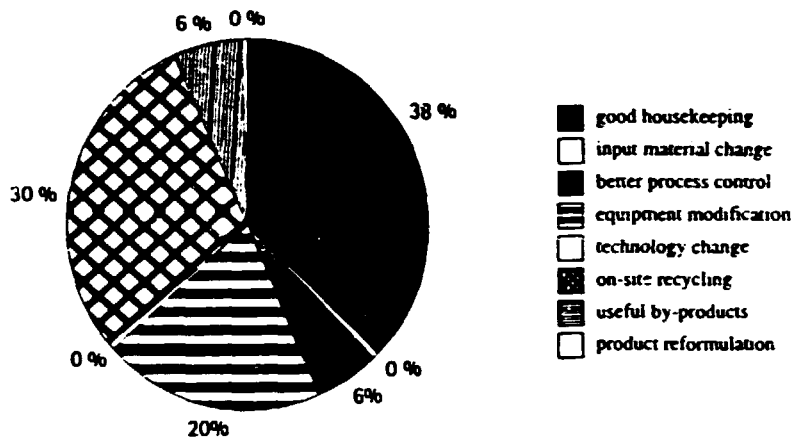


Figure 4.6: Section-wise division of waste minimization options (pesticides industry: 133 feasible options)

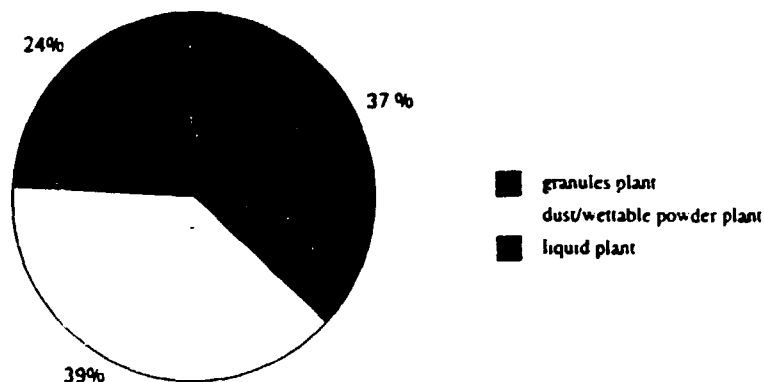
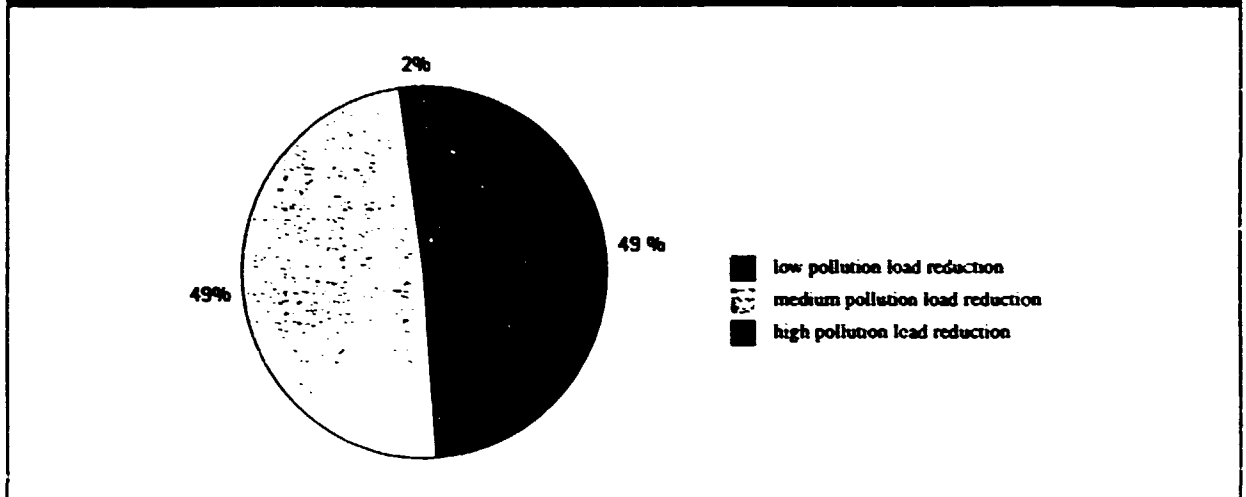


Figure 4.7: Division of waste minimization options according to environmental impact (pesticides industry: 133 feasible options)



high market demand for specific products.

Figure 4.6 however underscores the point that for each type of pesticides formulation plant, viable waste minimization options can be identified and implemented.

In the pesticides formulation sector, it was difficult to assess the media wise pollution load reduction. Thus a qualitative assessment of the overall pollution load reduction was made. Figure 4.7 shows the results. Since the quantum of pollutant discharge is small, most of the feasible waste minimization options have either

low, or at best medium, impact on pollution load reduction.

Even in low amounts, pesticides can have a significant effect on health and safety. Consequently, even small improvements in shop floor environment or containment of pollutants could have a salutary impact on reduction of safety and health hazards. A detailed hazard analysis was beyond the scope and capability of the technical study team, and thus only qualitative estimates were made. These are shown in figure 4.8. About 45 per cent of the feasible waste minimization options were identified as having a high impact on reduction of health

Figure 4.8: Division of waste minimization options according to perceived impact on reduction of safety and/or health hazard (pesticides industry: 133 feasible options)

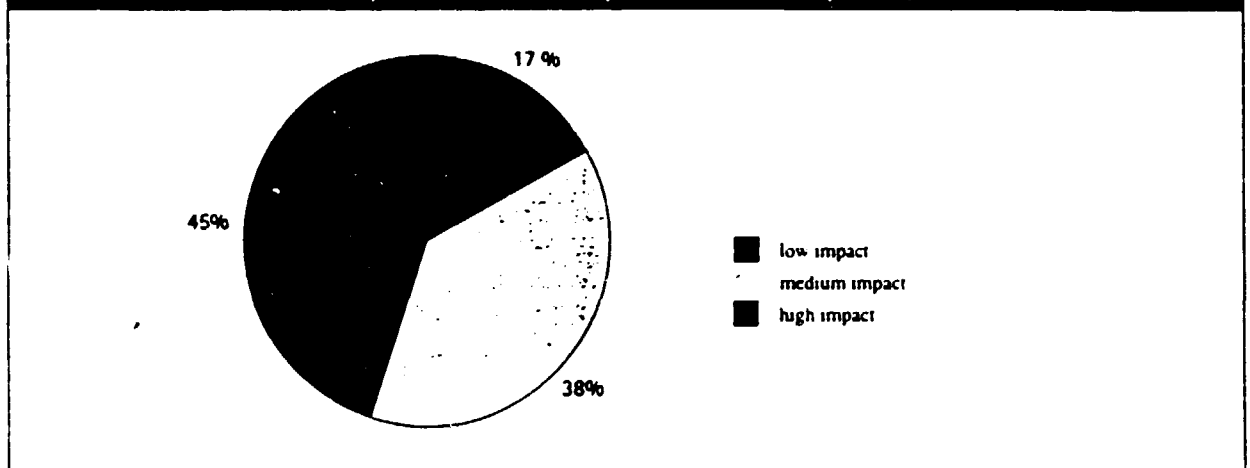
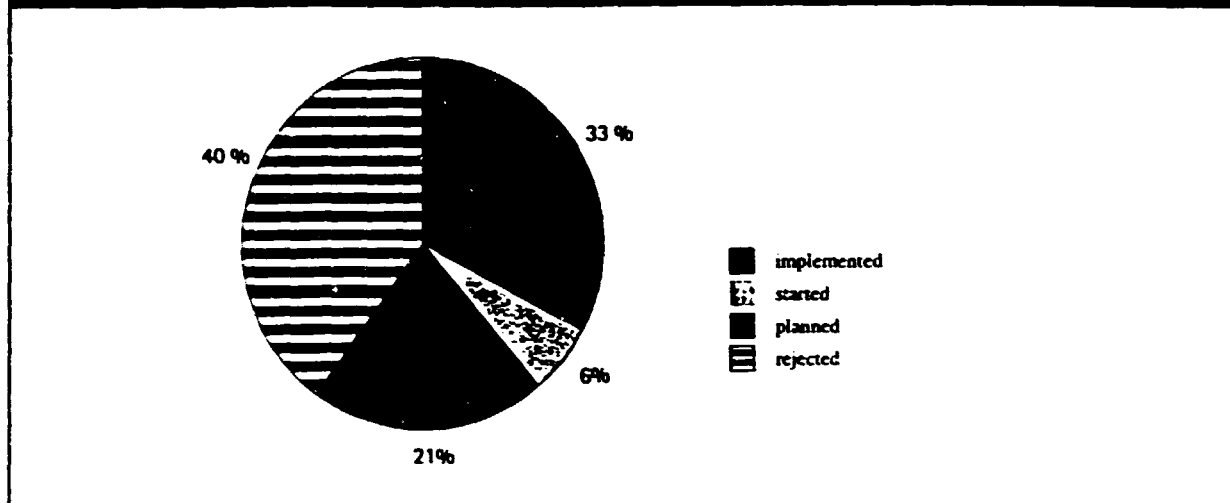


Figure 4.9: Implementation status of the waste minimization options (pesticides industry: total 224 options)



or safety hazards, which underscores the beneficial impact of the implementation of waste minimization in the pesticides formulation sector.

The implementation status of all options in the pesticides formulation industry is finally depicted in figure 4.9. A significant share of the options (33 per cent) could be implemented within the 15 month time-frame of the DESIRE project. In addition, a start has been made with the implementation of another 6 per cent of the options. A rather big share of the options (21 per cent) has proved to be feasible, but implementation has not yet started due to various reasons (like non-availability of capital, the need to plan for plant shut down in order to implement the option etc.). Finally, 40 per cent of the options have been rejected; in most cases the perceived cost reduction potential of these options was too small to attract the interest of the entrepreneur. However, in some cases, alternatives to options falling in this category could be developed which were less technically sound but had acceptable payback times. This was for instance the case with the suggestion to install a gear box on the dust blenders, which was too expensive, but could be replaced by a fluid coupling assembly, which proved to be able to solve the same waste generation cause. From figure 4.9, we conclude that the DESIRE project generally led to practical options because as many as 60 per cent of all options identified proved to be feasible upon detailed evaluation.

The overall financial impact of the DESIRE project in the pesticides formulation industry was positive.

The four participating pesticides formulation units invested \$23,550 in the first batch of 73 feasible waste minimization options. These options generate net annual savings worth \$20,850. This in turn means that the investments generated by the DESIRE project in the pesticides formulation industry had an overall pay back time of less than 14 months.

It should however be kept in mind that waste minimization in the pesticides formulation industry has broader consequence than just converting waste into profits. Most of the chemicals used are toxic and, in this particular case, the pesticides formulating industry covered in India formulate highly toxic and highly persistent pesticides. Therefore waste minimization and substitution of chemicals has a very high beneficial effect on human health as well as the environment.

#### 4.4 Textile dyeing and printing industry

Textile dyeing and printing is historically known as causing severe pollution to the environment. Although coloured waste water discharges from dyeing and printing operations are the most visible evidence of the environmental burden caused by this industry sector, several other environmental concerns play a role in textile dyeing and printing, such as use of toxic substances, high water- and energy-intensity of the production and air emissions of volatile organic compounds (VOCs).

Textile dyeing and printing consists of the following process areas:

- **Preparation section:** washing (scouring) and bleaching the fabric in order to prepare it for dyeing and printing;
- **Dyeing section:** dyeing of the fabric followed by fixation, removing unfixed dyes and finishing the fabric (washing, drying, heat setting, softening etc.). The dyeing section includes the preparation of the recipes and dyes for the dyeing processes;
- **Printing section:** printing the fabric followed by fixation, removing unfixed dyestuffs and finishing the fabric (washing, drying, heat setting, softening etc.). The printing section includes the preparation of the print paste and handling and washing of the printing screens;

**Utilities:** boiler house (steam generation, thermic fluid system), water softening plant, waste water treatment facility and power generation facilities.

The sequence of processes as well as the selection of chemicals, auxiliaries, dyestuffs and equipment depends heavily on the type of fabric (polyester, cotton, viscose etc.), the quality of the incoming goods (level of contamination of the grey fabric by dirt, coning oils, marking tints etc.) and the required product specifications (for the finished cloth). Waste minimization principles are applicable to all operations in textile dyeing and printing. Table 4.6 contains some illustrative examples of waste minimization practices for the textile dyeing and printing industry.

**Table 4.6: Illustrative waste minimization measures for textile dyeing and printing industry (Kuttiappan, 1995)**

Waste minimization technique	Illustrative examples with associated benefits
1. Good housekeeping	<ul style="list-style-type: none"> <li>• Closing water taps not in use in order to conserve water.</li> <li>• Proper mounting of printing screens and use of cello tape to avoid printing besides the fabric.</li> <li>• Proper inspection and maintenance of steam pipes, traps and valves in order to minimize steam losses and conserve energy.</li> </ul>
2. Input material change	<ul style="list-style-type: none"> <li>• Use of alternative, less polluting auxiliary chemicals, like formic acid instead of acetic acid, diosyn detergent instead of hydrosulphite etc.</li> </ul>
3. Better process control	<ul style="list-style-type: none"> <li>• Optimization of dyeing processes (steam pressures, time, chemical dosing and cycle times), in order to achieve the highest possible dye bath exhaustion.</li> </ul>
4. Equipment modification	<ul style="list-style-type: none"> <li>• Better insulation of steam and condensate lines, equipment, traps and tanks in order to reduce steam requirements.</li> <li>• Installation of automatic valve for switching off blanket wash water during non operation hours of the printing machine.</li> </ul>
5. Technology change	<ul style="list-style-type: none"> <li>• Use of low liquor jet dyeing equipment instead of high liquor dyeing equipment to conserve water, energy and auxiliary chemicals.</li> <li>• Installation of direct gas fired dryers and stenters (instead of indirect heating with thermic fluid) to conserve energy.</li> </ul>
6. Useful by-products	<ul style="list-style-type: none"> <li>• Apart from reuse of chemical containers, packaging materials and application of off specification fabric in for instance furniture industry, there seems to be little scope for waste minimization through application of useful by-products.</li> </ul>
7. On-site recycling	<ul style="list-style-type: none"> <li>• Installation of doctor blade on printing machine in order to collect print paste from printing belt for reuse.</li> <li>• Installation of an overhead storage tank to store the dye bath upon completion of the dyeing cycle and to reuse the dye bath for the next batch of fabric.</li> </ul>
8. Product reformulation	<ul style="list-style-type: none"> <li>• Design changes in the application of dyes and prints in order to enable the use of less polluting auxiliaries (like metal free dyes), to eliminate need for comparatively-polluting processes (like discharge printing) and to eliminate comparatively-polluting dye-chemistries (like sulphur dyes).</li> </ul>

The following industries were selected for participation in the DESIRE project:

1. M/s. Ashoka Fashions, Ahmedabad;
2. M/s. Bhavin Textiles, Surat;
3. M/s. Garden Speciality Prints, Surat;
4. M/s. Mahendra Suitings, Ahmedabad;
5. M/s. Paradise Prints, Surat;

Midway through the project, the management at Ashoka Fashion changed hands and the entire management as well as the waste minimization team were changed. The new management completely disowned the waste minimization programme and refused to participate in the DESIRE project any further. This unit therefore had to be left out. The findings at the remaining four units are summarized in annexes IX to XII.

The summaries of the mill-level final results illustrate the effectiveness of the DESIRE project in achieving both environmental improvement and financial benefits in the participating textile dyeing and printing mills. Significant differences are apparent when the achievements per unit are compared. The total number of options ranges from 22 to 38 per mill; between 29 and 64 per cent of these options have been implemented within the course of the DESIRE project. The share of the low cost options (requiring less than \$1,000 investment) is remarkably high: between 56 and 66 per cent of all options for each company. In order to visualize the differences between the participating mills, table 4.7 has been compiled.

In the four mills, a total of 119 waste minimization options have been identified and evaluated. The nature and complexity of the options range from comparatively simple improvements of housekeeping practices and repair of leaks to relatively radical technology changes (like gas fired stenters etc.). Figure 4.10 reveals some of these differences, since it contains the subdivision of all options according to the waste minimization technique employed. Two waste minimization techniques account for half of the waste minimization options; these are: on-site recycling (26 per cent) and better process control (24 per cent). Two other waste minimization options account for another third of the options, respectively good housekeeping (17 per cent) and input material change (16 per cent). Three other waste minimization techniques have a limited share of the options (respectively equipment modification (7 per cent), technology change (8 per cent) and product reformulation (2 per cent)). The last waste minimization technique (viz. creation of a useful by-product) could not be transferred into practical

waste minimization solutions in the textile dyeing and printing industry.

These waste minimization options apply to different parts of the textile dyeing and printing mills. Figure 4.11 shows the division of the options over the most important sections in the textile mills. Most options apply to the dyeing section (43 per cent) and the printing section (70 per cent). The remaining options address environmental concerns arising from the preparation section and utilities.

The waste minimization efforts in the textile dyeing and printing sector concentrated on water-related environmental concerns; 81 per cent of the options aimed at minimization of the waste water discharges (see figure 4.12). Most of these options have related environmental benefits, such as better raw material, chemicals, water and energy utilization. The second largest share belongs to the options aiming at minimization of air pollution (19 per cent); generally speaking these reductions of air emissions are achieved through minimization of the steam requirements throughout the mill, via for instance insulation, improved equipment design and lay out and better operating practices.

The implementation status of all options is finally depicted in figure 4.13. A significant share of the options (43 per cent) could be implemented within the 15-month time-frame of the DESIRE project. In addition, a start has been made with the implementation of another 30 per cent of the options. A comparatively small share of the options (14 per cent), has proved to be feasible, but implementation has not yet started due to various reasons (like non-availability of capital, need to plan for plant shut down in order to implement the option etc.). Finally, only 13 per cent of the options have been rejected owing to the limited technical or financial feasibility of the options. It can thus be concluded that most options were very practical; as many as 87 per cent of all options identified proved to be feasible upon detailed evaluation.

The four participating industries from the textile dyeing and printing industry invested \$50,650 for the implementation of the first batch of 51 feasible waste minimization options. The total annual savings of these options are expected to amount to \$244,500. The average payback of the waste minimization investments in the textile dyeing and printing sector was therefore within 3 months. The environmental benefits have not been assessed at the company level. Option level environmental impact assessments, however, indicate:



Table 4.7: Summary of sectorial results in textile dyeing & printing industry

Company	No. of options	Implementation	Pay back status	Option evaluation			Total impact	
				Environmental period	Financial impact	Environment	Investment	Environment
1. Bhavin Textiles	27						Investments: \$4,650 Savings: \$48,400 Payback: < 2 months	1,000 kg/mo. COD reduction 2,000 kg/mo. print paste reduction
2. Mahendra Suitings	22						Investment: \$3,700 Savings: \$30,800 Payback: < 2 months	1,000 kg/mo. COD reduction 10% print paste reduction 220 cm <sup>3</sup> /day water use reduction
3. Garden Speciality Prints	38						Investment: \$14,500 Savings: \$110,000 Pay Back: < 2 months	750 kg/mo. COD reduction 2,500 kg/mo. print paste reduction
4. Paradise Prints	32						Investment: \$27,800 Savings: \$55,300 Payback: < 6 months	6,300 kg/mo. COD reduction 2,600 kg/mo. print paste reduction 1,700 cm <sup>3</sup> /day water use reduction
<b>SECTORAL SUMMARY</b>	<b>119</b>						Investment: \$ 50,650 Savings: \$244,500 Payback: < 3 months	9,050 kg/mo. COD reduction more than 7,100 kg/mo. print paste reduction 1,920 cm <sup>3</sup> /day water use reduction

implemented  
 started  
 planned  
 rejected

low  
 medium  
 high

low  
 medium  
 high

Figure 4.10: Division of the waste minimization options according to waste minimization technique (textile industry: 119 options)

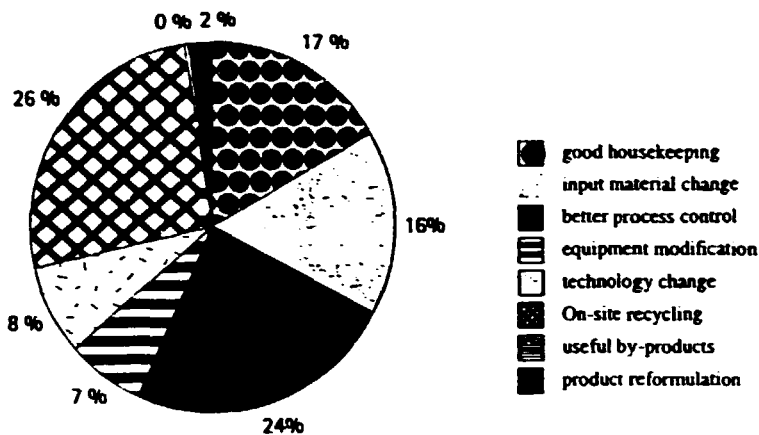
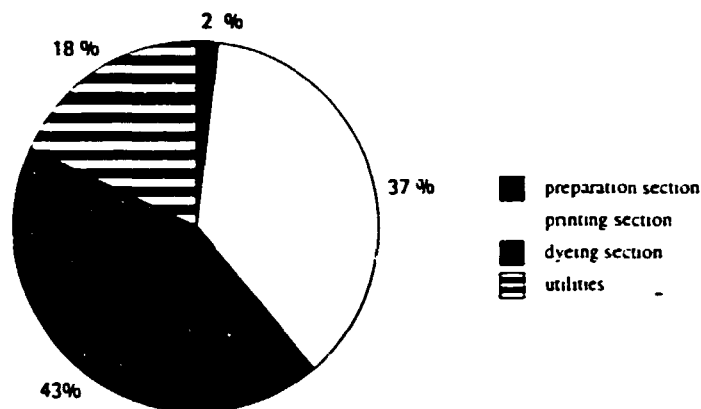


Figure 4.11: Section-wise division of waste minimization options (textile industry: 119 options)



- Significant reductions in the use of chemicals, energy and water;
- Remarkable reductions of the discharge of print paste remnants with waste water;
- Example substitutions of auxiliary chemicals by less polluting auxiliary chemicals.

Within the DESIRE project the textile dyeing and printing sector is characterized by the most active participation by the industry. In fact, at the start of the DESIRE project, the textile industry in Surat had already taken the initiative to form an association called

Waste Minimization Group Surat. As part of the DESIRE project, a waste minimization assessment has been conducted at some of the leading mills within this group (Paradise Prints, Bhavin Textiles and Garden Speciality Prints). The spin-off of the project could be gauged from the fact that other mills, which were not directly participating in the DESIRE project (Luthra Dyeing and Printing), took initiative on their own to start a waste minimization programme. The awareness is now so widespread that in the concluding seminar held for this sector in December 1994 at Surat, there were about 140 participants. The participating mills have achieved significant benefits in terms of water, energy and raw material conservation. In addition, the participating

Figure 4.12: Division of waste minimization options according to environmental impact (textile industry: 119 options)

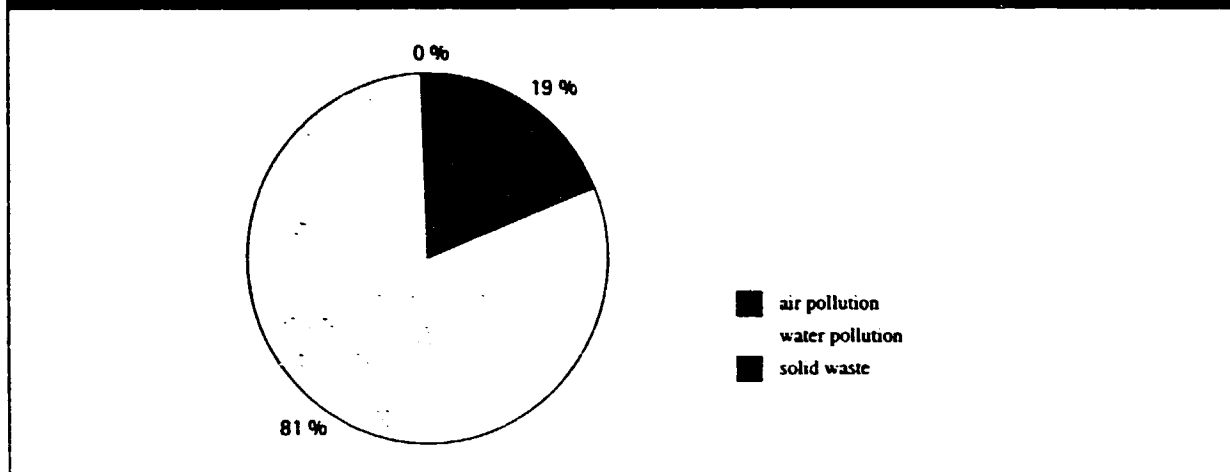
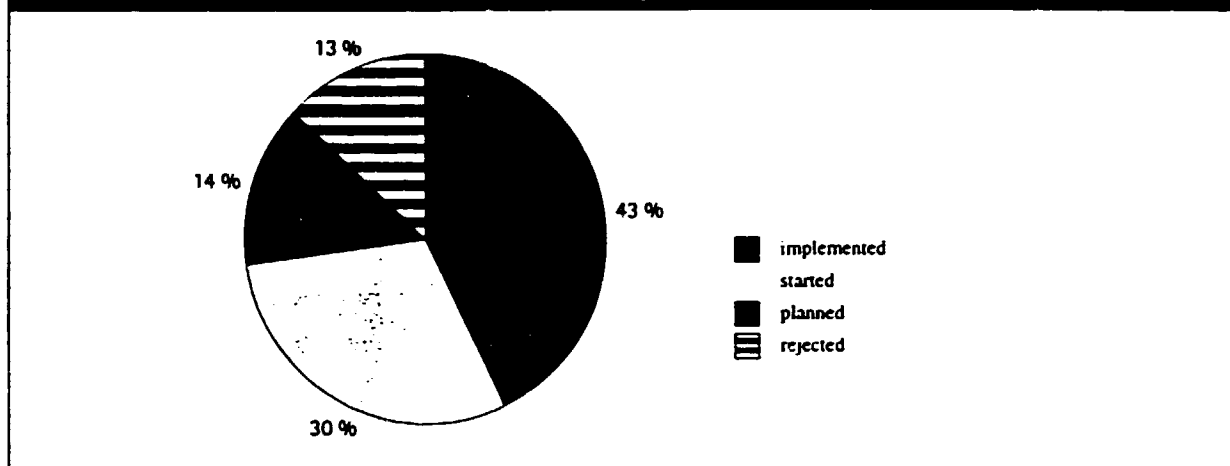


Figure 4.13: Implementation status of the waste minimization options (textile industry: 119 options)



mills themselves took the initiative to identify low polluting and less toxic substitute input chemicals.

#### 4.5 General Evaluation

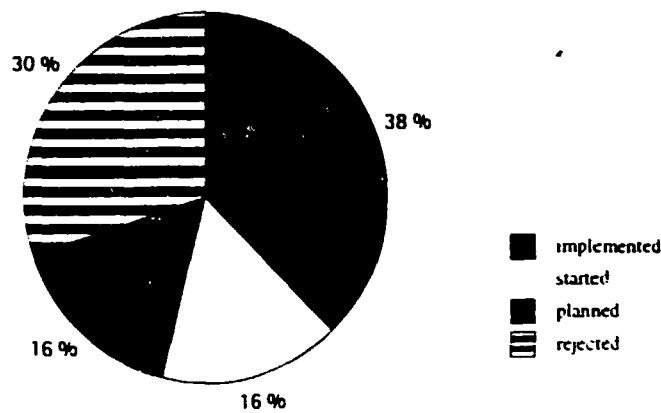
This section contains a comparative evaluation of the achievements in the three sectors in order to evaluate the total impact of the DESIRE project. In addition, some distinct features of the implementation of waste minimization will be discussed as well as some general conclusions drawn.

##### Total achievements

The participation in the DESIRE project enabled all 12 companies to identify many different waste minimization

options, which to a large extent could be implemented over the course of the DESIRE project. Figure 4.14 illustrates the division of the 540 waste minimization options according to their implementation status. A large share of the options (38 per cent) could be implemented within 15 months of the start of the plant-level waste minimization activities. Another 32 per cent of the options are also feasible; implementation of these options has already started (16 per cent) or is planned for the near future (16 per cent). Only as few as 30 per cent of the options generated proved to be not feasible and have been rejected by the companies. For these options the technology is either not yet available or not yet available at an appropriate scale for SSIs or far too expensive in

Figure 4.14. Implementation status of the waste minimization options  
(all sectors: 540 options)



view of the possible cost savings and total investments in plant equipment.

There are some differences among the sectors in terms of implementation status of the options. This is illustrated in table 4.8. There are rather large differences in the total number of options per sector; the pesticides formulation industry has almost twice as many options as the textile dyeing and printing industry. The pesticides industry has however the largest share of rejected options; therefore the differences in numbers of feasible options per industry sector are not significantly different. The rejected options for the pesticides formulation industry are therefore excluded from the remaining part of this general evaluation.

Given the huge differences in the complexity, nature and impact of the various options, the number of options is not an indication of the financial and environmental impacts of the options. Table 4.9 summarizes the financial impact of the implementation of the first batch of feasible options (196 options implemented within the time-frame of the DESIRE project). The investments as well as net annual savings are by far the highest in the agro-residue-based pulp and paper industry. The overall payback time of the 196 waste minimization options implemented in the DESIRE project is less than 6 months; the financial feasibility of waste minimization in textile dyeing and printing industry seemed significantly higher than the average of the three sectors and in the pesticides formulation industry significantly lower than the average of the three sectors. However, care is needed in the interpretation of these figures, since these figures

only include the options explicitly evaluated by the technical study team, whereas some companies have already identified and implemented additional waste minimization options on their own (as evidenced in the presentation of the participating companies at the industry specific workshops etc.).

The implementation of these waste minimization measures has contributed significantly to environmental improvement in areas such as the following:

- Minimization of waste water discharges (both in volume and pollution load);
- Minimization of air emissions (from steam generation as well as fugitive emissions from materials handling and processing);
- Minimization of solid waste generation;
- Conservation of materials, energy and water;
- Reduction of the use of toxics;
- Minimization of health and safety hazards (both at the shop floor level and in the direct vicinity of the plants).

Most options contribute to environmental improvement in several areas, such as material conservation, and waste minimization or water conservation and minimization of waste water discharges. It is therefore not feasible to

Table 4.8: Comparison of the implementation status per industry sector

Implementation status	Pulp and paper industry (*)	Pesticides formulation industry	Textile dyeing and printing industry	Total
• Implemented	82	72	51	206
• Started	37	13	36	86
• Planned	22	47	17	86
Subtotal feasible options	141 (71 %)	133 (59 %)	104 (87 %)	378 (70 %)
• Rejected	56	91	15	162
Grand total	197	224	119	540

\* Figures include Three Star Paper Mills.

Table 4.9: Financial impact of the options implemented in the course of the DESIRE project

Financial indicator	Pulp and paper industry *	Pesticides formulation industry	Textile dyeing and printing industry	Total
Number of options implemented	72	73	51	196
Investments (\$1,000)	347	23.55	50.65	421.2
Net annual savings (\$1,000)	672 **	20.85	244.5	937.35
Overall payback period (months)	6	< 14	< 3	< 6

\*Figures exclude Three Star Paper Mill

\*\*Figures exclude financial benefits from reduction of waste water treatment cost.

summarize the total environmental impact with one set of environmental indicators.

### Waste minimization features

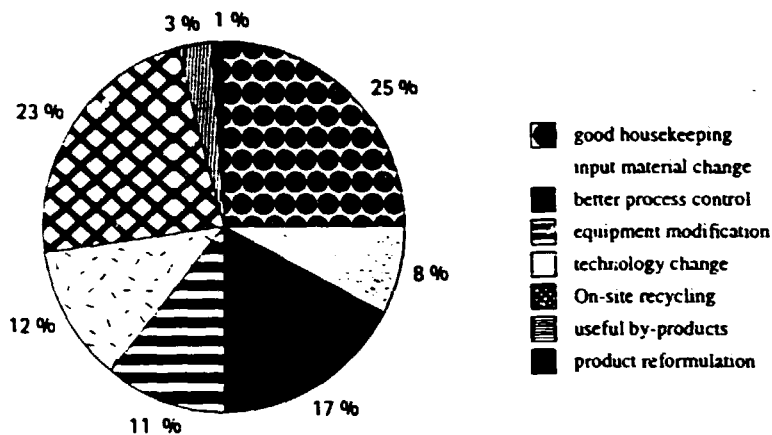
The results of the DESIRE project reveal a number of salient features of the waste minimization potential for SSIs. The following six are considered of vital importance for the dissemination of waste minimization.

1. Waste minimization is diverse: waste minimization is essentially a problem solving strategy rather than a solution: waste minimization puts the waste-generating process (the root problem) in the first place and employs a preventive mind-set to develop alternative solutions (waste minimization options). A variety of technical, operational, educational and managerial practices can be used to this end, but normally not exclusively to this end, which inhibits thinking of waste minimization in terms of a fixed set of solutions or technologies. The DESIRE results illustrate this

diversity of solutions (see figure 4.15). The options are divided among eight waste minimization techniques. Although on-site recycling (23 per cent), good housekeeping (25 per cent) and better process control (17 per cent) have the largest shares of the options, the waste minimization opportunities in the other categories should not be neglected.

2. Waste minimization protects the *environment*: the implementation of waste minimization options contributes to environmental improvement in various areas. The subdivision of the options according to the size of the reduction of the pollutant load (figure 4.16), shows that about half of the options have a low environmental impact, with the remaining having a medium or sometimes even a large impact on pollutant load. Since the impacts of different options add to each other at the company level, a considerable environmental improvement can be achieved; the short- to medium-term pollutant load reduction typically ranges between 25 and 50 per cent.

Figure 4.15: Waste Minimization is diverse (all sectors: 449 options)



3. Waste minimization is *simple*: waste minimization is to a large extent based on the application of common know how and entrepreneurship. Simple but effective waste minimization options were, for instance:

- Paper industry: repairing of leaks, optimization of the cooking process and segregation of initial black liquor.
- Pesticides formulation: cleaning and maintenance of spray nozzles and reuse of rinse solvents.
- Textile industry: doctor blade for print paste recovery, press switches for lights and proper insulation.

4. Waste minimization is *innovative*: the application of

the waste minimization concept might boost innovations in processes, products and technologies (equipment). Examples are:

- Paper industry: hot stock pulp refining and anthraquinone-assisted pulping.
- Pesticides formulation: new types of formulations and installation of fluid coupling assembly.
- Textile industry: use of low liquor jet dyeing equipment and direct dye bath reuse.

5. Waste minimization is *rational*: in numerous cases, waste minimization is achieved by rationalization of production. In each sector, several rationalization proposals lead to a serious reduction of waste

Figure 4.16: Waste minimization protects the environment (all sectors: 449 options)

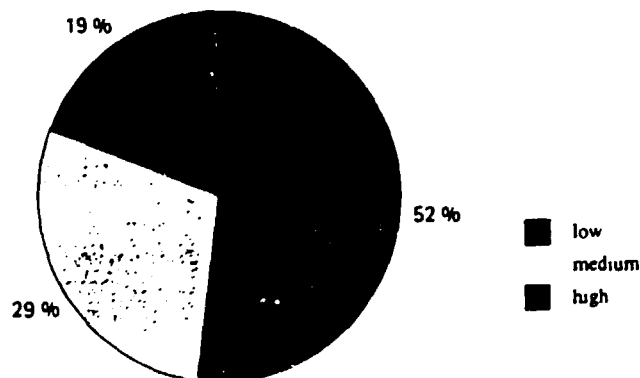
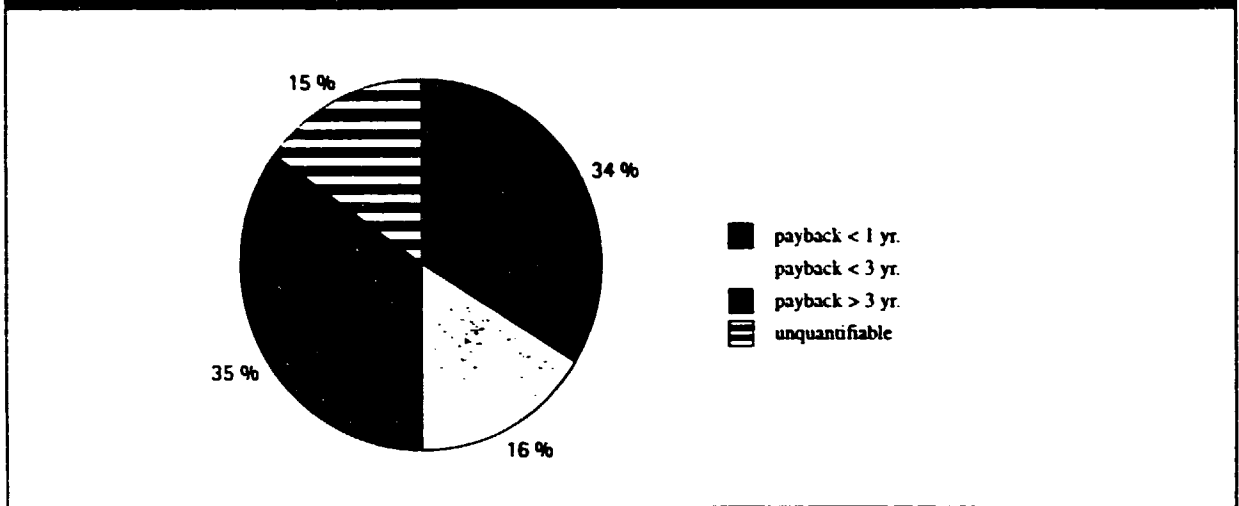


Figure 4.17: Waste minimization is economical (all sectors: 449 options)



generation and waste water discharges. Examples include:

- Paper industry: proper dedusting of agro-residues before pulping and use of broke pulper to avoid reprocessing of broke pulp.
- Pesticides formulation: premixing of fillers and solid active pesticides before pulverising and dedicating equipment to one type of product.
- Textile industry: standardization of print paste preparation and shade matching and provision of appropriate utensils to supply and recover print paste from printing machine.

6. Waste minimization is *financially attractive*: the rationalization of the production normally improves the material-, water- and energy-efficiency of production, which in turn might create attractive financial benefits. Many waste minimization options therefore pay for themselves in a short period of time. Figure 4.17 illustrates this. About one third of the options have a payback within one year. In total, half of the options have a payback of less than three years. The remaining options either have a longer payback period (over three years) or have financial benefits which could not be quantified within the framework of the DESIRE project.

The above features of waste minimization constitute a new acronym for DESIRE (Diverse, Environment, Simple, Innovative, Rational and Economical (see figure 4.18)). Such results can be achieved through the application of a systematic working method (DESIRE manual; see chapter 3), which specifies how to analyse

waste generation sources and causes, how to improve production processes (in order to avoid these waste generation causes) and how to integrate these improvements into the daily operation of the company.

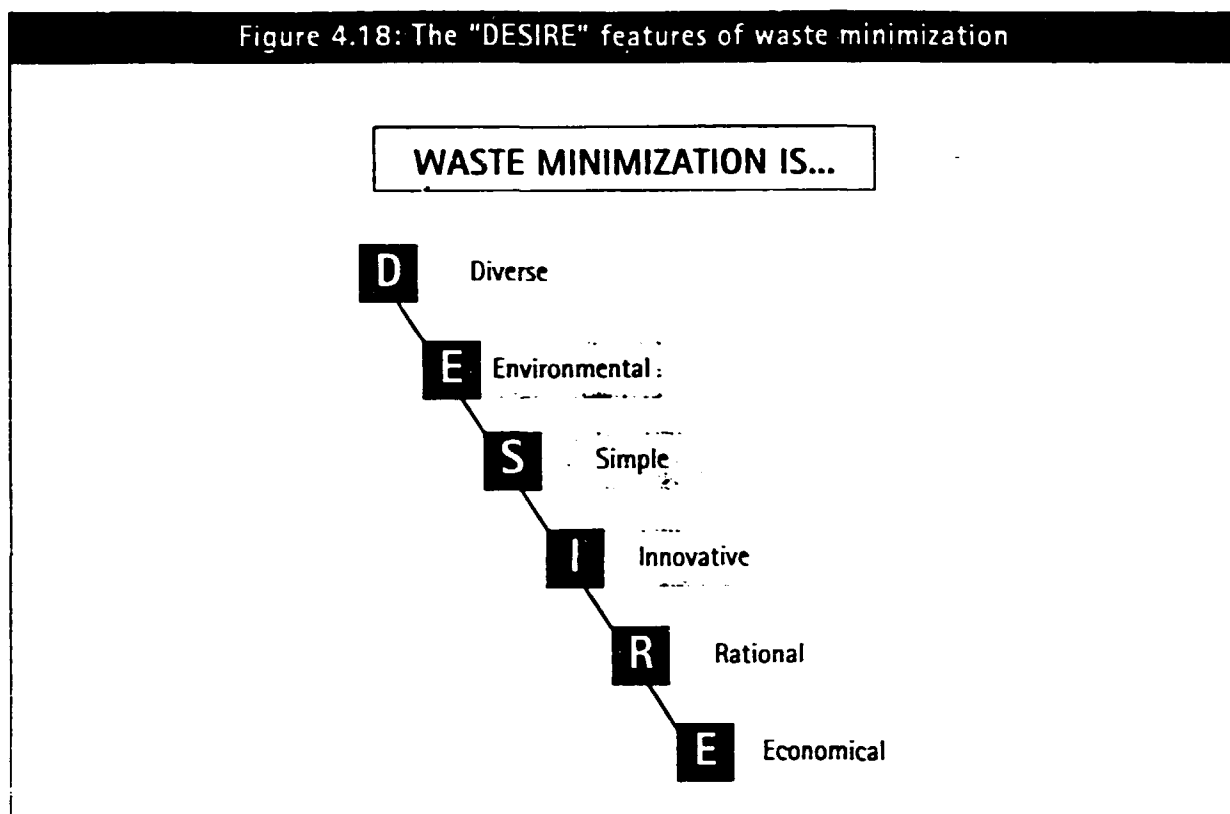
### Conclusions

In short, the four hypotheses formulated at the start of the DESIRE project have all been confirmed:

- There are *many opportunities* for waste minimization in Indian SSIs. These can be detected by making an integral analysis of the company, including – but not limited to – its production processes, input materials, waste streams and emissions.
- Many of these waste minimization opportunities can be implemented by small-scale industries within the *short term* (within 1 to 3 years).
- Waste minimization goes *beyond technical modifications*; it can also be achieved by improvement of operating practices, changes of input materials and recycling practices.
- The implementation of waste minimization will *benefit the company*; these benefits will include monetary savings as well as less tangible benefits such as improvement of working conditions, improvement of product quality and improvement of local environmental conditions around the facility.

The above conclusions are far-reaching. The concerted

Figure 4.18: The "DESIRE" features of waste minimization



action of the companies participating in the project and the technical study team assisted by the project consultants has resulted in preventive measures being implemented and the start of ongoing waste minimization activities in the companies. These results can, according to the DESIRE team, also be achieved in numerous other small-scale industries. Company decision makers do, however, need to create favourable conditions and allocate resources to the systematic identification, evaluation and implementation of waste minimization options. Government decision makers should in turn encourage and facilitate industrialists to do so. This brings us to the opportunities for waste minimization fostering policies (see chapter 5).

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# Towards an action programme

## 5.1 Introduction

In 1992, the Indian MOEF issued the *Policy Statement for Pollution Abatement in Small-scale Industries* (1992). The policy calls for assistance to SSIs in adopting cleaner technologies and recognises pollution prevention/waste minimization as the first priority for environmental management in the industrial sector. As this policy statement did not yet include details on how to provide assistance to SSIs, the fourth objective of the DESIRE project (see section 1.3) can actually be interpreted as developing an action programme for the implementation of the waste minimization component of this policy statement. This chapter therefore analyses the policy lessons from the DESIRE project in order to support the Ministry of Environment and Forest and the Central Pollution Control Board as well as industrial stakeholders to develop appropriate action plans to promote waste minimization.

The results and experiences of the trial implementation of waste minimization in selected SSIs under the DESIRE project have been presented in the previous chapters (chapters 2, 3 and 4) of this report. In terms of policy lessons, the following hierarchy of conclusions emerges:

- Most importantly, the DESIRE project has demonstrated that *waste minimization can result in significant financial and environmental benefits for SSIs* (see chapter 4). Waste minimization proved to be a viable, short-term strategy for achieving the dual objective of industrial development and environmental protection. It is therefore desirable to ensure that a significant number of SSIs in India start to understand waste minimization and develop activities to implement the waste minimization potential in their operations.
- Secondly, the DESIRE project has shown the need to use a systematic *audit methodology* to identify and implement waste minimization solutions tailored to the specific conditions and capabilities of a particular industry (see chapter 3). Waste minimization fostering policies should thus in principle enable companies to

apply this systematic audit methodology which in turn will guide them to the most practical waste minimization measures for their operations.

- Thirdly, it has become evident that companies face a *huge array of constraints* to applying this systematic audit methodology to their operations. In the DESIRE project, intensive individual support by outside experts has enabled the participating companies successfully to apply the audit methodology. While doing so, a number of catalysts have been used and enabling measures have been identified. It can thus be concluded that individualized support and guidance to companies is an effective mechanism for achieving waste minimization in SSIs.

Given the resource intensity of demonstration projects like the DESIRE project, the challenge is how to ensure a multiplier effect once waste minimization results have been demonstrated.

Although lessons can be learned from international experiences in for instance the United States and Europe (WRITAR, 1994; Dieleman, 1991; EU, 1994; UNEP, 1994), a localized dissemination and promotion strategy will have to be developed which fits the Indian industrial structure and the Indian set of constraints to, and enabling measures for, waste minimization. To this end the enabling measures identified in the DESIRE project (see sections 2.2 – 2.7), have been classified as those internal and external to firms (see table 5.1). Generally speaking, governmental agencies should be able to develop policies that create the external enabling measures. The internal enabling measures cannot be created directly by Government activity; however training and social policies might in the long run add to the development of these internal enabling measures.

This chapter concentrates on opportunities to create these external enabling measures. Implementation mechanisms are to be developed which can be implemented by the environmental authorities (in particular the MOEF, the Central Pollution Control

Table 5.1: Classification of enabling measures identified in the DESIRE project

Type	Internal to the enterprise	External to the enterprise
1. Attitudinal	<ul style="list-style-type: none"> <li>• Encourage experimentation.</li> <li>• Publicize early successes.</li> <li>• Develop simple management indicators.</li> </ul>	
2. Systemic	<ul style="list-style-type: none"> <li>• Training session for plant-level waste minimization team.</li> <li>• Top down housekeeping drive.</li> </ul>	<ul style="list-style-type: none"> <li>• Dissemination of success stories.</li> </ul>
3. Organizational	<ul style="list-style-type: none"> <li>• Organize capable waste minimization team.</li> <li>• Recognise waste minimization efforts.</li> <li>• Assign costs to production and waste generation.</li> </ul>	
4. Technical		<ul style="list-style-type: none"> <li>• Dissemination of waste minimization techniques and technologies.</li> <li>• Need-based support for environment-driven R&amp; D.</li> </ul>
5. Economic	<ul style="list-style-type: none"> <li>• Proper cost allocation and planned investments.</li> </ul>	<ul style="list-style-type: none"> <li>• Long-term industrial policies.</li> <li>• Financial incentives.</li> </ul>
6. Governmental		<ul style="list-style-type: none"> <li>• area-wide, voluntary waste minimization groups.</li> <li>• Enforcement of environmental legislation.</li> </ul>

Board and state pollution control boards) and which will likely be supported by industry. In section 5.2, three such mechanisms will be described. In section 5.3, a description will be given of how to create demand for these mechanisms and how to meet this demand (or create supply of these implementation mechanisms). Finally, some concluding remarks will be given as to the institutions that should become involved and ways of cooperation (section 5.4).

## 5.2 Implementation mechanisms

The external enabling measures identified in the course of the DESIRE project have been discussed in various settings with governmental and industrial representatives in order to develop implementation mechanisms which can be implemented by the environmental authorities and which will likely be supported by industry. Although consensus could be reached about the usefulness of three implementation mechanisms, a lot of details still need to be discussed and worked out before these can actually be implemented. The proposed implementation mechanisms are:

1. *Waste minimization circles*: area-wide support for

industries co-operating on a voluntary basis with a view to exchanging waste minimization opportunities for solving common environmental problems in the participating industries:

2. *Obligatory waste minimization audits*: the inclusion of the requirement to submit a waste minimization audit in procedures for obtaining financial benefits, like sales tax exemption, soft loan for investments etc.

3. *Waste minimization demonstration projects*: subsidized external assistance to selected industries in a particular industrial sector or region in order to demonstrate the waste minimization potential. Dissemination of the results as well as training of waste minimization experts are considered integral parts of such demonstration projects in order to ensure that implementation of waste minimization will not be restricted to the companies directly participating in the demonstration project.

The impact of these implementation mechanisms on the establishment of the external enabling measures is depicted in table 5.2. Generally speaking, waste

Table 5.2: Impact of 'implementation mechanisms' on the establishment of the 'external enabling measures'

External enabling measures	Implementation mechanisms		
	Circles	Obligatory audits	Demonstration projects
1. Dissemination of success stories	****	—	**
2. Dissemination of waste minimization techniques and technologies	**	—	****
3. Need-based support for environment-driven R&D	*	*	***
4. Long term industrial policies	—	***	—
5. Financial incentives	—	**	—
6. Area-wide, voluntary waste minimization groups	*****	—	*
7. Enforcement of environmental legislation	*	*	*

Note: number of asterisks indicates the expected contribution of each implementation mechanism to the establishment of the respective external enabling measure

- \* only indirect contribution
- \*\*\* direct contribution
- \*\*\*\*\* targeted contribution
- no contribution

minimization circles and demonstration projects are particularly effective for the dissemination of waste minimization experiences and might contribute to the initiation of environment-driven R&D and improvement of the overall level of enforcement of the existing environmental regulations. The impact of obligatory waste minimization audits is hard to evaluate because it is not yet exactly known in which financial schemes the obligatory audits will be introduced. However, this implementation mechanism could create a powerful financial incentive for waste minimization and contribute to the development of medium- to long-term industrial policies.

Except for the waste minimization circles, the environmental authorities have not yet launched policies to create these implementation mechanisms. The conditions, for, as well as expected outcomes of, these implementation mechanisms will therefore be elaborated below.

### 1. Waste minimization circles

The concept of a waste minimization circle has been derived from the successful experiences of the Waste

Minimization Group in the textile industry in Surat. Box 5.1 summarizes the history of this Waste Minimization Group. MOEF has taken the lead to support 25 groups of companies operating a common effluent treatment plant (CETP) to develop trial waste minimization circles.

The expected outcome of the establishment of waste minimization circles is in the first place that an increasing number of companies in a particular region – and possibly in a particular industry – become involved in waste minimization. The circle builds upon the commitment of a number of environmentally conscious industrialists and their willingness to share information with other companies, probably even with competitors. Once the initiative has been taken, social mechanisms contribute to the further expansion of the circle as well as to the dissemination and continuation of waste minimization; the initiators (early adopters) undertake action to stay ahead of the others and thus sustain the perceived recognition from being among the first, while the late adopters wish to undertake action to come up to the level of the early adopters. It is most likely that the circles concentrate on comparatively obvious, low- and

### Waste Minimization Group Surat

In India, a significant portion of textile process houses having an installed capacity of around 10 million meters per day are located in and around Surat. Waste Minimization Group Surat (WMG) is the result of voluntary efforts of a group of environment-conscious technical experts from textile processing, dyestuffs and chemical industries situated in and around Surat. The main objectives of this group are:

- To create awareness of pollution, its prevention and control;
- To create awareness of source reduction of costs and of pollution by optimum utilization of chemicals in various stages of application, dye waste treatment and reuse etc.;
- To create awareness of cost reduction that can be achieved by efficient utilization of water and energy (and circulate information on resource inputs for selected commonly practised wet processing steps to serve as clean technology standards);
- To share experiences and circulate information on environmental properties of dyes and chemicals used in the textile industry;
- To share experiences and circulate information on the financial and environmental aspects of eco-friendly alternatives to the conventional dyes and auxiliaries;
- To circulate environmental regulations imposed on the textile industry in different countries with a view to comparing the local industry with the regulatory measures adopted internationally.

WMG started in 1993 with some 15 members. Informative meetings are held in order to exchange waste minimization experiences among the participants and to elaborate on common issues, such as dye bath reuse and recovery of print paste remnants. In 1994, a newsletter came into being. The first issues addressed special topics like chemical substitutions, water conservation and organization of a plant level waste minimization programme. At the end of 1994, membership had risen to over 150 persons. The DESIRE project was covered extensively by WMG; the WMG activities have contributed to the fact that by the end of 1994, some 20 process houses had started with the implementation of the most successful waste minimization options identified in the DESIRE project.

no-cost waste minimization opportunities for common environmental problems in the first place, which in turn are excellent starting points for experimentation by industries not yet active in waste minimization. Given the low cost, the general applicability and the obvious benefits of these options, it is very likely that these late adopting companies will be enthusiastic about their early waste minimization experiences and thus become more active in waste minimization. Once suppliers, technical institutes and industry associations join the waste minimization circle, the circle might start to explore technical constraints to waste minimization, which in turn could result in cooperation among companies for environment-driven R&D.

Although waste minimization circles seem to be a

powerful tool for the dissemination of waste minimization, it might be rather complicated to get these established given the conditions that have to be met for the fruitful development of waste minimization circles. First of all, environmentally conscious industrialists have to be identified who might be willing to take the initiative for a waste minimization circle. Within the circle, participating industrialists will be requested to share information and cooperate in ways in which they are not accustomed given their concern regarding confidentiality and competitiveness. Next, the circles should have access to appropriate methodological and technical assistance. In terms of methodology, the circles need assistance on how to organize and conduct waste minimization audits. In terms of technology, information on the latest technical developments in the

industry sector as well as environmentally benign alternatives will be requested. In order to avoid duplication of efforts by waste minimization groups in different parts of the country, there exists a need for a national information clearinghouse. Finally, it goes without saying that the support of the circles (technical assistance, national network etc.) as well as the activities of the circles (seminars, newsletters, study tours etc.) require funds. Especially in the start-up phase, with comparatively few members, it is not likely that a waste minimization circle can be self sustaining.

Given the need to encourage environmentally-conscious industrialists to take the lead in a waste minimization circle, it might be useful to link a waste minimization circle with an existing board for a CETP or to initiate a demonstration project in the first place. The obvious advantage of linking a waste minimization circle with a CETP board is that an existing institutional framework can be used to spread the waste minimization message. The drawback is however that CETP is based on non-voluntary cooperation (forced by environmental legislation), which in turn is not the optimal breeding ground for undertaking proactive steps like waste minimization. The obvious advantages of building a waste minimization circle on a demonstration project seem to be that appropriate methodological and technical back up can be provided in the initial phase. In the course of the demonstration project, the participating companies can experience the benefits of cooperation, which in turn might set the stage for a non-competitive environment for dissemination of the experiences in the waste minimization circle. The obvious drawback from this approach is however that a new institution has to be founded for the waste minimization circle.

## **2. Obligatory waste minimization audits**

Several schemes exist to promote the development of SSIs. Fiscal incentives like sales tax exemptions and 100 per cent depreciation allowances exist for selected industries in the SSIs segment in order to boost their development. In addition, funds and soft loans are available for the construction of pollution control systems, both for individual companies and groups of companies (common effluent treatment plants). In these schemes, no weight is given to environmentally sound industrial growth versus traditional industrial growth or to waste minimization versus end-of-pipe pollution control investments. The inclusion of the requirement to submit a waste minimization audit as part of the application within these schemes would create a financial incentive for companies to conduct waste minimization audits and implement the feasible

measures.

The obligatory waste minimization audits will incite companies to conduct waste minimization audits. Most probably these waste minimization audits will reveal numerous low-, or even no-cost, waste minimization options (like good housekeeping, proper process control and maintenance), which should be implemented by the companies, given the cost-saving potential of these options. In addition, the audits might result in some high-cost waste minimization options, for which the companies require additional funds for implementation. Soft loans and a 100 per cent depreciation allowance could be made available for these investments. The obligatory waste minimization audits should thus contribute to the implementation of the obvious no- and low-cost waste minimization options by the companies and to the preferential allocation of the available environmental investment funds for implementation of high-cost waste minimization options in industries having implemented their available low cost options.

The proper deployment of this implementation mechanism requires the creation of quality control procedures for the waste minimization audits submitted by companies. The independent quality control for the waste minimization audits should evaluate whether all waste minimization approaches are seriously addressed and whether provisions are taken to safeguard the ongoing implementation of the no- and low-cost options, and they should verify the feasibility of the selected high-cost options. Separate criteria will have to be developed for audits submitted for obtaining ongoing fiscal benefits (like sales tax exemptions) and audits submitted for obtaining investment subsidies (like preferential loans or a 100 per cent depreciation allowance). Preliminary experiences from the introduction of an obligatory waste minimization audit for soft loans in China showed that this is actually a strong drive for companies willing to set up new or to expand existing facilities. However, the possibility to apply for a preferential loan tends to limit the focus of the companies to high cost waste minimization opportunities, causing them to neglect short-term, no- and low-cost waste minimization opportunities (Van Berkel et al, 1994).

Since the financial schemes are only available in the formal economy, the obligatory waste minimization audits will only be effective for SSIs in the organized sector, which need external funds. With numerous SSIs having significant shares of business in the unorganized, informal sector, the obligatory waste minimization audits will not likely impact major parts of SSIs in the

short term.

### 3. Waste minimization demonstration projects

Waste minimization demonstration projects consist of technical assistance and methodological guidance to a limited number of selected industries in order to create convincing examples of the successful application of waste minimization at the company level. These examples, in turn, should incite related industries to start with waste minimization on their own. The DESIRE project was the first systematic Indian waste minimization demonstration project. Although future demonstration projects can be conceptualized according to the main features of the DESIRE project, these future projects can be less complex and resource intensive if proper use is made of the results of the DESIRE project (in particular of the waste minimization guide and the results of the barriers and incentives study).

The expected short-term result of a waste minimization demonstration project should be the actual implementation of waste minimization measures in the participating companies. In addition, provisions should be made to safeguard implementation of the successful waste minimization measures in related companies. To this end, the preparation of a sector-specific technical waste minimization manual, the organization of seminars and workshops and the training of experts should be considered integral parts of any waste minimization demonstration project.

The most important starting condition for a waste minimization demonstration project seems to be the willingness of selected companies in a particular area – and possibly in a particular sector – to act as demonstration companies; this includes the commitment to allocate resources (staff time and a token fee) to the identification and evaluation of waste minimization measures, to allocate funds to the implementation of feasible waste minimization measures and to share waste minimization results and experiences. With a view to institutional capacity-building for waste minimization and the dissemination of the results, it is necessary to obtain the involvement of the industry association, professional organizations and technical research institutes. In addition, it could be explored whether or not local environmental authorities could play an active role in local waste minimization projects. Although such participation might be resisted by industry in the first place, it was found in the Netherlands that such participation in the long term was appreciated by both industries and Government

officials (see box 5.2)

Table 5.3 contains a summary of the expected outcomes and conditions of each of the proposed implementation mechanisms.

### 5.3 Starting conditions

Once the implementation mechanisms have been conceptualized, one should assess how to create both the demand for, and supply of, these mechanisms. The following contains some suggestions to create these starting conditions.

#### Creating the demand

The objective of these starting conditions is to encourage companies to start waste minimization with the use of one of the implementation mechanisms; that is, to join a waste minimization circle, to apply for financial benefits based upon a completed waste minimization audit and/or to participate in a demonstration project. Information transfer and awareness raising are key items to start with. In more detail, the following can be undertaken to create the demand for waste minimization:

1. *Information exchange and awareness raising:* The public promotion of waste minimization should aim at making industrialists aware of the financial and environmental benefit of waste minimization and encouraging them to start with the experimentation on waste minimization in their own operations. A tailor-made communication strategy should be developed and implemented. This should clearly specify different target groups within SSIs, and link each of these target groups with an appropriate message and appropriate communication (like manuals, seminars, leaflets, newsletters etc.) and dissemination tool. Given the rather informal and unorganized structure of SSIs, the actual delivery of the message to each of the companies should be given high priority.

Generally speaking, two goals can be distinguished in the public promotion of waste minimization. The first is to build awareness for waste minimization that leads to the investigation and implementation of available obvious options. The second is to achieve long-term organizational change that integrates waste minimization in all functions and activities of industries (Luken, 1995). In the short term, the first goal seems most appropriate for Indian SSIs. Given the numerous low- and no-cost, highly cost effective waste minimization options with significant reductions of

**Box 5.2: Involving local authorities in waste minimization demonstration projects in the Netherlands (Van Berkel, 1995)**

In the Netherlands, there are generally good and highly influential contacts between officials from local environmental authorities and local industries. Once local environmental authorities succeed in using these contacts for pushing the industries to take more care about the environmental situation and for offering some kind of motivational – or even technical – assistance for assessing waste minimization in industries, local authorities can become powerful players in the dissemination of waste minimization practices.

Having recognised the critical role of local governments in shaping industrial environmental management, especially in small- and medium-sized enterprises, a number of regional waste minimization projects has been executed over the last five years in the Netherlands. These projects generally aimed at two separate, but interrelated, objectives, respectively:

1. to create examples of the successful application of waste minimization concepts and methods in leading industrial companies in the respective region;
2. to create the conditions for ongoing cleaner production fostering policies within the local environmental administration.

To achieve this, a local demonstration project took place in which local environmental authorities, industries and outside consultants co-operated. In addition, a local waste minimization-fostering policy has been developed with the model strategy depicted in figure 5.1. Industries will be approached with three separate, but interrelated, strategies. Strategy 1, motivation, deals with the dissemination of information in order to encourage enterprises on a voluntary basis to start waste minimization activities. Strategy 2, demonstration, aims at the identification of industry specific waste minimization opportunities, which can be used as starting points by industries in the respective industry sector. Strategy 3, continuation, aims at the integration of waste minimization in the day-to-day operation of the enterprises.

Figure 5.1: Model strategy for local waste minimization fostering policies.

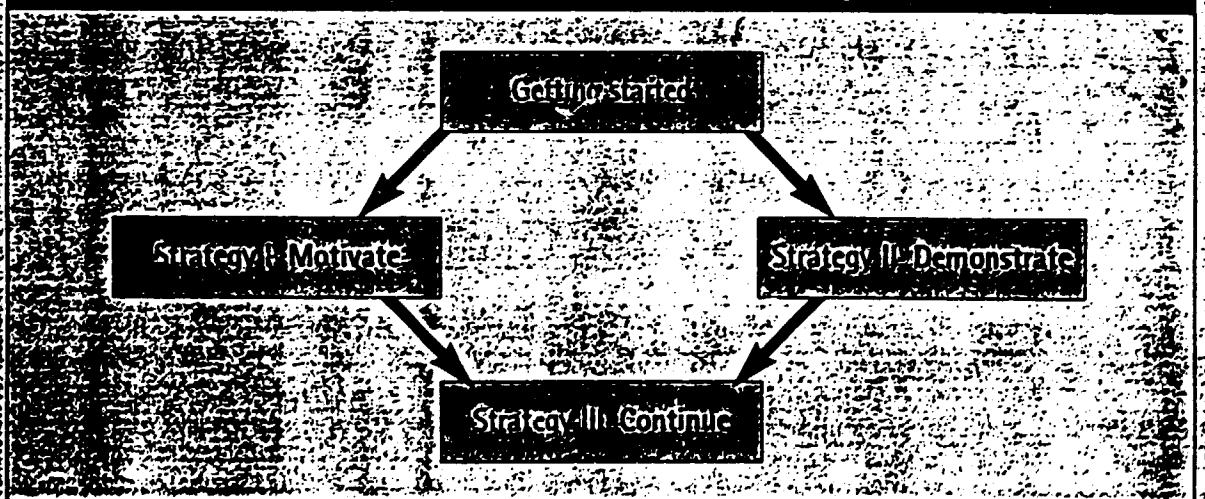


Table 5.3: Summary of key features of the waste minimization implementation mechanisms.

Implementation mechanism	Expected outcome	Conditions	Remarks
1. Waste minimization circles	<ul style="list-style-type: none"> <li>Increasing number of companies in region and/or sector start with waste minimization.</li> <li>Dissemination and implementation of comparatively-obvious, low- and no- cost options via social mechanisms.</li> <li>Cooperation between companies for environment-driven technology development.</li> </ul>	<ul style="list-style-type: none"> <li>Environmentally-conscious industrialists will have to take the lead.</li> <li>Appropriate technical and methodological back up.</li> <li>Establishment of a national network for information exchange.</li> <li>Funds for support to, and activities of, waste minimization circles.</li> </ul>	<ul style="list-style-type: none"> <li>CETP boards are probably not the best organizations to start waste minimization circles, given the non-voluntary nature of the CETPs.</li> <li>It is suggested to link the waste minimization circle to a local demonstration project.</li> </ul>
2. Obligatory waste minimization audits	<ul style="list-style-type: none"> <li>Strong drive for the implementation of both low and high cost waste minimization options.</li> <li>Preferential allocation of finances for waste minimization as compared to end-of-pipe control and treatment.</li> </ul>	<ul style="list-style-type: none"> <li>Establishment of provisions for independent quality evaluation for the approval of the waste minimization audits submitted by industry.</li> <li>Agreement with industrial authorities on financial schemes to be used to this end.</li> </ul>	<ul style="list-style-type: none"> <li>Impact depends heavily on the selection of the financial schemes that will be subjected to obligatory audits.</li> <li>Only effective for the organized sector.</li> </ul>
3. Waste minimization demonstration projects	<ul style="list-style-type: none"> <li>Convincing company-level examples of the implementation of waste minimization.</li> <li>Inventory of practical waste minimization opportunities for dissemination to other companies.</li> <li>Training of experts and institutional capacity building for waste minimization.</li> </ul>	<ul style="list-style-type: none"> <li>Willingness of companies to act as demonstration units.</li> <li>Interest of industry associations, professional organizations and/or technical research institutes to become involved in the dissemination of results.</li> <li>Funds for providing subsidized waste minimization consultancy to the demonstration companies.</li> </ul>	<ul style="list-style-type: none"> <li>Demonstration projects can be used to catalyse the establishment of a waste minimization circle.</li> <li>It deserves recommendation to explore opportunities for participation of local environmental authorities in the demonstration projects.</li> </ul>

wastes and emissions identified in the DESIRE project, this alone might result in major waste minimization achievements. Another important aspect in the planning of public promotion activities is to evaluate why companies have not yet started waste minimization (WRITAR, 1994). It is most likely that information is missing; industrialists either do not understand the consequences of their actions (especially in regard to total waste costs) or do not fully understand the availability or applicability of waste minimization to their current methods of production. Supply these missing links, and, according to this *information missing model*, generators will say "Ah" and move

forward with the implementation of waste minimization. It might be, however, that motivation rather than information is missing; industrialists do not perceive the need to look holistically at their environmental practices. By doing so, they would realize that efficiencies are to be gained, and thereby money is to be saved, and they would finally proceed with the implementation of waste minimization. This *motivation missing model* actually calls for improvement of environmental legislation and its enforcement and public pressure. For export-oriented industries, much is to be expected of pressure from overseas buyers reflecting environmental concerns



from consumers in western Europe and the United States of America (van Berkel, 1994).

2. *Enforcement and improvement of environmental regulations:* Apparently industries don't yet feel the need to seriously address environmental concerns. Proper enforcement of environmental regulations should assure that companies actually comply with existing environmental regulations and incur the real cost of doing so. While doing so, environmental agencies should familiarize themselves with waste minimization concepts and approaches in order to evaluate all environmental initiatives of industries properly in addition to inspecting for compliance with end-of-pipe regulations. In industrialized countries with mature environmental enforcement practices (like the Netherlands), it proved to be useful to involve local environmental authorities in the planning and implementation of waste minimization demonstration projects (see also box 5.2). In addition to the proper enforcement of existing environmental regulations, opportunities for improvement of the environmental regulations should be analysed. Waste minimization could benefit from:

- Change from concentration to load-based environmental standards;
- Development of regulations for solid, non-hazardous waste and industrial use of ground water;
- Shift from single media to multimedia environmental regulations, covering all environmental concerns (waste water discharges, air emissions, solid waste, hazardous waste etc.);
- Development of requirements for company environmental management and reporting systems.

3. *Development of financial incentives:* Apparently waste and emission generation and excessive resource consumption are still too cheap to really bother the industrial entrepreneur. Proper resource pricing, especially for fuels, power (electricity) and natural auxiliaries (ground water, cooling water, land etc.) as well as development of fool-proof provisions to terminate free-rider opportunities might thus greatly help in fostering waste minimization. In addition, initiatives should be taken to make more funds available for investment subsidies and tax benefits for companies implementing waste minimization. This includes coordination between various donors to result in complete sectoral and geographic coverage.

### Creating the supply

The objective of these starting conditions is to create the institutional capacity to support companies in waste

minimization. Practical training of waste minimization experts and linking technology development to the needs and capabilities of SSIs are key items to start with. In more detail, the following can be undertaken to create the supply of waste minimization expertise:

1. *Capacity building:* As proven by the study on barriers and incentives for waste minimization (see chapter 2), SSIs strongly rely upon outside experts to get waste minimization implemented. Experts having basic waste minimization skills are still few, which calls for practical training of experts from institutions as diverse as small industries service institutes, professional organizations, industry associations, consultants and technical institutes. As each institution has a different role in fostering waste minimization in SSIs, different training packages are needed. Industry associations and small-scale service institutes might have the most important role in fostering information dissemination and should thus be trained in communication and outreaching skills in order to convince entrepreneurs to undertake waste minimization activity. Consultants and technical institutes could probably support industries in conducting the plant level waste minimization audits and should thus be well trained in technical and methodological aspects of waste minimization audits. Generally speaking, it is highly advisable to link training of these different types of waste minimization experts with practical audits at companies (as part of demonstration or dissemination projects).

2. *Establishment of a technology cooperation chain:* The limited access to technical information as well as limitations in technology employed by SSIs were among the most prominent technical constraints (see section 2.5). Both evidence the malfunctioning of the cooperation between end-users of technology (SSIs) and agencies involved in technical development (small industries service institutes and technical institutes). Mechanisms are to be devised which fine-tune technical development to the needs, capabilities and environmental concerns of SSIs. To this end, part of the financing of the technical research institutes could for instance be allocated to environment-driven technical development.

3. *Training policies:* Most of the internal enabling measures (see table 5.1) have a comparatively general nature and aim at improving industrial management in SSIs and enhancing entrepreneurship

among SSIs owners. To this end, training policies could be developed, which will not only foster waste minimization but contribute to improvement of the managerial capacities of SSIs in general. Attention should be given to training of the 'new generation' (inclusion of business administration and industrial management in engineering education and professional curricula), and on-the-job training. The latter should be very practically oriented and could, for instance, be shaped as a series of short workshops to be delivered by distinguished practical experts in late afternoon sessions prior to a common dinner or other social activity at a local social club.

The link between these starting conditions and the implementation mechanisms is depicted in figure 5.2. This figure stipulates the recommended promotion and dissemination strategy based upon the experiences from the DESIRE project.

#### 5.4 Concluding remarks

This chapter assessed the policy lessons from the DESIRE project, starting with the enabling measures identified in the course of the company-level waste minimization assessments. The primary focus has been on the establishment of implementation mechanisms that support these external enabling measures. Three such mechanisms have been identified and seem to be implementable by environmental authorities and acceptable for industry. These are:

1. Waste minimization circles;
2. Obligatory waste minimization audits;
3. Waste minimization demonstration projects.

Expected outcomes as well as necessary conditions have been discussed. In addition, supportive actions have been analysed which might create the demand for, and supply of, waste minimization services. The resulting policy strategy has been depicted in figure 5.2. This model policy strategy still needs further elaboration, to which companies as well as industrial and environmental authorities should contribute.

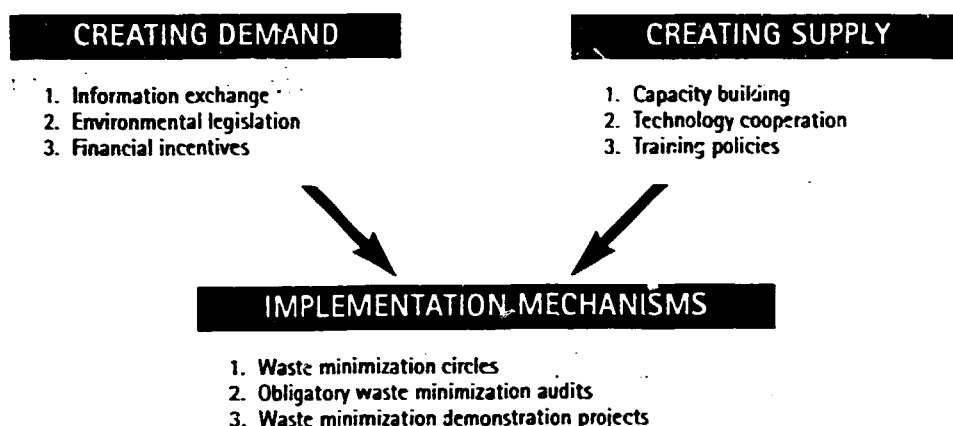
The development of waste minimization fostering policies goes much beyond the traditional environmental policy domain. In figure 5.2 the development of training policies to improve managerial skills and the deployment of fiscal incentives are examples of such unconventional environmental policies. A recent qualitative survey of policy options to exploit the competitiveness-enhancing potential of cleaner

production suggested opportunities for the promotion of waste minimization in the following policy fields of the European Union (Molier et al, 1995):

- *Financial and industrial policies:* In order to accelerate the industry's self interest in waste minimization, environmentally sensitive cost accounting and capital budgeting tools could be promoted, via for instance information dissemination and demonstration projects, subsidies for consultancy services in this respect and tax benefits. Without any doubt, environmental levies (on the use of virgin resources) and environmental tax advantages (depreciation allowances for environmental investments) will contribute to the implementation of waste minimization.
- *Employment and training policies:* Waste minimization often brings along new tasks and activities which require altered attitudes, new management and supervisory skills and extra environmental know-how. Virtually all existing continuous education programmes can be used to boost the development of such "care taking" and "improved housekeeping" attitudes as well as to create the awareness of production costs and quality at all levels within industry.
- *Environmental policies:* Waste minimization teams established in the local or regional governments can assist small- and medium-sized enterprises in developing waste minimization activities. Waste minimization can be integrated in the environmental permits, for instance via inclusion of research obligations, behavioural prescripts and specifications for environmental management systems. In addition, voluntary initiatives of industries could be supported, for instance via support of the issuance of environmental hallmarks by industry associations.
- *Technology policies:* Support could be provided for the development of "blue-prints" (specifications of the best possible environmental improvements in the sector) as well as for specific environment-driven R&D. Another interesting approach is to foster bench marking among industries in order to establish the best operating practices for a given technology and to allow for the dissemination of these practices throughout the industrial sector.

In order to assure the deployment of such a variety of policy tools for the promotion of waste minimization,

Figure 5.2: Recommended strategy for promotion and dissemination of waste minimization



it will be extremely important for the various stakeholders to cooperate and exchange information and experiences. The following entities should play a role in this network:

1. *Government:* industrial and environmental ministries which set the stage by adopting national industrial and environmental policies.
2. *Environmental agencies:* central and state pollution control boards along with their regional branches play a critical role in the dissemination of general information on waste minimization and the enforcement of environmental regulations.
3. *Technical institutes:* Including small industries service institutes, sectoral research institutes and industrial R&D agencies focusing on solving the technical constraints encountered in the implementation of waste minimization in industry.
4. *Industrial organizations:* including industry associations, the Confederation of Indian Industries etc., focusing on general awareness raising on the business opportunities of waste minimization and on the dissemination of generally applicable waste minimization approaches.
5. *Consultants:* including management as well as technical consultants, assisting companies in the identification, evaluation and implementation of

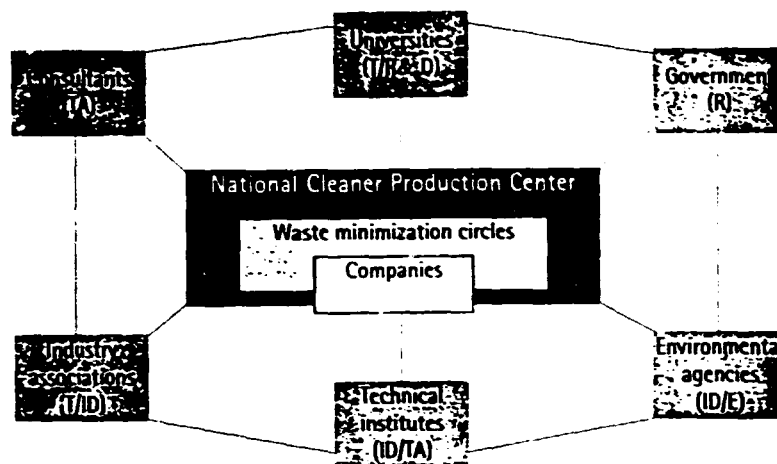
waste minimization opportunities.

6. *Universities:* including technical universities, the Indian Institute of Technology and professional schools, which should include waste minimization in the existing engineering and business management curricula in order to properly educate the future generation of industrialists. In addition, universities can play a critical role in interdisciplinary research on issues related to the introduction of waste minimization in SSIs.

The proposed network of these institutions is depicted in figure 5.3.

It is evident that a major effort is needed to establish such a network. First of all, key organizations in each of the listed categories will have to be identified and motivated to become involved in the implementation of waste minimization. Next, training should be provided to experts from the selected organizations in order to create centres of waste minimization expertise. Once such basic skills and expertise have been created, mechanisms need to be developed for coordination among the participants in the network. The newly established Indian National Cleaner Production Centre could play an important role in establishing and developing such a network over the coming years.

Figure 5.3: Schematic presentation of the proposed network for promotion of waste minimization in SSIs



Notes: T = Training  
 E = Enforcement  
 ID = Information dissemination  
 R = Regulations  
 TA = Technical assistance

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# Ashoka Pulp and Paper (Delhi)

Ashoka Pulp & Paper is an agro-residue-based pulp and paper mill producing unbleached semi-kraft paper having an average production capacity of 36 tons per day. At the start of DESIRE, the unit used a raw material mix of 75 per cent agro-residue (wheat straw) and 25 per cent waste paper. Bagasse is fired in conventional boilers in order to produce steam for the operation of the pulp and paper mill. Key environmental baseline data for Ashoka Pulp & Paper were:

- Annual raw material consumption: 16,335 tons of wheat straw and 5,346 tons of waste paper;
- Annual energy consumption: 10,450 MWh and 18,150 tons of bagasse;
- Annual water consumption: 1,864,500 m<sup>3</sup>;
- Wastewater discharges: 5,551 m<sup>3</sup>/day, with 5,117 kg

of BOD, 5,621 kg of TSS, 25,214 kg of COD and 34,824 kg of TS.

A division of the wastewater discharges to the constituent waste water sources is given in table I.1.

Ashoka Pulp & Paper participated in the DESIRE project with the twin objectives of production cost reduction and cost-effective compliance with environmental regulations. The pressure from the local public for improving environmental performance and the need to conserve water due to ensuing water shortages especially in summer months, were other reasons behind the company's decision to pursue actively waste minimization. The in-house team consisted of the director, the works managers and an operator. In cooperation with the technical study team, 50 waste minimization options have been generated and evaluated. The most successful options are summarized in table I.2. At the end of the 15 months cooperation in

Table I.1: Baseline wastewater sources at Ashoka Pulp and Paper

Wastewater sources	Parameters				
	Flow (m <sup>3</sup> /day)	BOD (kg/day)	TS (kg/day)	COD (kg/day)	TS (kg/day)
Potcher mechano chemical digester	887	1401	1113	8009	11043
Potcher spherical digester	985	2362	1451	13894	14381
Decker filtrate	1053	560	1017	1179	3377
<b>Total pulp mill</b>	<b>2925</b>	<b>4323</b>	<b>3581</b>	<b>23082</b>	<b>28801</b>
Centrifugers I	136	15	111	38	815
Centrifugers II	125	22	86	60	738
Water pump pit overflow	80	53	50	116	225
Inclined screen I	414	200	506	532	1283
Inclined screen II	509	296	1121	788	1701
Paper machine I	808	93	85	270	806
Paper machine II	514	115	81	328	455
<b>Total paper mill</b>	<b>2586</b>	<b>794</b>	<b>2040</b>	<b>2132</b>	<b>6023</b>
<b>Total mill</b>	<b>5511</b>	<b>5117</b>	<b>5621</b>	<b>25214</b>	<b>34824</b>

the DESIRE project, Ashoka had implemented 24 waste minimization options. In addition, 11 options were still under implementation and for two other options, implementation still had to take off. Finally, 13 waste minimization options were rejected given their limited technical and/or financial viability.

The overall impact of waste minimization at Ashoka Pulp & Paper is assessed in table I.3. The environmental benefits per ton of paper produced are in the range of 30 to 40 per cent. This is partially due to the increase of the share of waste paper pulp in the final product (increased from 25 per cent to 38 per cent). Additionally, Ashoka

Pulp & Paper reaped the combined benefits of elimination of obvious waste sources and causes and improvement of the overall process efficiencies.

A total of \$95,000 was invested in the 24 options implemented by now and net annual savings are about \$160,000. Thus the overall payback of the implemented options is less than seven months. The overall reduction in terms of COD load per ton of paper produced is about 30 per cent allowing for an additional annual saving of approximately \$47,000 in effluent treatment cost.

Table I.2: Most successful options at Ashoka Pulp and Paper

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Installation of additional dryers on paper machine	I = \$51,667 S = \$74,333 P < 0.7 year	No major impact.	Capacity increase of 5 tons/day, with same infrastructure and water requirement.
2. Installation of broke pulper at paper machine.	I = \$10,000 S = \$8,000 P < 1.3 year	TS and COD load reduced by 120 and 90 kg/day respectively.	Reduces reprocessing and washing of broke pulp and thus conserves fibres and fillers.
3. Timely replacement of upper press roll to minimize press picking	I = \$6667 S = \$16,667 P = 0.4 year	COD load reduced by 300 kg/day. Reduction of steam requirements.	The measure requires close monitoring of press roll to replace it as soon as press picking shows a rising trend.
4. Double felting to reduce press picking	I = \$8,333. S = \$21,667 P < 0.4 year	Reduced kerosene contamination in effluent by about 500 lt./day.	The measure improved mechanical de-watering, thereby reducing steam consumption per ton of paper production.
5. Sedimentation save-all for fibre recovery.	I = \$10,000 S = \$10,000 P = 1 year	TS and COD load reduced by 1.6 and 1.2 ton/day. Water requirement reduced by 600 m3/day.	Simple option identified and implemented after evaluation of the potential of fresh water substitution and fibre recovery with the available white water.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period

**Table 1.3: Assessment of overall impact of waste minimization at Ashoka Pulp and Paper**

Parameter	Before	After	Change	Most important measures
1. Production capacity (ton paper/day)	36	42	+ 17 %	Extra dryers on paper machine; minimization of spills/leaks; optimization of cooking; additional waste paper pulping.
2. Waste water volume (m <sup>3</sup> /ton finished paper)	153	92	- 40 %	Several water recycling measures; elimination of spills/leaks; increased share of waste paper pulp.
3. COD load (kg/ton finished paper)	700	498	- 29 %	Optimization of cooking; replacement of press roll; double felting of press roll; water recycling measures; increased share of waste paper pulp.
4. TS load (kg/ton finished paper)	980	700	-40 %	Fibre recovery; water recycling measures; increased share of waste paper pulp.
5. Effluent treatment cost (Rs lakh/year)	116	97	- 17 %	Reduction of daily COD and TS load.
6. Chemical cost (Rs lakh/year)	155	144	- 7 %	Optimization of cooking process.
7. Energy (Rs lakh/year)	430	393	- 8.6 %	Insulation; hot stock refining; process optimizations.

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# Bindlas Duplex (Muzzaffarnagar)

Bindlas Duplex is an agro-residue-based pulp and paper mill having an average production capacity of 28 tons per day of unbleached raft paper. On completion of the ongoing expansion, the capacity of the mill is expected to be about 40 tons per day. The raw material mix consists of 87 per cent agro-residue, 10 per cent rags and 3 per cent waste paper; the agro-residue mix varies upon seasonal availability of sarkanda, wheat straw and bagasse. Bindlas Duplex operates a rice-husk fired fluidized bed boiler to meet the steam requirements of the pulp and paper mill.

The in-house team consisted of the managing director, the works manager and the maintenance supervisor. This team was supported by the technical study team. In the course of the DESIRE project, 51 waste minimization options have been identified and evaluated. The most successful options are summarized in table II.1. Upon completion of the project (after 15 months), Bindlas Duplex had implemented 18 waste minimization options. In addition, 10 options were still under implementation and for seven options implementation still had to take off. The remaining 16 waste minimization options had been

Table II.1: Most successful options at Bindlas Duplex

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Installation of high velocity hood on steam dryer	I = \$56,666 S = \$53,333 P < 1.1 year	Marginal reduction in steam requirement (which in turn minimizes air emissions from boiler house).	Cost intensive, but economically feasible option due to increase in production capacity. Installation required a major equipment shut down.
2. Optimization of pulp cooking process (steam pressure, temperature, chemical dosing etc.)	I = \$11,666 S = \$73,333 P < 0.2 year	Overall pollution load reduced by 10 %.	Option required hardly any investment; implemented in second phase of the project.
3. Fibre saver for recovery of fibres from centri-cleaner reject	I = \$7,333 S = \$8,333 P < 0.9 year	Reduction in TSS and COD load by 2 %.	An additional high pressure pump was required to ensure constant pressure for effective fibre recovery.
4. Installation of additional press set to increase mechanical dewatering of paper	I = \$16,666 S = \$12,666 P < 1.4 year	Marginal reduction of steam requirement (which in turn minimizes air emissions from boiler house).	Press roll could be installed given space availability; measure reduced paper breaks and increased production.
5. Fresh water substitution and installation of self closing nozzles on hoses	I = \$8,333 S = \$6,666 P < 1.3 year.	Reduction of effluent volume by 25 %.	This measure enabled the mill to operate at full instead of 60 % capacity in dry season.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period



rejected given their low financial and/or technical feasibility.

The overall impact of the implementation of waste minimization at Bindlas Duplex is given in table II.2. Since additional agro-residue pulping capacity has been installed, the raw material mix has not changed significantly.

Bindlas Duplex invested a total of \$104,000 for the implementation of the first batch of 18 waste minimization options. These will bring net financial benefits worth \$330,000. The overall payback of the implemented options is thus less than four months. The overall reduction of the COD load per ton finished paper is about 28 per cent, allowing for an additional reduction of \$43,000 on effluent treatment cost.

**Table II.2: Assessment of the overall impact of waste minimization at Bindlas Duplex**

Parameter	Unit	Change
1. Production capacity	ton finished paper/day	+ 22 %
2. Waste water volume	m <sup>3</sup> /ton finished paper	- 25 %
3. COD load	kg/ton finished paper	- 28 %
4. TS load	kg/ton finished paper	- 40 %
5. Effluent treatment cost	Rs/year	- 35 %
6. Chemicals cost	Rs/year	- 6 %
7. Energy cost	Rs/year	-5.5 %

# Raval Paper Mills (Rae Bareilly)

Raval Paper Mills is an agro-residue-based pulp and paper mill producing 10 tons per day of unbleached semi-kraft paper and 15 tons per day of bleached and dyed writing and printing paper. The raw material mix varies according to seasonal availability and production requirements (paper quality specifications); raw materials include wheat straw, rice straw and waste paper. Both rice husk and coal fired boilers are in operation to meet steam requirements. Raval Paper Mills was keen to participate in the DESIRE project, given the potential to reduce effluent treatment cost, increase productivity (and profits) and to conserve water (thereby enabling continuation of production in summer months).

Key environmental baseline data for Raval Paper Mills were:

- Annual raw material consumption: 7,920 tons of wheat straw, 2,640 tons of rice straw, 990 tons of elephant grass, 660 tons of bagasse, 1,129 tons of unbleached waste paper, 1,923 tons of bleached waste paper and 825 tons of rags;
- Annual energy consumption: 7,000 MWh and 13,000 tons of rice husk;
- Annual water consumption: 1,452,500 m<sup>3</sup>;
- Waste water discharges: 4,258 m<sup>3</sup>/day, with 5,051 kg of BOD, 8,393 kg of TSS, 24,764 kg of COD and 30,270 kg of TS.

A division of the wastewater discharges to the constituent wastewater sources is given in table III.1.

The waste minimization programme was managed by the in-house project team consisting of the works manager, the technical project manager, the pulp mill supervisor, the maintenance supervisor, a laboratory analyst and an operator. The technical study team assisted the team in identifying and evaluating a total of 65 waste minimization options. The most successful options are summarized in table III.2. In the course of the DESIRE project (within 15 months), Raval Paper Mills succeeded in the implementation of 30 feasible options. Another 20 options proved to be feasible; out

Table III.1: Baseline wastewater sources at Raval Paper Mills

Wastewater sources	flow (m <sup>3</sup> /day)	BOD (kg/day)	TS (kg/day)	Parameters	
				COD (kg/day)	TS (kg/day)
Unbleached potcher	1209	3712	4938	20660	18090
Beater wash	320	196	295	1125	4700
Pulp mill centricleaner	29	23	58	73	100
Pulp mill Decker filtrate	316	51	395	170	554
Bleach potcher	632	165	654	414	1903
Hydro pulper potcher	214	80	142	250	400
<b>Total pulp mill</b>	<b>2720</b>	<b>4227</b>	<b>6482</b>	<b>22692</b>	<b>25747</b>
Paper machine centricleaner	132	138	498	393	750
Wire pit water	438	222	533	531	1273
Couch decker filtrate	378	464	880	1148	2500
<b>Total paper mill</b>	<b>1538</b>	<b>824</b>	<b>1911</b>	<b>2072</b>	<b>4523</b>
<b>Total Mill</b>	<b>4258</b>	<b>5051</b>	<b>8393</b>	<b>24764</b>	<b>30270</b>

of these, 12 were already under implementation, while for the other eight feasible options, implementation still had to take off. Finally, 15 waste minimization options were rejected, given their limited technical and/or financial viability.

The overall impact of waste minimization at Raval Paper Mills is assessed in table III.3. The environmental benefits per ton of paper produced are in the range of 30 to 40 per cent. This is due to the combined impact of elimination of obvious waste sources (repairs, spills etc.), improvement of raw material dedusting, proper

provisions for black liquor collection and comparatively small, but significant, improvements of process efficiencies.

The implementation of the first batch of 30 feasible waste minimization options required an investment of \$150,000 and generates net annual savings of \$182,000. The overall payback period at Raval Pulp was therefore less than 10 months. The overall environmental impact consists of a 34 per cent COD reduction per ton finished paper; this in turn creates an additional saving of \$55,000 on effluent treatment cost.

**Table III.2: Most successful options at Raval Paper Mills**

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Modification of existing raw material dedusting system.	I = \$1,667 S = \$8,333 P = 0.2 year	Reduction of COD and TS discharges from pulp washing and centrifuging, by respectively 1.6 and 2.2 ton/day.	Dedusting efficiency improved from 40 to 70 % for fines (below 40 mesh size). Dedusting improves utilization of chemicals and steam in pulping and reduces water consumption for pulp washing.
2. Insulation.	I = \$8,333 S = \$12,667 P < 0.7 year	Steam conservation of 0.2 ton steam/ton paper (which in turn minimizes air emissions from boiler house).	Insulation installed on digester, steam lines and condensate lines and tank.
3. Fine-tuned dilution control at fan pump.	I = \$333 S = \$2,667 P < 0.2 year	Only marginal indirect environmental benefits due to better machine operation.	Simple and easy to implement; improved consistency control on pulp feed to paper machine.
4. Provision of high consistency pump in couch pit.	I = \$5,000 S = \$27,667 P < 0.2 year	Reduction of TS load by 1.0 ton/day.	Fibre loss after paper break (250 kg/break) fully recoverable; significant reduction of volume of dilution water.
5. Water pressure control for edge cutting nozzles.	I = \$4,000 S = \$6,667 P = 0.6 year	TS and COD reduction of respectively 0.3 and 0.4 ton/day.	In addition, this option eliminates on average 5 paper breaks per week.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period

Table III.3: Assessment of overall impact of waste minimization at Raval Paper Mills

Parameter	Before	After	Change	Most important measures
1. Production capacity (ton paper/day)	25	27	+ 8 %	Minimization of spills and losses.
2. Wastewater volume (m <sup>3</sup> /ton finished paper)	170	120	- 30%	Recycling of backwater; elimination of spills/leaks; provisions for proper collection of black liquor.
3. COD load (kg/ton finished paper)	990	657	- 34 %	Optimization of cooking; provisions for proper collection of black liquor; water recycling measures; improvement of raw material dedusting.
4. TS load (kg/ton finished paper)	1210	714	-41 %	Fibre recovery; improvement of raw material dedusting; water recycling measures.
5. Effluent treatment cost (Rs lakh/year)	72	55	- 25 %	Reduction of daily COD and TS load.
6. Chemical cost (Rs lakh/year)	148	138	-6.5 %	Improvement of raw material dedusting; optimization of cooking process.
7. Energy (Rs lakh/year)	422	401	- 5 %	Insulation; process optimizations.

# Three Star Paper Mill (Dadri)

Three Star Paper Mills was a 100 per cent waste paper based mill at the beginning of the project. It changed its pulping mill in order to utilize agro-residues, in particular bagasse and wheat straw, as the basic fibre source. Due to this transformation, the mill was unable to implement most of the waste minimization options suggested in the first phase of the project, since these pertained to waste paper based paper production only. However, during the transformation, the mill became aware of the cost savings achieved in other agro-residue-based pulp and paper mills. Some of the generic waste minimization options for agro-residue-based paper production could therefore be implemented in the construction of the new pulp mill. In addition, Three Star Paper Mills operates a coal-fired fluidized bed boiler.

The in-house waste minimization team consisted of the managing director, the works manager and the maintenance supervisor. The technical study team

worked with the plant-level team to monitor baseline performance of the waste paper mill and to generate waste minimization and energy conservation options. A total of 31 options have been considered. The most successful options are summarized in table IV.1. In total, 19 options are feasible; 10 could be implemented over the course of the DESIRE project, while for four additional options implementation had started and for the remaining five feasible options, implementation still had to take off. In view of the change of the raw material mix, 12 waste minimization options initially generated had to be rejected.

Since paper production based on agro-residues had just started at the end of the DESIRE project, it was not possible to collect reliable data for the evaluation of the overall financial and environmental impact of the waste minimization programme at Three Star Paper Mills.

Table IV.1: Most successful options at Three Star Paper Mill (Chandak, 1995)

Waste minimization measure	Financial viability (estimated)	Environmental impact (anticipated)	Remarks
1. Timely replacement of upper press roll to reduce press picking.	I = \$6,667 S = \$16,667 P = 0.4 year	COD load reduction of 175 kg/day; reduction of steam requirement: (which in turn minimizes air emissions from boiler house).	This measure requires close monitoring of press roll to replace it as soon as press picking shows a rising trend.
2. Insulation.	I = \$6,500 S = \$8,333 P < 0.8 year	Steam conservation of about 0.15 ton steam/ton paper; marginal reduction of air pollution from boiler house.	Insulation installed on steam lines, digester and condensate lines and tank.
3. Installation of two-stage vacuum pulp washers.	I = \$50,000 S = \$16,667 P = 3 year	Reduction of wash water requirement by about 40 m <sup>3</sup> /ton paper.	The improved washing efficiency increases product quality. High cost investment in the frame of the conversion to an agro-residue-based pulp mill.

I = Investment    S = Net savings (after deduction of annualised operating cost)    P = Payback period

Savings as well as environmental impacts are estimated figures since post-implementation measures could not be carried out during the project period.

# Baroda Minerals and Grinding Industries (Ahmedabad)

Baroda Minerals & Grinding Industries is mainly a job order formulator for big producers of pesticides (like Bayer, Searle and Cynamide). It produces dust powder (methyl parathion and BHC) and liquids (such as cypermethrin, fenvalerate, endosulfan, methyl parathion and monocrotophos). The production equals about 7,000 tons of formulated products per annum. Given its long history in working as a job formulator which has to attain the high quality and safety standards of the parent companies, Baroda Minerals & Grinding Industries had already implemented several waste minimization practices at the start of the DESIRE project. The company wished to participate in the DESIRE project in order to share its own experiences and to explore outstanding waste minimization opportunities.

A waste minimization team has been established with active participation of the occupier, a management trainee and two plant supervisors. The technical study teams assisted the plant level team in the identification

and evaluation of waste minimization options. In the course of the project 47, waste minimization options have been considered. At the end of the project 18 feasible options had been implemented, while two other feasible options were under implementation and four other feasible options had been accepted for implementation. The remaining 23 options had been rejected by the company, given the perceived low relevance for the company and/or the limited technical and financial viability. The most successful options are summarized in table V.1.

The implementation of the first batch of 18 feasible waste minimization options required an investment of about \$700. The expected annual savings are about \$1,500. The overall payback period is therefore within 6 months. It proved to be impossible to arrive at a reliable quantification of the overall environmental impact of these waste minimization options.

**Table V.1: Most successful options at Baroda Minerals and Grinding Industries**

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Installation of rotary air lock valve to avoid pressurisation of blender.	I = \$200 S = not quantifiable P = short	Reduction of fugitive emissions of pulverized soapstone contaminated with active pesticide. Reduced health hazards.	Savings occur due to reduction of materials losses and reduction of compensation costs.
2. Recovery of left-over active pesticide by rinsing drums with suitable solvent and reusing solvent as part of recipe in next batch of compatible formulation.	I = nil S = \$1,300 P = immediate	Reduction of generation of toxic fumes from storage and handling of 'empty' drums.	Savings calculated with average production figures and technical material costs.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period

# Northern Minerals (Gurgaon)

Northern Minerals is one of the largest professionally managed pesticide formulation plants in Northern India. It formulates, packages, distributes and markets its own brand of pesticides, including granules (approximately 1250 tons/year phorate production), dust powder (approximately 800 ton/year, mainly fenvalerate (0.4 per cent) and malathion (5 per cent), wettable dust powder (approximately 160 tons/year, mainly BHC (50 per cent), mancozeb (75 per cent) and altrazin (50 per cent)) and emulsion concentrates (approximately 1500 ton, mainly endosulfan (35 per cent), quinolphos (25 per cent), fenvalerate (20 per cent), butachlor (50 per cent) and cypermethrin (10-25 per cent)). Major pollutants are toxic fumes caused during raw material charging and

blending, reprocessing of expired and off-specification products, waste generation due to unloading of dust blender for restarting after power failure and spillage during raw material handling.

A plant-level waste minimization team took the lead in the identification, evaluation and implementation of waste minimization options. This team consisted of the general manager, the deputy general manager, manager of the quality control laboratory and two production supervisors. With the guidance of the technical study team, 57 waste minimization options could be generated. A total of 35 options proved to be feasible; out of these 14 were implemented during the course of

Table VI.1: Most successful options at Northern Minerals

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Installation of fluid coupling assembly to avoid unloading of dust blender after power failure.	I = \$1,333 S = \$1,100 P = 1.2 year	Avoidance of waste generation after power failure. Reduced workers exposure to toxic fumes/health hazards	Savings calculated on average power failure (1/week) with most common dust product. To be implemented.
2. Use industrial vacuum cleaner.	I = \$833 S = not quantifiable P = medium	Reduction of fugitive emissions of soapstone (contaminated with active pesticide). Reduced workers' exposure to health hazards.	Replaces manual sweeping of the floor.
3. Automatic volumetric filling and packing machine for small liquid packages.	I = not yet quantified S = not yet quantified P = medium	Reduction of spillage and excessive filling of bottles.	Reduction of filling time and filling losses. Option to be implemented.
4. Recovery of left-over active pesticide by rinsing drums with suitable solvent and reusing solvent as part of recipe in next batch of compatible formulation.	I = nil S = \$1,500 P = immediate	Reduction of generation of toxic fumes from storage and handling of 'empty' drums. Reduction of drum disposal costs.	Savings calculated with average production figures and technical material costs.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period

the DESIRE project, while implementation of another option had started. Twenty of these feasible options still have to be implemented. The company rejected 22 options, given their perceived low technical and/or financial viability. The salient features of the most successful options have been summarized in table VI.1. In addition to the implementation of waste minimization options, progress has been achieved in setting up systematic data recording systems and training employees. It is envisioned that these measures will enable the continuation of waste minimization at Northern Minerals.

Until now, the investment for the implementation of the waste minimization options has been minimal. The implementation of the remaining feasible options requires an investment of \$4,150 and should give annual savings worth about \$2,650. The overall payback period is therefore just within 19 months. The waste generation options reduce fugitive emissions and should minimize reprocessing requirements; however both these environmental advantages could not be quantified reliably within the DESIRE project.



# Super Industries (Ahmedabad)

Super Industries formulates, packages, distributes and markets its own brand of pesticides. The production includes granules (phorate; approximately 1,000 tons/year), dusts (about 2,800 tons/year, mainly fenvalerate (0.4 per cent), methyl parathion (2 per cent), BHC (5-10 per cent) and malathion (5 per cent)), wettable powders (about 15 tons/year; mainly BHC (50 per cent)) and liquids (approximately 85,000 litres/year; mainly dichlorophos (76 per cent), fenvalerate (20 per cent) and methyl parathion (50 per cent)). In the course of the DESIRE project, Super Industries started to set up a new granules plant. Major polluting areas in this company are toxic fumes (active pesticides and solvents) from the blenders during charging, blending and discharging, reprocessing of expired and off specification product, fugitive soapstone powder emission from dust handling operations, and spills and leaks from pumps and charging lines.

At the announcement of the DESIRE project, Super Industries showed a keen interest and strong commitment to participate and learn waste minimization

practices. The in-house team consisted of the occupier, the production manager, the production in charge, the laboratory in charge and the maintenance in charge. As part of the DESIRE project, a training session has been held in order to build the project team and to familiarize the project team with the waste minimization objectives, practices and data gathering and evaluation tools. The plant-level team received assistance and guidance from the technical study team. In the course of the project, 56 waste minimization options have been generated and evaluated. sixteen feasible options had been implemented at the end of the DESIRE project, while an additional number of eight feasible options was under implementation. From the remaining options, 12 should be considered feasible and the company is willing to implement them, while the other 20 options should be considered as not feasible. The salient features of the most successful options have been summarized in table VII.1.

The implementation of the first batch of 24 waste

Table VII.1: Most successful options at Super Industries

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Improved material and product handling facilities at new granules plant.	I = \$12,000 S = \$7,500 (expected) P < 2 year	Reduction of material losses and overfilling of packages. Significant reduction of workers' exposure to health hazards	This measure actually consists of a number of options: <ul style="list-style-type: none"> <li>• Semi-automatic weighing and packing line;</li> <li>• Enclosure of charging and discharging hoppers;</li> <li>• Proper ventilation systems;</li> <li>• Improved layout for technical spray pumps.</li> </ul>
2. Recovery of left-over active pesticide by rinsing drums with suitable solvent and reusing solvent as part of recipe in next batch of compatible formulation.	I = nil S = \$2,000 P = immediate	Reduction of generation of toxic fumes from storage and handling of 'empty' drums. Reduction of drum disposal costs.	Savings calculated with average production figures and technical material costs.

I = Investment    S = Net savings (after deduction of annualised operating cost)    P = Payback period

minimization options required an investment of \$13,350. The annual savings are expected to mount up to \$8,350 upon completion of the new granules plant (early 1995). The overall payback will thus be within 20 months (Chandak, 1995). Given the low rates of waste and emission generation, it was not possible to

quantify the environmental impact equivocally. Table VII.2 summarizes the estimated overall impact. It may be concluded that although remarkable reductions have been achieved in waste generation, the financial gains are almost negligible.

**Table VII.2: Estimated overall impact of waste minimization at Super Industries**

Item	Before waste minimization	After waste minimization	Estimated financial gain
1. Technical left over in empty drums	175 kg/year	10-12 kg/year	\$800/year
2. Blender cleansings	36 kg/year	Negligible	\$10/year
3. Technical spills and leaks	45-65 kg/year	Negligible	\$250/year

## Vimal Pesticides

Vimal Pesticides is mainly a job formulator for big pesticides manufacturing and marketing companies, like Searle, Cynamide and Lupin. Vimal Pesticides produces granules (approximately 2,000 tons/year, mainly phorate (10 per cent) and butachlor (5 per cent)), dust (about 2,500 tons/year, mainly methyl parathion (2 per cent) and fenvalerate (0.4 per cent)), wettable dust powder (approximately 150 tons/year, mainly carbendazim (50 per cent)) and liquids (approximately 400,000 litres/year, mainly dimethoate (30 per cent), cypermethrin (10 – 25 per cent) and monocrotophos (30 per cent)). In order to qualify for the job work, Vimal Pesticides has to meet the quality, safety and environmental standards of the big companies, which in turn has been an incentive to implement waste minimization. Major polluting areas at Vimal Pesticides are toxic fumes emission from raw material charging and blending, reprocessing of expired and off-specification products, waste generation due to unloading of dust blenders for restarting after power failure and spillage during raw material handling. The plant level project team took the lead in the implementation of waste minimization. The team consisted of the occupier, the production manager, the laboratory in charge, the maintenance in charge and a production supervisor. The technical study team assisted this plant level team; in the course of the DESIRE project a lot of ideas have been generated.

Several of these could be transferred by the plant level team into practical waste minimization solutions. A total of 64 waste minimization options has been considered during the project period. Within the first 15 months, 25 waste minimization options could be implemented, while implementation had started for another two feasible options. In addition, the feasibility of another 11 waste minimization options has been proved; the company plans to implement these in the near future. The remaining 26 options have been rejected by the company, given the low technical and/or financial feasibility. The salient features of the most successful options have been summarized in table VIII.1.

Vimal Pesticides invested \$5,350 for the implementation of the first batch of 25 feasible waste minimization options. These options generate annual savings which mount up to \$8,350. The overall payback of these options is thus within 8 months. The environmental benefits are visible in the plant, in terms of reduction of waste generation and minimization of workers' exposure to toxic fumes. However, quantification of these improvements proved to be impossible within the frame of this project. Table VIII.2 contains preliminary estimates of the overall impact. It may be concluded that although remarkable reductions have been achieved in waste generation, the financial gains are almost negligible.

Table VIII.1: Most successful options at Vimal Pesticides

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Installation of fluid coupling assembly to avoid unloading of dust blender after power failure.	I = \$1,333 S = \$1,100 P < 1.3 year	Avoidance of waste generation in case of power failure. Workers' exposure to toxic dust (and subsequently health hazards) reduced.	Savings calculated on average power failure (1/week) with most common product.
2. Dust unloading and weighing in trolley, which can then be lifted and placed over the charge hopper of the dust blenders.	I = \$400 S = \$5,000 P < 0.1 year	Reduction of fugitive dust emissions from charging; improvement of shop floor air quality.	Option successfully tried, but will only be implemented in next season.
3. Recovery of left-over active pesticide by rinsing drums with suitable solvent and reusing solvent as part of recipe in next batch of compatible formulation.	I = 0 S = \$2,000 P = immediate	Reduction of generation of toxic fumes from storage and handling of 'empty' drums. Reduction of drum disposal costs.	Savings calculated with average production figures and technical material costs.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Pay back period

Table VIII.2: Estimated overall impact of waste minimization at Vimal Pesticides

Item	Before waste minimization	After waste minimization	Estimated financial gain
1. Technical left over in empty drums	1250 kg/year	25-30 kg/year	\$1,400/year
2. Technical spills and leaks	80-90 kg/year	negligible	\$300/year

## Bhavin Textiles (Surat)

Bhavin Textiles is a job order textile dyeing and printing unit and belongs to Colour:tex Ltd, a leading dyestuff manufacturer in Gujarat. The current grey cloth processing capacity is 50,000 metres per day. Of the cloth processed, 80 per cent is polyester and the rest is acrylic. Sarees and dress materials are the final finished goods (about 30 product varieties). The unit commenced its processing during the mid term project review period of the DESIRE project.

The main processing steps are washing, scouring, desizing, weight reduction, whitening/dyeing, heat setting, printing, reduction clearance, drying and packaging. Wastewater effluent is generated from almost all the processing steps except heat setting, drying and packing.

The unit participated in the project to develop a management information system (MIS) for waste minimization, in addition to exploitation of available potential for waste minimization. Being a new unit, the management was keen to develop a systems approach to be able to tackle the problem of waste in the long run. The project team took the lead in the implementation of

waste minimization. It consisted of the director, the production manager and the technical manager. The technical study team assisted this plant-level project team. After the field study conducted by the team and evaluation of the data collected for water, raw materials, chemicals and energy, the audit team specifically looked into waste minimization opportunities for dyeing, printing and washing. Special emphasis was given to water conservation, due to water shortages in the region. A total of 27 waste minimization options has been considered during the project period. Within the first 15 months, eight waste minimization options could be implemented, while implementation had started for another 13 feasible options. The remaining six waste minimization options have been rejected by the company, given the low technical and/or financial viability. The salient features of the most successful options have been summarized in table IX.1.

Bhavin Textiles invested a total of \$4,650 in these feasible waste minimization options. The savings accrued were on the order of \$48,400 giving an overall payback period of less than 2 months.

Table IX.1: Most successful options at Bhavin Textiles

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Development of Management Information System to control batch size in jet dyeing.	I = 0 S = \$21,600 P: immediate	Only minor environmental impact due to optimization of dyeing process.	The option would enable to produce more with same infrastructure and water requirement.
2. Chemical substitutions.	I = 0 S = \$4,800 P: immediate	COD load reduced by 718 kg/month.	Oxalic acid replaced by oxalic + mineral acid; acetic acid by catalst D; hydrosulphite by Diosyn HF and citric acid by citric W. No impact on product quality.
3. Dye bath recycle for white dyeing.	I = \$650 S = \$1,300 P = 0.5 year	Reduction of water and auxiliary chemicals consumption.	Implementation required installation of an insulated holding tank.
4. Condensate and cooling water recycle.	I = \$4,000 S = \$12,000 P < 0.4 year	Reduced water consumption.	Reduced fouling of heat transfer surface in heat exchangers and boilers.
5. Standardization of print paste stock preparation.	I = 0 S = \$8,700 P: immediate	Reduced solid waste generation.	The option required improvement of procedures and skills of personnel.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period

# Garden Speciality Prints (Surat)

Garden Speciality Prints is a textile dyeing and printing unit and belongs to the Garden Group of companies, a leading fabric and dress material manufacturer in India. The current cloth processing capacity is 80,000 metres per day with a process mix of printed goods (45 per cent) and dyed and finished goods (55 per cent). Only synthetic fabric is processed. Sarees and dress material are the final finished goods. The main processing steps are washing, scouring, desizing, drumming (only for chiffon), weight reduction, whitening/dyeing, heat setting, printing, reduction clearance, drying and packing. Wastewater effluent is generated from almost all processing steps except heat setting, drying and packing. Garden Speciality Prints participated in the project to improve its efficiency of operation both in terms of chemicals usage and energy usage. Being a market leader, the company wanted to maintain its superiority even on the environment front.

Garden Speciality Prints is comparatively well staffed. The plant level waste minimization team therefore consisted of the director, technical manager, assistant technical manager, processing superintendent, printing manager, assistant printing manager, assistant dyeing manager and maintenance engineer. The technical study team assisted the plant level team in implementing the systematic waste minimization audit methodology. Upon completion of the preliminary assessment of the consumption of water, energy and chemicals in all processes, desizing and scouring, weight reduction, dyeing, printing and washing were selected as audit focuses. The detailed assessment included the utility requirements, particularly steam generation and distribution. In the course of the project, 38 options have been generated and evaluated. Seventeen waste minimization options had been

implemented at the end of the project. For another 10 feasible options, implementation had started, while for yet another four feasible options, implementation still had to take off. The remaining seven options proved to be not feasible, and were subsequently rejected by the plant management. The salient features of the most successful options have been summarized in table X.1.

Being an integrated mill specialized in production of small batches of speciality fabrics offered both advantages and disadvantages for the implementation of waste minimization. Several options commonly applicable in small-scale commission dye houses, for instance, could not be implemented by Garden Speciality Prints. These included dyebath recovery and reuse (hampered by differences in quality specifications to be attained per batch of dyed goods) and reduction of chemicals inventory (comparatively large inventory of speciality chemicals needed to serve all fabric varieties). On the other hand, Garden Speciality Prints could implement options which are normally not feasible in commission dyeing, such as extending the length of the cloth pieces (their own weaving looms have been modified in order to increase the cloth length from 100 to 300 metres), increasing the minimum design length (through changes in marketing policies that would reduce start-up losses per printing job) and reducing processing steps (through integration of scouring and dyeing processes for particular fabric varieties).

Garden Speciality Prints invested, in the course of the DESIRE project, a total of \$14,500 in implementing the feasible waste minimization options. The savings accrued were on the order of \$110,000, giving an overall payback period of less than two months.

Table X.1: Most successful options at Garden Speciality Prints

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Replacement of continuous water wash with two-stage pre-washing fill and draw type bath in weight reduction.	I = \$1,200 S = \$1,800 P < 0.7 year	Reduction of the alkali loss in wastewater.	The option enables recovery of lean alkali solution which can be recycled for scouring, weight reduction bath make up or jet dyeing.
2. Chemical substitutions.	I = 0 S = \$5,400 P: immediate	Reduction of COD load,	Oxalic acid replaced by oxalic + mineral acid; acetic acid by catalyst D; hydrosulphite by Diosyn HF and citric acid by citric W. No impact on product quality.
3. Installation of press light switches for viewing lamps in jet dyeing machines	I = \$100 S = \$19,300 P: immediate	Reduction of the electrical energy consumption.	The measure required installation of press type switches to put on viewing light when required.
4. Replacement of costly leader cloth with low grade (or off specification) grey cloth for initial printing table setting.	I = 0 S = \$45,000 P: immediate	Low-grade (waste) cloth used to avoid wastage of high quality cloth.	The measure is a typical resource conservation measure of using a low grade resource in order to conserve the high grade resources for better use.
5. Recovery of residual print paste from squeegee, screens and containers.	I = 0 S = \$10,000 P: immediate	COD reduction; residual print paste was discharged with rinse water before.	The option required improvement in systems and procedures and skills of personnel.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period



# Mahendra Suitings (Ahmedabad)

Mahendra Suitings is a textile dyeing and printing unit for its own brand products as well as on commission basis for other textile companies. The current grey cloth processing capacity is 90,000 metres per day. Suitings, shirtings and other dress materials made from cotton, synthetic and blended fabrics are processed. The main processing steps are washing, whitening/dyeing, heat setting, printing, reduction clearance drying and packing. Wastewater discharges are caused by almost all the processing steps except heat setting, drying and packing. The unit participated in the DESIRE project with a view to reduce the operating costs.

The plant level project team took the lead in the identification, evaluation and implementation of waste minimization options. The team consisted of the managing director, technical manager and printing supervisor and was assisted by members of the technical study team.

Upon completion of the preliminary assessment of chemicals, water and energy use for all processing areas, the project team focused on the waste minimization opportunities for bleaching, dyeing, printing and utilities. In the course of the DESIRE project, a total of 22 waste minimization options were generated and evaluated. Within the 15 months duration of the project, 14 feasible options were implemented, and implementation started for another two feasible options. Of the outstanding six options, two are considered feasible and should be implemented shortly, whereas the other four have been rejected given their low financial and/or technical feasibility. The salient features of the most successful options have been summarized in table XI.1.

Mahendra Suitings invested a total of \$3,700 in implementing the above-mentioned five waste minimization measures. The savings accrued were of the order of \$30,800 giving a payback period of less than two months.

Table XI.1: Most successful options at Mahendra Suitings

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Recycling of washing discharge from mercerising to meet caustic requirement of bleaching.	I = \$1,000 S = \$11,000 P < 0.1 year	Reduction of COD load and reduction of total caustic consumption.	The option eliminated the caustic lye requirement of the bleaching operation (saving 60 kg/day caustic lye).
2. Installation of press switches for viewing lamps in jet dyeing machines.	I = \$100 S = \$9,000 P: immediate	Reduction of the electrical energy consumption.	The measure required installation of press type light switches to put on the view light when required.
3. Use of steam condensate in jet dyeing machines for dye liquor preparation.	I = \$1,000 S = not yet quantified P = short term	Better dyeing quality; reduced soft water consumption; heat recovery.	The measure is under consideration for implementation in new machine.
4. Optimize excess air levels in thermic fluid heaters.	I = \$300 S = \$9,000 P < 0.1 year	Energy conservation (reduction of lignite consumption) and reduction of air emissions.	The measure required installation of ash door and provision to keep this closed when not in use.
5. Condensate and flash steam recovery.	I = \$1,300 S = \$1,800 P < 0.8 year	Reduction of soft water requirement.	Reduced load on water softening plant and boiler.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period

## Paradise Prints (Surat)

Paradise Prints is a commission textile dyeing and printing unit. The current cloth processing capacity is 60,000 metres per day with a product mix of polyester (90 per cent) and nylon (10 per cent). Only synthetic fabric is processed. Sarees and dress material are the final finished goods.

The main processing steps are washing, scouring, weight reduction, whitening/dyeing, heat setting, printing, reduction clearance, drying and packing. Wastewater effluent is generated from almost all the processing steps except heat setting, drying and packing.

The company had started its own waste minimization activities long before the start of the DESIRE project. It had concentrated on the substitution of chemicals (in order to reduce COD/BOD load per ton processed fabric and to reduce toxicity of effluents) and conservation of water and energy (Desai, 1994). Paradise Prints is a forerunner in the entire Surat belt of textile processing houses. The unit participated in the project to improve upon its waste minimization strategy and identify additional process-oriented waste minimization measures. Being a market leader, Paradise Prints wanted to maintain its superiority even on the environment front.

A plant level audit team was made up for the evaluation of the processes and waste minimization options. The team consisted of the director, technical manager, dyeing master, dyeing assistant master and two assistants. Upon completion of the preliminary assessment of the chemical, water and energy consumption and waste water discharges from all processing areas, the team focused on waste minimization opportunities for desizing and scouring, weight reduction, dyeing, printing and washing. Over the course of the DESIRE project, 32 waste minimization options have been considered. Twelve options have been implemented during the project. Implementation has already started for another 11 feasible options and is to start for yet another five options. The last four options have been rejected, given their poor financial and/or technical performance. Salient features of the most successful waste minimization

options have been summarized in table XII.1.

According to the technical study team, Paradise Prints invested a total of \$27,800 in implementing the feasible waste minimization measures. The savings accrued were of the order of \$55,300 giving a payback period of six months.

According to the perceptions of the management of Paradise Prints, participation in the DESIRE project was particularly successful in the following areas:

- *Dye bath reuse:* Four jet dyeing units have been equipped with overhead tanks to reuse spent dye bath from disperse dyeing. Reusing the dyebath 10-12 times has become routine practice. Dyebath reuse has led to 85 per cent COD reduction from jet dyeing, 90 per cent water conservation in jet dyeing, 40 per cent energy conservation in jet dyeing and 80 per cent reduction of chemical costs in jet dyeing. The investment of about \$ 30,000 in overhead tanks, piping and valves had a payback period of less than six months.
- *Recovery of print paste remnants:* Edge carry-over has been reduced through the application of cellotape on the printing screens. Four printing machines have been equipped with a doctor blade to recover about 18 tons of print paste remnants. The remnants are sorted in different shades and reused in the preparation of next batches of bulk print paste colours. Consequently, COD discharge has been reduced by 900 kg/day. In addition, this has enabled the reduction of the water consumption for print belt washing from 70,000-80,000 litres/machine per day to 10,000 litres/machine per day. The annual savings through print paste recovery and reuse mount up to \$56,000.
- *Solvent recovery:* An on-site distillation system will be installed to recycle the solvent used for blanket wash. The reduction in solvent consumption is estimated at 3,500 kg/year. The net annual benefit will be in the range of \$36,000.

Paradise Prints has developed its own software to evaluate progress in reducing COD load (computed COD discharge on the basis of the monthly consumption of chemicals). In the first two years of

waste minimization activities, COD discharge has been reduced from 150 kg/ton of fabric to 80 kg/ton of fabric. In terms of concentration, COD came down from 252 mg/l to 51 mg/l.

Table XII.1: Most successful options at Paradise Prints

Waste minimization measure	Financial viability	Environmental impact	Remarks
1. Replacement of continuous water wash with 2 stage pre-soaking fill & draw type bath in weight reduction.	I = \$1,200 S = \$1,800 P < 0.7 year	Reduction of the alkali loss in waste water.	The option enables recovery of lean alkali solution which can be recycled for scouring, weight reduction bath make up or jet dyeing.
2. Chemical substitutions.	I = 0 S = \$3,500 P: immediate	Reduction of COD load by 3070 kg/month and BOD by 1950 kg/month.	NI detergent replaced by Ginasol 6836, acetic acid by catalyst D, hydrosulphite by diosyn HF and citric acid by citric W. No impact on product quality.
3. Installation of individual piping for circulation of thermic fluid.	I = \$1,600 S = \$4,000 P = 0.4 year	Reduction of the thermal energy consumption (natural gas requirement).	The measure required installation of individual piping systems for thermic fluid heater to each stenter.
4. Replacement of manual washing with continuous washing range.	I = \$25,000 S = \$36,000 P = 0.7 year	50 % reduction in effluent volume along with significant reduction of energy and chemical requirement.	The measure is a typical technology change option.
5. Recovery of residual print paste from squeegee, screens and containers.	I = 0 S = \$10,000 P : immediate	COD reduction; residual print paste was discharged with rinse water before.	The option required improvement in systems and procedures and skills of personnel.

I = Investment

S = Net savings (after deduction of annualised operating cost)

P = Payback period