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UNIDO
To Mr. V BYSUK
VIENNA INTERNATIONAL CENTRE
P.O. BOX 300
A-1400 VIENNA
AUSTRIA

Saint-Nicolas, 17 October, 1997

Subject: INDIA

Dear Mr. Bysyuk,

Please find attached a copy of the programme schedule and the book issued from the National Seminar on " Recycling and Plastics Waste Management".

Best regards,

Vincent SCIASCIA — Gibelplast

GENERAL RECOMMENDATIONS ISSUED FROM THE SEMINAR.

1. Organisation of Plastics Industry.
2. Improve Safety and Hygiene in the plant.
3. Improve Quality Control and Standard of the goods.
4. Strict regulation on plastic waste from Hospital.
5. Strict regulation on the use of plastics waste in the Food Industry.
6. Collection and Sorting.
7. Technologies transfer
8. Training of the operator
9. Survey on the actual situation in India (Separation on the plastic waste collected in India and the plastics imported)
10. The Municipality board must take part in the concept of Plastic Waste Management. (Actually it is only the private sector (scavenger) collect the plastics waste.)
11. Labelisation of plastics end-product.

NATIONAL SEMINAR ON

RECYCLING AND PLASTICS WASTE MANAGEMENT

24th-26th SEPTEMBER 1997

ORGANISED BY CIPET

AT

HOTEL THE TRIDENT, CHENNAI - 27

TENTATIVE PROGRAMME SCHEDULE

24th September, 1997

09.00 a.m. to 10.00 a.m.		**REGISTRATION**
10.00 a.m. to 11.00 a.m.		**INAUGURAL SESSION**
Welcome Address	:	**Dr J S Anand**, Director, CIPET
Presidential Address	:	**Shri N R Banerji** Secretary to the Govt. of India Dept of Chemicals & Petrochemicals
Inaugural Address	:	**Shri M Arunachalam** Hon'ble Union Minister for Chemicals & Fertilizers
Vote of Thanks		
11.00 a.m. to 11.30 a.m.	:	**TEA**
11.30 a.m. to 12.30 p.m.	:	**Key Note Address**
Role of Polymer BlendsTechnology in Plastics Recycling	:	Dr L A Utracki, National Research Council, Canada
12.30 p.m. to 1.30 p.m.	:	**LUNCH**

PLASTICS WASTE MANAGEMENT - ISSUES & STRATEGIES

TECHNICAL SESSION - I - Chairmen	:	**Mr A R Parasuraman, NOCIL, Mumbai** **Dr Paramjit Singh, University of Punjab, Chandigarh**
1.30 p.m. to 2.30 p.m.	:	*Special Expert Lecture - I*
Plastics Waste Management Global Issues and Strategies	:	Mr Vincent Sciascia, UNIDO Consultant, Belgium
2.30 p.m. to 3.30 p.m.		
Plastics Waste Management	:	Dr Saroj, Ministry of Environment & Forest, N.Delhi
Plastics Waste Management - Emerging Global Scenario and Issues	:	Mr S K Mathur, Reliance Industries, Mumbai
Plastics Waste Management Systems and Policies	:	Mr O P Ratra, Consultant, New Delhi
3.30 p.m. to 4.00 p.m.	:	**TEA** (Video Presentation)
TECHNICAL SESSION - II - Chairmen	:	**Shri S K Mathur, Reliance Industries Ltd., Mumbai** **Shri S K Sharma, CIPET, Ahmedabad**
4.30 p.m. to 6.00 p.m.		
Life Cycle Study of Plastics Waste	:	Ms Shyamala Krishna, CEE, Bangalore
Recycling-Need of an Integrated Approach	:	Mr V P Malhotra, SIIR, New Delhi
Plastics Recycling Issues and Future Strategies	:	Mr Vipin Mittal, Flex Industries, Ghaziabad

26th September, 1997

DEVELOPMENTS IN RECYCLING PROCESSES/ MACHINERIES/ APPLICATIONS

TECHNICAL SESSION - VII - Chairmen	:	**Dr Ranganath Shastri, Dow Chemicals, USA** **Prof. Kothandaraman, Anna University, Chennai**
09.00 a.m. to 10.00 a.m.		*Special Expert Lecture - IV*
Plastics Recycling - A 1997 Perspective	:	Mr Colin J Williamson, UK
10.00 a.m. to 11.00 a.m.		
Chemical Recycling of (Polyethylene Terepthalate)	:	Dr S Sivaram, NCL, Pune
Recycling of Nylon 6	:	Dr M Srinivasan, SRF, Chennai.
Effect of the Addition of Recycled Polypropylene under the influence of Compatabilizers	:	Dr K S Jagadeesh, CIPET, Mysore
11.00 a.m. to 11.30 a.m.	:	TEA
TECHNICAL SESSION - VIII - Chairmen	:	**Dr S Sivaram, NCL, Pune** **Dr R P Singh, IIT, Kharagpur**
11.30 a.m. to 1.00 p.m		
Application of Thermoanalytical Techniques in the field of Polymer Recycling	:	Mr Janoschek, Netzsch, Germany
Recycling Technologies for Common Plastics: and Recycling Programme for India		Dr A K Gupta, IIT, New Delhi
Recycling of Polyester, Nylon and Polyolefins Waste	:	Prof. Pushpa Bajaj, IIT, New Delhi
Recycling of PET	:	Mr Y R Anand, UNIMARK, Mumbai
1.00 p.m. to 2.00 p.m.	:	**LUNCH**
TECHNICAL SESSION - IX - Chairmen	:	**Dr A K Gupta, IIT, Delhi** **Dr Vijaikumar, CIPET, Lucknow**
2.00 p.m. to 4.00 p.m.		
Equipments for Plastics Recycling	:	Dr A K Banerjie, Inventa Technologies, Chennai
Modern Trends in Plastic Recycling	:	Mr R C Sanghavi, Satellite, Mumbai
Medical Plastics Waste Management	:	Dr Alok R Ray, IIT, New Delhi
Proposal for Indian Centre for Plastics in Environment	:	Mr Sujit Banerji, NOCIL, Mumbai
1 Slide Presentation	:	**Presentation by Lintas** ***on behalf of Plastindia Foundation***
4.00 p.m. to 4.30 p.m.	:	TEA

PANEL DISCUSSION & CONCLUSION

4.30 p.m. to 6.00 p.m.

Chairman	:	**Shri S K Sood** **Joint Secretary (PC)** **Dept. of Chemicals & Petrochemicals** **Ministry of Chemicals & Fertilizers, Govt of India.**
Panel Members	:	**Ms. Lalitha B Singh**
		Chairmen of all Technical Sessions

PROCEEDINGS

50th Independence Anniversary

NATIONAL SEMINAR

ON

RECYCLING AND PLASTICS WASTE MANAGEMENT

24 - 26 SEPTEMBER, 1997

Assisted by

WORLD BANK

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INDIAN PETROCHEMICALS CORPORATION LIMITED
VADODARA

Edited by

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CONTENTS

PLASTICS WASTE MANAGEMENT GLOBAL ISSUES & STRATEGIES

Vincent Sciascia
UNIDO Consultant,CIBELPLAST S.A.
Rue Vinave, 65, B-4420 Saint-Nicolas, Belgium.

PREFACE.

As the United Nations agency charged with accelerating and coordinating industrial development, UNIDO has the responsibility to ensure that cleaner industrialization is at the top of the agenda. Because the Organization works with the private as well as the public and cooperative sectors of the industry, it can act as a focal point for promoting sustainable development.

This new concept of development, which entails the integration of environmental issues into every activity and takes into account social dimensions, the interests of various social groups, and the conversation and management of resources, will provide a basis for sustainability.

Some of the biggest challenges facing the world in the twenty-first century will be those related to energy management, water resource management and transfer of cleaner technologies.

By eliminating waste at source, cleaner production, also referred to as pollution prevention or waste minimization, improves the quality of environment and can even enhance industrial profitability. Following the conference on Ecologically Sustainable Industrial Development in 1991 and UNCED in 1992, cleaner production has been accepted as one of the key means by which industry can improve the environment, while remaining competitive and profitable.

Within the context of Agenda 21, it is important that the industries remain productive and continue to play their roles in economic and social development, in harmony with the environment and with natural resources and raw materials.

As an integrated part of these activities UNIDO has elaborated a programme of polymer waste management offering the developing Countries the requested technical and others services. This programme is described in detail in this paper.

I. INTRODUCTION.

The crisis of plastics waste management has been reached within the past few years, especially in the developed countries, and has made recycling of plastics one of the major areas of concern.

Although plastics make up only about 7%, by weight, of total solid wastes, discarded plastics are highly visible. Their visibility has been perceived as a big problem and made plastics a target in the management of solid waste. Indeed in the past years, no effort had been paid in the field of plastic waste treatment. Recently a change in the approach of this problem has been noted everywhere in the world and has pushed the Authorities to take the necessary steps to reduce the amount of plastic waste.

In facts, many plastics consumer items have short life spans and quickly make their way into the waste streams. More than half of the discarded plastics are found in the form of packaging, an area frequently targeted for recycling, packaging material which is about 40% of the total consumption for developed Countries.

Although not a significant portion by weight, plastics due to their volume are a very visible and form about 30% of municipal solid wastes. Furthermore plastics, together with paper, are the fastest growing segments of solid wastes.

The result of the special position of the plastics in the solid wastes has been the rapid introduction of a tremendous amount of legislation that attempt to deal with the problems of solid wastes.

Consequently, plastics waste is taking on a new economic importance, not only in terms of revenues generated by the plastics waste treatment and disposal industry, but also because plastics waste may have a residual value as a secondary raw material which can be recovered or reused.

The quantity of plastics waste arising is generally considered to be growing across the globe as a result of increases in the world's population, increasing industrialization, increasing urbanization and rising standards of living. Moreover, major advances in the development of new plastic materials have increased the diversity and complexity of the waste streams.

Plastics waste is increasingly becoming an international issue. Exporting plastics waste to countries with less stringent controls and lower public awareness of the issues has been used to counter the rising costs of the disposal and the growth of the Not In My Back Yard (NIMBY) syndrome in many industrialized countries.

Traditionally, the collection of statistics on wastes has had a relatively low priority in many countries. Consequently the statistical data base for the plastics waste is poor, especially in the historical context. This paucity in the availability of reliable statistics on both plastics waste generation and disposal is seen by many as an impediment to identifying the best or most practical plastics waste management options, establishing priorities and to assessing the effectiveness of the policy action.

During the past decade or so the area of the of waste management has been further characterized by a significant change in perception. In place of a preoccupation with the "safe management" of wastes and investment in pollution control equipment, waste managers are increasingly turning to a more preventative or integrated approach to waste management, i.e., one which involves changing processes and products in order to minimize the total volume of wastes generated by manufacturing process.

This "cleaner production" concept was endorsed at the United Nations Conference for Environment and Development (UNCED) in June 1992 (Agenda 21).

Nevertheless, the rapid rise of plastics consumption and its further potential rise clearly justify the attention of UNIDO to prepare a programme in a perspective of sustainable growth, plastics consumption, waste prevention, proper use of the raw material, stimulation of re-use, environmental aspects including the proper management of production and post-consumer plastics waste and recycling.

In this paper a brief analysis is made of the plastics industry world-wide in terms of production, consumption, produced waste (treatment and disposal) and legislation.

II. RECENT TRENDS IN PLASTICS INDUSTRY.

II.1. World production and consumption

Against a background of a world production of around 100,000 tons/year of 'Classical' thermosets and derivatives of natural materials, the development of plastics into bulk scale materials started around 1930 with the introduction onto the market of standard thermoplastics based on styrene, vinyl chloride, ethylene, and later also propylene polymers, and with the transition from coal-based to petroleum-based chemicals and new condensation and addition polymers since the 1950's, and lasted for four decades with a doubling of production every five years. In 1973, at the peak of this growth to over 40 million ton/year, the industrial countries of Western Europe, the USA and Japan had about a 90% share. After the subsequent slump in the market in the years of recession, the world volume of plastics production has practically doubled again with a total of approximately 77 million ton/year. In 1993, the total world demand was over 100 million tonnes for the first time. According to conservative estimates, by the year 2000, the plastics industry will produce around 140 million tonnes.

The petrochemical industry uses up ± 7% of the total consumption of oil and gas and 60 percent of petrochemical end-products consist of plastics and resins, 10 percent consist of synthetic fibres, 10 percent of elastomers and 20 percent of other materials. Plastics are the largest group. (Figure 1 and 2)

Figure II.1

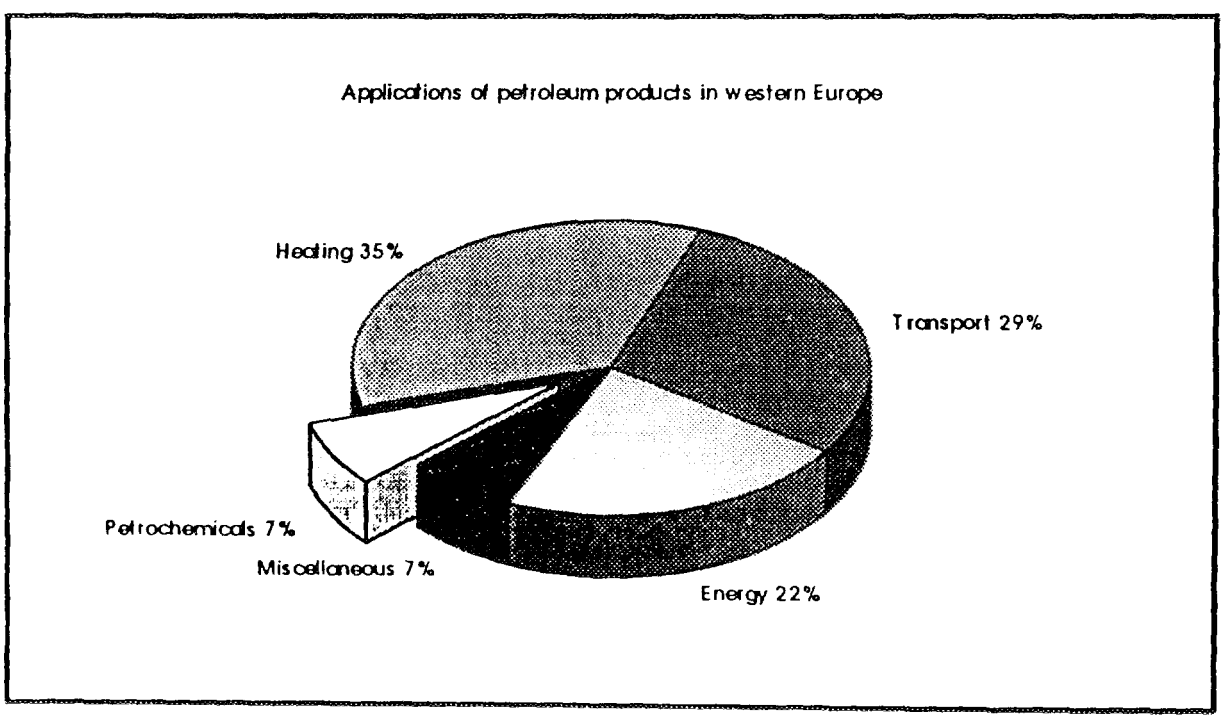
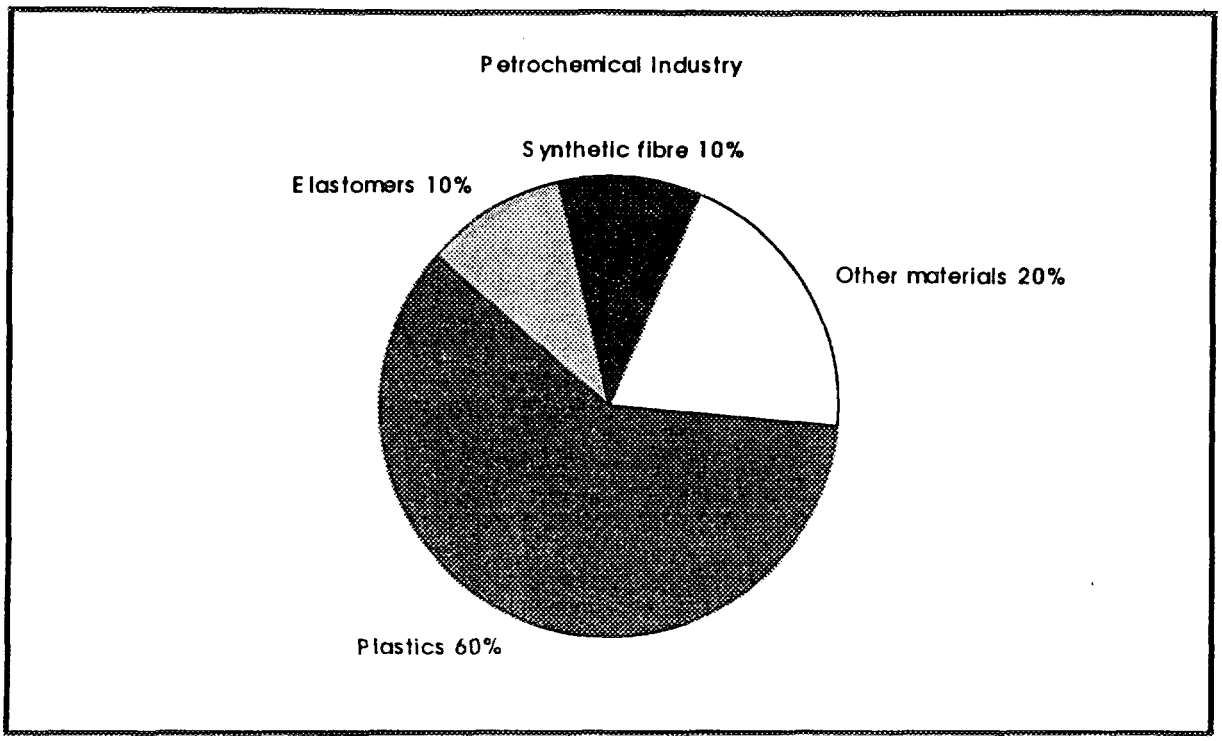


Figure II.2.



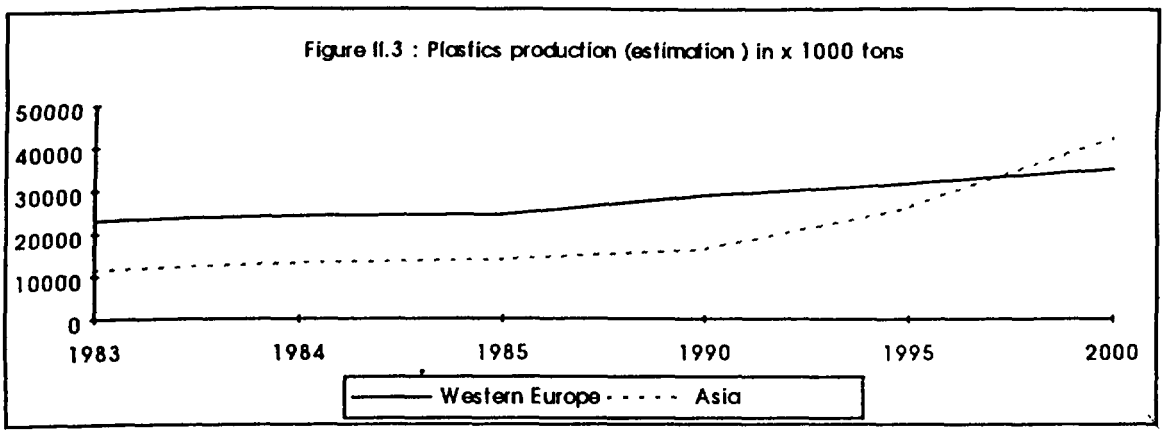
At present, the production growth figures on the average have declined to some 4% annually for the industrialized countries. But for the developing countries the annual growth rates are still in the order of 10 to 14% per annum. (Table II.1)

Table II.1 : Plastics production (estimation) in x 1000 tons

Region	Production (in 1000ton)						Change (in %)	Share (in %)		
	1983	1984	1985	1990	1995	2000	83/90	1983	1990	1995
Western Europe	23010	23910	24210	28600	31577	34864	3.47	34.42	28.56	24.54
North America	20808	22602	23590	26500	29258	32303	3.91	31.13	26.47	22.74
Asia	11328	12966	13742	16200	26090	42019	6.14	16.95	23.60	29.58
Eastern Europe	8099	8797	9140	10489	12897	15858	4.22	12.12	11.67	11.16
Latin America	2565	2943	3088	5018	8156	13256	13.66	3.84	7.38	9.33
Oceania	686	700	800	1192	1776	2646	10.54	1.03	1.61	1.86
Africa	350	385	400	565	198	1127	8.78	0.52	0.72	0.79
Total	66846	72303	74970	88564	110552	142071	4.64	100.00	100.00	100.00

Source : International Plastics Handbook

European Plastics News, March 1996



Western Europe and North America, with a share of about a third of the production and consumption, are still the chief plastic producers and consumers. Asia has been able to increase its production share considerably. With a production of scarcely 10 million ton/year in Japan, this growth depends primarily on the increase in production in China, Taiwan and South Korea. Taking into account the recently developed production capacities in the Near East, Asia will in the future claim an even higher share of overall production volumes. The capacities being developed in the developing countries, including Latin America, are for the most part production plants for thermoplastic standard polymers for domestic consumption and export. In this area, a decline of the share of Western Europe, USA, and Japan together, from the still approximately 67% of world sales in 1985 and 55% by 1995 is noted.

As from the comparison data with some new industrialized countries on ever with other ASIAN countries, a substantial different rate plastic utilization per capital per annum can be clearly noted. The total consumption during the last 3 years has increased with a rate of approximately 15%. (Table II.2)

Table II. 2-Per capita consumption of mains thermoplastic by region, 1991, (kilograms per capita)

Region	LDPE	LLDPE	HDPE	PP	Total
North America	9.00	6.80	11.60	9.00	36.40
Western Europe	11.70	3.10	8.10	10.10	33.00
Eastern Europe	3.20	1.00	1.40	1.10	6.70
South America	2.56	0.28	1.40	1.36	5.60
Asia-Pacific	1.20	0.50	1.20	1.64	4.54
Africa	1.00	0.20	0.60	0.50	2.30

Source: G. K. Adams, "Polyolefins", Paper presented at CMAI Seminar on Petrochemicals, Houston, Texas, 25 and 26 March 1992.

The per capita consumption of plastics in developing countries is much lower than the industrialized countries and mainly directed towards products of first necessity. Furthermore the significant improvements in living standards for the developing countries will generate big increases in plastics use and ultimately plastics waste. However, both the local production and the available inventory can be expected to grow considerably in the future the consumption of plastic.

Plastics have now become indispensable materials not only in the industrial countries but also in the developing countries, where the proportion of plastics applications in the industrial field is also continually increasing.

Plastics are an attractive and advantageous alternative to many traditional materials such as metals, paper and glass. They have found applications in almost every industrial sector. Their widespread use attests to their versatility, their quality as a material and their economic advantage over other materials. Packaging, food protection, production of automobiles, agriculture, medicine, construction, household appliances, and sports are just some of the areas where the application of plastics has contributed to better product quality and performance.

II.2 World production capacity and consumption of mains thermoplastic by region

Five commodity polymers (HDPE, LDPE and LLDPE, PP, PVC and PS) are the largest in terms of world production.

II.2.1 High-Density Polyethylene (HDPE)

World consumption of HDPE will grow to about 14.5 million tones per year in 1995 from less than 10.5 million tones per year in 1988. Widespread plant construction will allow capacity to grow and to keep pace with demand. Annual average growth will be 5.7 percent (table II. 3).

Table II. 3- World capacity and consumption of HDPE by region, 1988/ 1995, (Thousands of tons)

Region	Capacity		Consumption		Average
	1988	1995	1988	1995	Annual Growth (%)
Africa	100	265	210	260	3.40
Asia-Pacific	1309	2924	1571	2479	8.25
Eastern Europe	940	2305	856	1363	8.46
Japan	903	964	760	905	2.72
Latin America	497	932	505	910	11.45
Middle East			140	220	8.16
North America	3730	5066	3679	5291	6.26
Western Europe	2380	2790	2600	3500	4.94
Total/Average	9859	15246	10321	14431	5.68

Source: Economist Intelligence Unit, "Petrochemicals: an industry and its future", Special report No. 2067, 1991. European Plastics News, January 1996

II.2.2 Low- Density and Linear Low-Density Polyethylene (LDPE and LLDPE)

World consumption of LDPE and LLDPE will grow from 17.7 million metric tons per year in 1988 to over 22.5 million metric tons per year in 1995 (table II. 4). LDPE supply and demand should remain in balance throughout the 1990s provided that HDPE demand continues its growth of about 6 percent.

Table II. 4- World capacity and consumption of HDPE by region, 1988/ 1995, (Thousands of tons)					
Region	Capacity		Consumption		Average Annual Growth (%)
	1988	1995	1988	1995	
Africa	210	450	347	420	3.00
Asia-Pacific	1485	4015	2510	4187	9.54
Eastern Europe	2238	3103	1968	2401	3.14
Japan	1522	2159	1353	1600	2.60
Latin America	1371	2008	983	1380	5.77
Middle East	1304	1484	397	520	4.42
North America	6577	9300	5071	6231	3.26
Western Europe	6313	7573	5080	5900	2.30
Total/Average	21023	29870	17709	22639	3.97

Source: Economist Intelligence Unit, "Petrochemicals: an industry and its future," Special report No. 2067, 1991. European Plastics News, January 1996

II.2.3 Polystyrene (PS)

As technological advances in product design continue, demand for PS increases. Globally, PS demand will grow by 3.3 percent annually, reaching 12.55 million tones in 2000 from 8.9 million tones in 1990 (table II. 5). Areas of fast growth will be Africa, Eastern Europe, the Middle East and the Pacific Rim.

Table II. 5- World Demand and Capacity for PS, 1985-2000, (Millions of Tons)				
Years	1985	1990	1995	2000
Capacity	8.71	10.85	12.05	13.26
Demand	6.45	8.90	10.63	12.55

Source : Oil & Gas Journal, 1 April 1991, p. 21. European Plastics News, July 1996

II.2.4 Polypropylene (PP)

PP has an important advantage: it is an exceptionally adaptable material and has an ever-increasing number of applications. These advantages, together with its competitive cost, make it especially attractive to developing countries. For example, it can be used for furniture in general.

World-wide demand is forecasted to grow 7.5 percent per year through 1995. Traditionally, PP has grown as more materials became available and producers are confident that the resin will still have a high demand especially in developing countries.

Table III. 6- World consumption of PP by region, 1988/ 1995, (Thousands of tons)				
Region	1988	1990	1995	Avg. Annual Growth 1988-1995 (%)
Africa	125	150	225	8.8
Eastern Europe	740	815	1240	7.7
Far-East/Oceania	1910	2190	3040	6.0
Japan	1450	1755	2150	5.8
Latin America	520	665	1160	12.1
Middle East	185	225	325	8.4
North America	2705	3315	4515	7.6
Western Europe	3000	3420	5000	7.6
Total/Average	10635	12535	17655	7.5

Source: Economist Intelligence Unit, "Petrochemicals" an industry and its future", Special Report No. 2067, 1991. European Plastics News, January 1996

II.2.5 Polyvinyl Chloride (PVC)

The world's PVC production facilities are operating at about 90 percent of their capacity, producing 18 billion tons per year. The main consumption of PVC is in construction and housing (60% of global production), and packaging (15%). In the medium term, PVC use will be affected by the solid waste issue, the housing market and car sales. PVC demand is closely related to per capita gross national product (GNP), and developing countries will be the most important areas for the expansion of PVC markets.

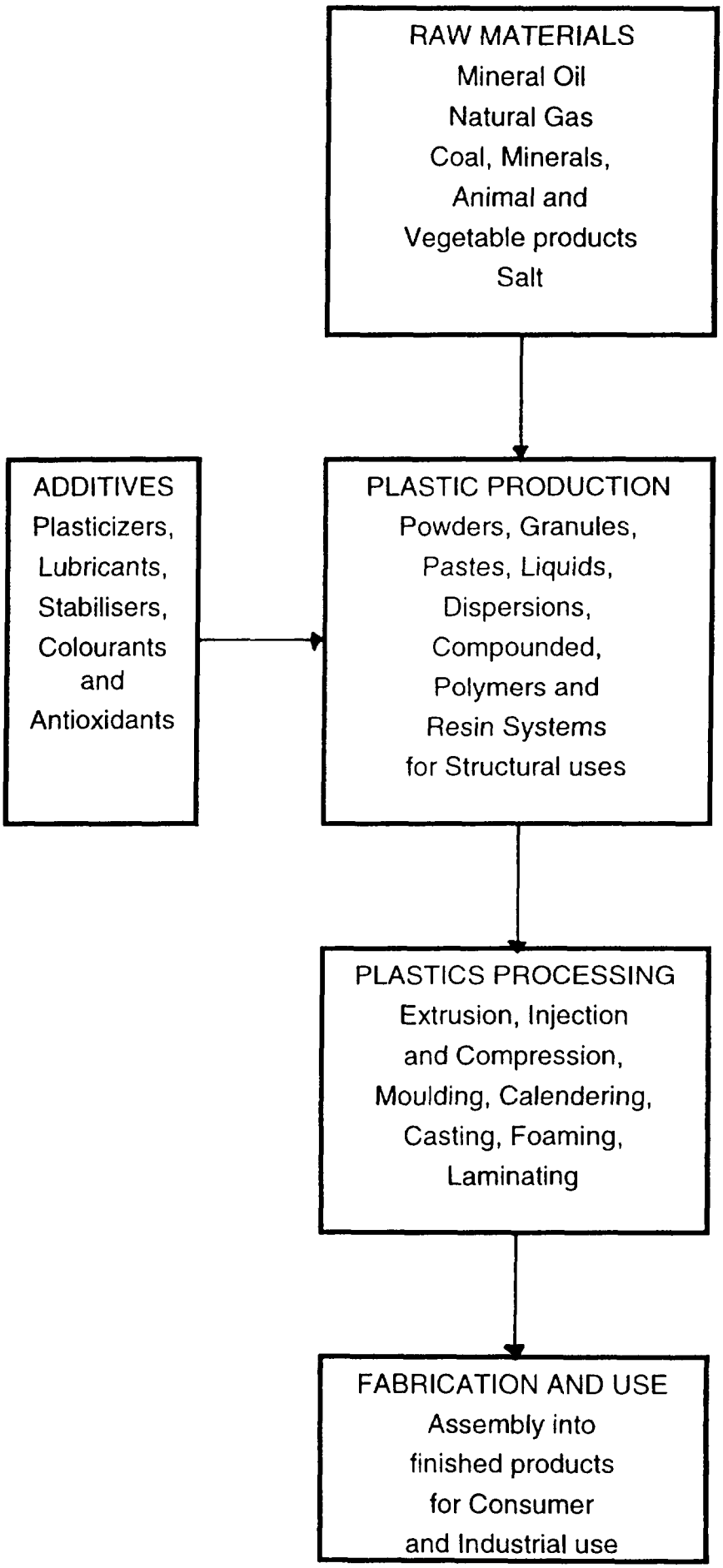
General Remarks:

Consumption figures in African and Asian countries for all type of plastics are probably underestimated as a result of the intense recycling activity and the importation of plastic scraps (industrial and post-consumers plastics waste).

At present, there are no available data with respect to the consumption pattern. There is probably emphasis on products of first necessity, such as PVC shoe soles, LDPE buckets, PVC and PE water ducts, PE or PVC agricultural film and multi-coloured PVC ribbon curtains.

II.3 Main elements of plastic product processing.

FigureII.4 illustrates the production steps that apply to plastics manufacture and conversion to products.


RAW MATERIALS
Mineral Oil
Natural Gas
Coal, Minerals,
Animal and
Vegetable products
Salt
ADDITIVES
Plasticizers,
Lubricants,
Stabilisers,
Colourants
and
Antioxidants
PLASTIC PRODUCTION
Powders, Granules,
Pastes, Liquids,
Dispersions,
Compounded,
Polymers and
Resin Systems
for Structural uses
PLASTICS PROCESSING
Extrusion, Injection
and Compression,
Moulding, Calendering,
Casting, Foaming,
Laminating
FABRICATION AND USE
Assembly into
finished products
for Consumer
and Industrial use

Remarks:

In most developing countries there is little conversion capacity available, so that many plastic products are imported, either as a part of various kind of equipment or as packaging. Local production is generally less diversified from the viewpoint of both the plastics and the conversion methods used. (Africa)

Some conversion methods, such as extrusion and calendering, are mainly directed to the production of semi-finished goods (sheets, plates, profiles, tubes, etc.), others are mainly used for producing machine parts (injection) or packaging (blow moulding, thermoforming, injection).

The unit investment required is highly variable depending on the following factors:

- type of processing;
- size and capacity of the unit;
- new or second-hand equipment
- level of automation
- presence of peripheral equipment (automatic feeding of granulate, collection, grouping and packaging of products).

Many developing Countries face economic problems which may lead to an inadequate supply of spare parts. The use of second-hand equipment can sometimes be recommended for the following grounds:

- lower acquisition cost;
- lower level of sophistication required for operation;
- better capacity of using reclaimed instead of virgin materials.

The conversion of plastics requires a sizeable amount of electric power. The availability of adequate amounts of cooling water is also an important factor in selecting a site for the production facilities.

III. SOURCES OF PLASTICS WASTE

In order to look at the best methods of collection for used plastics, this table Figure III.1 classifies the broad origins and examines degree of purity of the waste obtained.

This analysis concludes that Municipal Solid Waste (MSW) provides a large proportion of used plastics. To facilitate recycling , a separation prior the collect is recommended for MSW.

III.1 Plastics waste from the agriculture sector.

Agriculture primarily uses PE, PP and PVC plastics. The plastic materials used in agriculture generally have a short to medium life-span.

Examples:

of short-lived: covering greenhouses and fertilizer sacks,

of medium -lived: irrigation pipes, drums, tanks

The waste is estimated at 60% of the consumption.

III.2 Plastics waste from the automotive sector.

Currently, 15% to 20% of an automobile is made of non-metallic materials (glass, rubber, plastics, etc.). It was estimated that about 30% of the consumption are discarded as waste.

III.3 Plastics waste from the construction sector.

The construction industry uses mainly PE and PVC plastics. The construction sector typically uses plastics in applications for much longer than any other major industry sector, making it difficult to estimate the waste generated based on consumption. Construction industry sources have established 10% of current consumption as a reasonable estimate of generated waste.

III.4 Plastics waste from the large industry and distribution sectors

This sector is the second after the MSW to produce large amount of plastics wastes. It includes bags, drums, containers, packaging film and etc.. It was estimated that 90% of the consumed plastics are discarded.

III.5 Transformation industry.

This plastic wastes are generated during the plastic processing. Plastic wastes consist of, runners, distorted and incomplete formed products, surpluses, products rejected during quality control and material arising during the starting-up or the shutting-down of the plant.

Even smaller firms can no longer afford to waste these raw materials. Waste is carefully segregated at the source, according to its nature, colour, and additives. Contamination by dust, oil or burned (i.e. thermally decomposed) material is avoided. In general, the plastic wastes is ground and recycled, either directly in the same or a similar production, or in a less critical application.

III.6 Manufacturers.

Plastics waste generated by polymer manufacturers consists of:

- production wastes, such as the deposits formed on the walls of a polymerization vessel or the driers, or sludges separated from process waters;
- off grade products;
- extrusion purging and lumps;
- floor sweepings;
- wastes arising during quality control and laboratory testing.

Figure III.1 TOPOLOGY OF PLASTICS WASTE

	Origin of plastics waste		Primary Collection schemes: Internal recycling	Private collection	Municipal collection	Voluntary schemes	Degree of purity	Packaging materials content
Post-users plastics waste	Agricultural						Low	Variable
	Automotive			•			High	Nil
	Construction, demolition and civil works			•			Variable	Low
	Households	Municipal Solid Waste		•			Low (except if separately collected)	High
	Large domestic items				•	•		
	Retailers							
	Small/medium industries							
	Wholesalers/ supermarkets	Large distribution and industry		•			High	100%
	Large industry			•			Variable	High
Plastics processors and resin manufacturers waste	Plastics processors waste		•	•			High	Nil
	Resin manufactures waste		•	•			High	Nil

III.7 Plastics in Municipal solid waste.

The most important potential source of plastics waste is to be found in consumer wastes, arising in trade and industry and in private households.

Municipal refuse in industrialized countries typically contains about 7wt.% of plastics, mainly packaging materials, consisting of various grades of PE, PP, PVC, PS, PET. Engineering plastics may occur under the form of kitchen utensils and in various parts and mechanisms

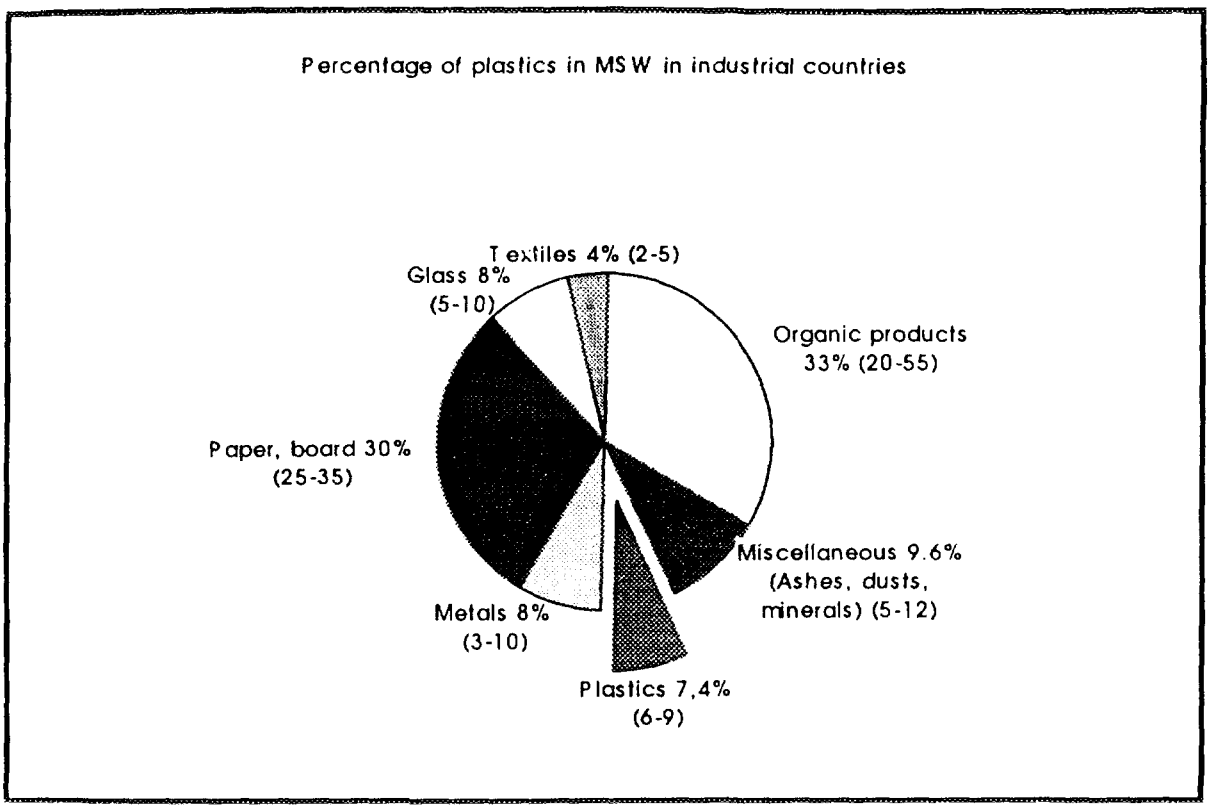


Figure III.2

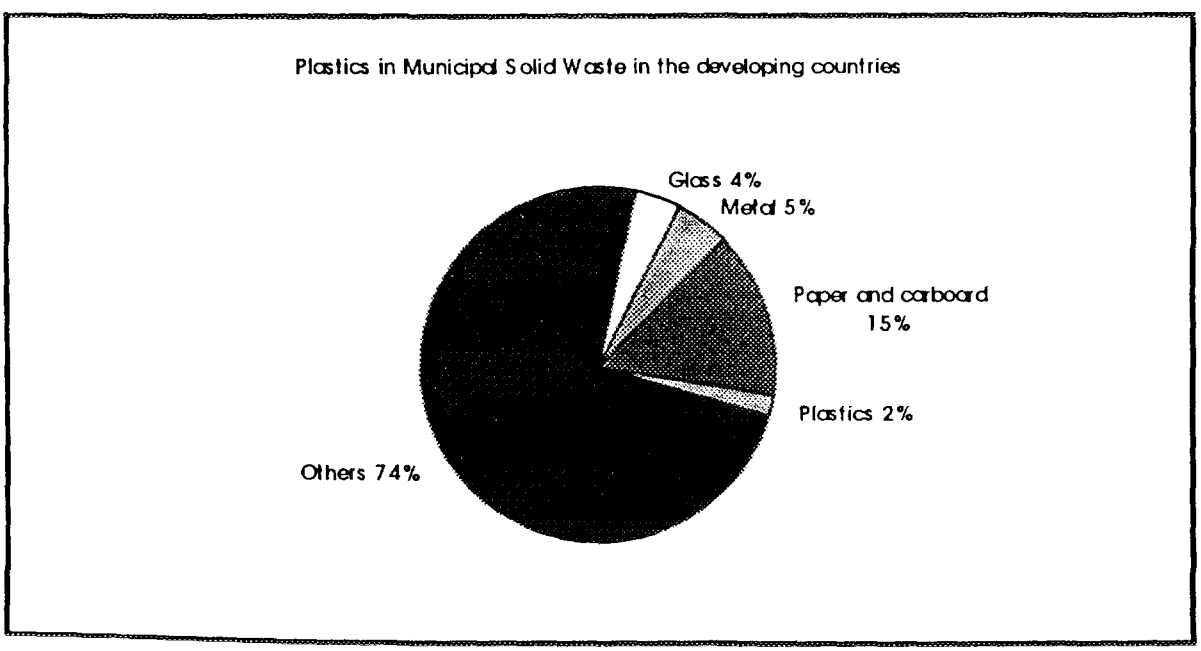


Figure III.3

Consumer wastes form largely untapped sources of recyclable plastics. Some well defined industrial wastes have been recycled after use, e.g. plastic containers, fertilizer bags, agricultural film, shrinking film, shockproof packaging, etc.

A major difficulty lies in the logistic problem of collecting suitable amounts of plastics, which are reasonably free from putrescibles and contaminants and can be transported economically to the cleaning, grading and reprocessing plant.

IV. WASTE MANAGEMENT IN THE GLOBAL ISSUES.

The global issue for the plastics waste management is to use combination of all the techniques to obtain the best environmental results.

Each system should be evaluated on case-by -case basis, taking into account such factors as suitability of material for each waste management option, location, availability of technology, transport, infrastructure and markets.

As to take into consideration the following factors:

- Reduction at source,
- Re-use,
- Recycling : - mechanical recycling (collection and sorting)
  : - chemical recycling
  : - energy recycling
- Disposal in landfill.

But putting this rule into practice can be difficult. For developing countries, effective technology may be too expensive; for developed countries it is often cheaper to bury the waste in landfill, so only environmental legislation insures the best Waste Management.

IV.1. Reduction at source.

Reducing the waste generated during the plastic-product manufacturing process and/or reducing the amount of the eventual waste of disposed product by using less plastic to produce it. Today's plastics packaging is up to 80% lighter than 20 years ago through a combination of better raw materials, improved converting techniques and more efficient design.

Example:

	1978	1990
Yoghurt pots (125 g)	6.5 g (PS)	3.5 g (PS)
Two litres bottle	120 g (HDPE)	67 g (HDPE)

Source Gervais-Danone and CSEMP

Methods:

Recycling in line,

Reduction of product weight by redesign,

Use a different or better plastic for the same application

Improvement of machinery, process controls, and quality control.

All hereabove mentioned methods involve a financial benefit for the manufacturers in reducing their raw material consumption and operating or waste disposal costs.

IV.2. Re-use.

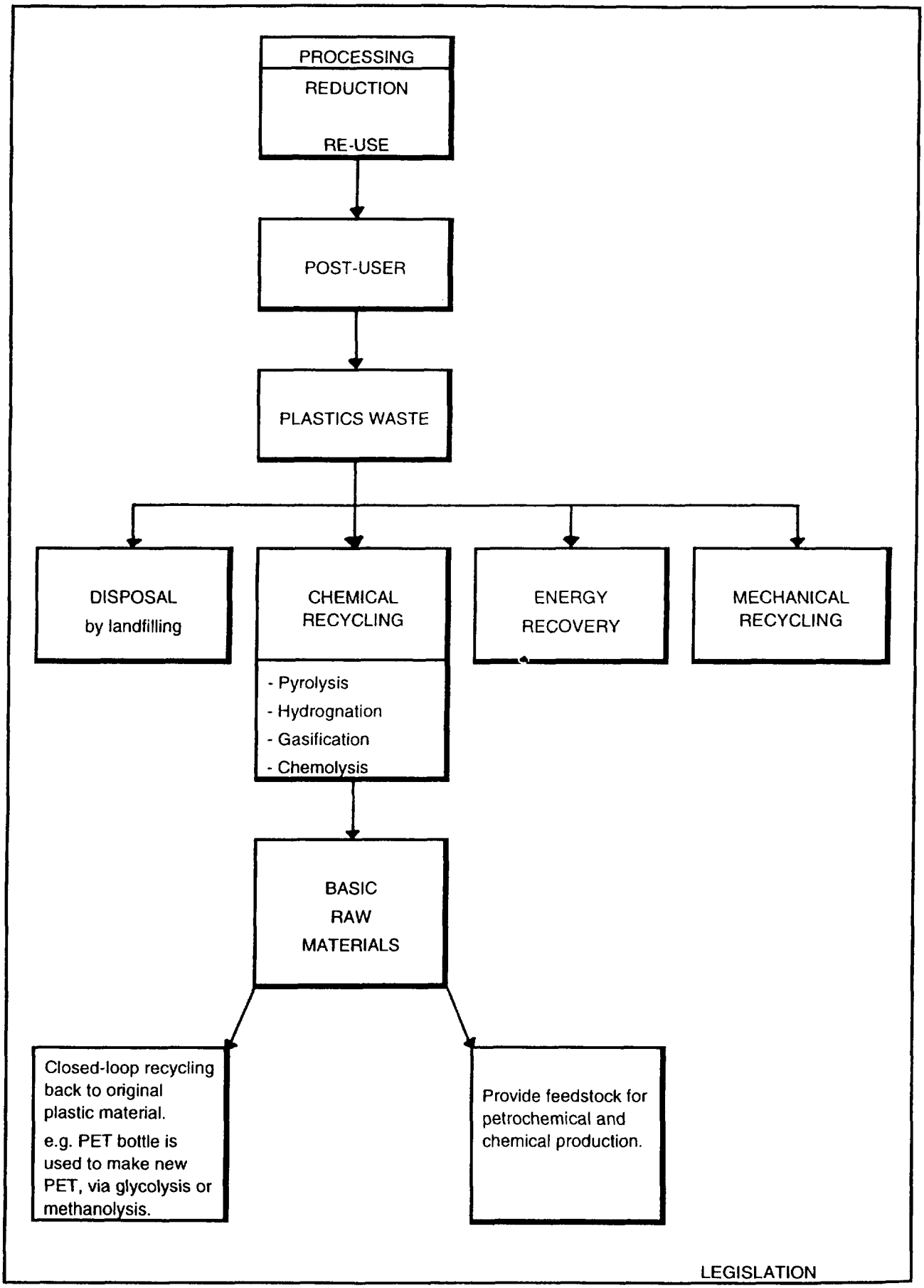
Ensures an extended life; reducing the volume of waste. Re-use is appealing concept but the net environmental gain of re-use systems need careful consideration before making the decision that re-use is always best.

Examples:

The carrier bag is probably one of the most popular re-use items in Europe.

The plastics industry is currently exploring methods of re-use in the drink market (soft drinks)

Figure IV.1. Integrate waste management



IV.3. Recovery of plastic wastes.

IV.3.1 Pre-user plastic wastes.

Generated by plastics manufacturers and conversion industries. The pre-user wastes do not pose large problems in terms of recovery.

IV.3.2 Post-users plastics waste.

IV.3.2.1 Collection and sorting of plastic wastes.

The collection and sorting of plastic wastes are typically the first two steps involved in post-user plastic waste recycling. The plastics may be sorted (from non-plastics) before being collected, or they may be separated from a mixed waste stream (sorted after collection).

Sorting before collection appears to be the more successful method to date. The plastics are kept separate from non-plastic wastes by the end user (who generates the plastics waste). The user can then bring the plastics to a central collection point where the plastics are collected and kept separate. The advantages of these methods over sorting after collection are that the plastics are usually cleaner and the labour-intensive process of separating plastic wastes from a mixed stream of MSW is avoided since the required manpower to separate the wastes is supplied by the waste generators themselves. These methods, therefore are dependent upon household participation (e.i. in Belgium, France, Germany, etc.).

Throughout all developing countries, scavenging of solid waste is widely practiced as a means of making a living. The total number of persons who are dependent on income derived from scavenging is estimated several million of people. These scavengers form the basis of a highly effective and productive recycling system. In some Asian Country, the plastic recovery is more that 40% (mechanical recycling)

IV.3.2.2 Recycling of plastic wastes.

Recycling refers to a process in which plastic wastes are used for mechanical, chemical and energy recycling. Figure IV.1 is a flowchart outlining different methods of recovery which exist today as explain hereafter.

IV.4. Mechanical recycling

Mechanical recycling, or recycling into materials refers to recovery and processing of used plastics for use in new applications.

Figure IV.2: Recovery as percentage of sector's plastics consumption

Country	% Mechanical recycling	Year
Western Europe	7	1990
USA	2	1993
India	37	1991
Japan	12	1993
Pakistan	30	1991
Philippines	44	1991

Sometimes recycling is not desirable or possible because:

- the material is grossly polluted or burnt, or has taken up moisture from the air;
- the material is composite, e.g. multi-layered film, insulated of electric cable, coated textile and various floorings;
- the production method does not incorporate a step, in which the wastes can be melted. Its occurs in the thermoforming of PVC-sheet, the rotation moulding of plastic powders and in the conversion of plastic semi-products to a final product by operations such as welding, gluing, cutting, drilling, etc.
- the dimensional specifications are too strict. Milled plastic scrap has not the same bulk density and flow properties as virgin material. The addition of scrap may alter the metering of plastics by the screw, hence also the temperature and viscosity of the melt and ultimately the degree of filling and pressure in the mould. For this reason the scrap is often being regenerated or, at least, added in a fixed proportion to virgin material.
- the raw materials cost in some cases is only of secondary importance (electronic industry).

IV.5 Chemical recycling.

Chemical recycling involves either the depolymerization of long-chain plastic molecules into their original monomer molecules or the breakdown of the polymer and monomer constituents into useful industrial chemicals. There are a range of chemical recycling technologies currently being explored:

Pyrolysis: Breakdown of the molecules by heating in vacuum. These processes lead to gaseous or liquid hydrocarbons which can be further processed in refineries.

Hydrognation: By treating plastics with hydrogen and heat the polymer chains are cracked down to a valuable hydrocarbon oil which can again be used in refineries and chemical plants.

Gasification: Plastics are heated with air or oxygen. The resulting synthesis gas, consisting of carbon monoxide and hydrogen, can be used for the production of methanol or ammonia or even as a reducing agent for steel production in blast furnaces

Chemolysis: By applying solvolytic processes- such as hydrolysis, alcoholysis or glycolysis - polyesters, polyurethane and polyamides can be recycled back to their basic monomers for repolymerisation into the original plastics.

Example:

Veba OEL has a licensed capacity for chemical recycling 40 000 tonnes of plastics waste per year. The company runs the plant on a commercial basis.

The BASF chemical recycling pilot plant has started with a capacity of 15 000 tonnes per year. This capacity will increase to 300 000 tonnes per year.

IV.6 Energy recovery

Incineration is the next most common method of disposal for municipal wastes. Data in TableII.16 (see annexe II) indicate that in Japan and Switzerland more than 75 per cent of municipal waste is incinerated. In many instances energy can be recovered from waste incineration; this practice has a number of benefits which enable to save

energy resources, to reduce emissions of carbon dioxide, and to reduce demand for landfill space.

Regarded by some as a legitimate and important contributor to the recycling of plastic waste, the incineration and waste to energy solution is fiercely resisted by others who point out problems of toxic emissions and oppose the building of incineration.

Throughout Asian countries, the majority of MSW which is landfilled and some countries such as South Korea use the incineration with energy recovery.

Incineration is a unit process that uses thermal decomposition to convert a solid waste to a less bulky, toxic or noxious material.

Incineration offers the benefits of reducing waste volume, completely eliminating harmful bacterial and viral constituents, destroying many toxic organic compounds and allowing waste heat recovery.

Incineration has been a traditional disposal and volume reduction concept used to conserve sanitary landfill space in areas where suitable landfill capacity is not available within an economical hauling distance. Incineration reduces the weight and volume of solid waste while producing a residue which can be used as a fill material.

Solid waste incinerators can be design with or without energy recovery. Where revenue can be generated by selling or utilizing energy, the income can be used to cover some of the operating costs of incineration.

Solid waste incineration is used in USA, Europe and Japan since many years and the steam produced by burning solid waste can be recuperated. It can be used for industrial processes, or can be utilized in a turbine generator to produce electricity.

	Recycling	Incineration	Landfill
W -EUROPE	15%	30%	55%
JAPAN	5%	70%	25%
USA	10%	5%	85%

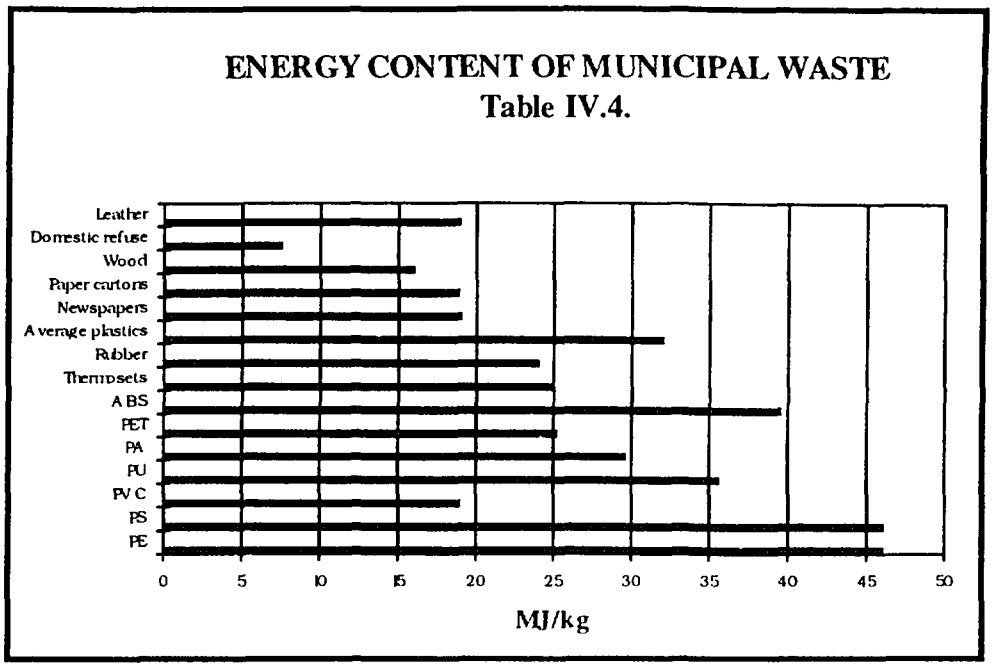
Table IV.3: Global municipal solid waste in (%)

Incineration is capable to reduce the weight of refuse by 80% and the volume by over 90%. The residue from the refuse is inert and may be disposed off in landfill.

Incineration can be performed and operated with safety conditions. The key is a high temperature combustion, proper controls, and trained, experienced operators. Today's modern incinerators operate with drastically reduced emission levels below those associated with risks to humans and the environment.

The incineration has turned to energy recovery.

Most plastics have a high calorific value given here after :



The role of plastics content in the MSW is very important for the well-established MSW incineration programmes and facilities. The energy content of plastics renders them the most valuable of the major categories in MSW from an energy point of view. The overall energy value of the waste stream depends upon the composition of the waste. Changing lifestyles have led to an increased share of plastics and paper in the materials mix, increasing the heat value of this waste.

Composition	Energy released upon combustion MJ/kg	Western Europe		Shanghai China	
		%	MJ/kg	%	MJ/kg
Plastics	35.0	7.4	2.59	5.5	1.92
Paperboard	16.8	30.0	5.04	7.5	1.26
Glass	0.0	8.0	0.00	2.5	0.00
Organic products	7.5	33.0	2.48	80.0	6.00
Textiles	25.0	4.0	1.00	0.0	0.00
Metals	0.0	8.0	0.00	0.5	0.00
Others	5.0	9.6	0.48	4.0	0.20
Total		100.0	11.59	100.0	9.38

Table IV.5: The caloric value of MSW. (estimation)

Table IV.5. highlights the extent to which plastics have a higher heat value than other components of the waste stream. In fact, the contribution to the energy content of MSW is several times greater than the physical proportion would imply for the Western Europe whereas for the majority of Asian Countries the organic products is the higher contribution to energy content of MSW. We can also establish than the caloric value of MSW in the Asian Countries is lower about 20%.

Incineration cost.

Indeed incinerators of the latest generation including energy saving and fumes cleaning adequately complete the sorting and recuperation operations with the burning of the elements which have a calorific power and no economical interest as for example the fragments of plastic films.

The arguments in favour of the treatment of solid waste in energy plants are not just environmental. These plants can also represent a viable economic investment offering a competitive return.

Clearly a great deal depends on local conditions, however the following figures demonstrate the European average of costs involved.

	Initial investment	Running costs/ income			Average total cost
	Expenditure in plant and equipment (capital)	Loan repayment	Processing cost	Income from energy sales	
Average cost	1750 US$ per tons treated per hour	30 US$ /T (over 20 years at 10%)	32.3 US$/T (inclusive of residue/ash disposal	16.6 US$/T	45.7 US$/T

Table IV.6 :Cost of incineration

Source : Syndicat Professionnel des Producteurs de Matières Plastiques.

IV.7 Disposal by landfilling

The reaction against landfill as the primary method of waste disposal is part of the general upsurge of concern about the state of the environment. More specific difficulties relating to potential shortages of capacity have resulted in a near-crisis situation in parts of the Asian Countries and have given impetus to recycling and other methods of waste disposal.

Landfill is still the predominant waste disposal method in the Asian Countries, but its share is declining rapidly. Many landfill sites have closed and a number of the remaining sites have only a limited life-span.

This decline is particularly marked in the densely populated areas as such the big cities (Manila, Shanghai, Bangkok, Jakarta, Beijing and New Delhi, etc), where land shortages have pushed up tipping fees and the price of new landfill sites. There is also growing public resistance against installation of landfill facilities in near local neighbourhoods.

Landfill is also the only disposal method in Asian Countries expect for South Korea where the incineration is used for the treatment of MSW.

Landfill will generally decline, not only because land shortages but because environmental concerns, which are particularly directed towards plastics. Such concerns surround the following perceptions about what happens to plastics in landfill:

- Plastics are widely believed to comprise a major share of landfill in volume terms.
- There has been speculation that plastics impair the structural integrity of landfill.
- Plastics are said to slow down the degradation of other materials in the landfill.
- The reputation of plastics for non-degradability also intensifies attacks on their landfill role. Many plastics are certainly slow to degrade, but it appears that in the increasingly dry conditions required in today's tightly regulated landfill sites, slow degradation is not only a problem for plastics. Excavations have revealed newspapers which are decades old and virtually intact.
- The biggest concern about landfill is the possibility of toxic additives and fillers from plastic materials leaching into the ground-water. Again, as in other areas relating to landfill, knowledge of what actually occurs is limited.

Landfill is the most common method for the municipal solid waste disposal. It is also a final method, landfill being the ultimate destination of waste.

Case Study 1: Manila - Philippines.

The waste is dumped in an open area and allows decomposition. Its only advantage, a relatively low disposal cost, is far outweighed by the disadvantages : odour, scattering of lightweight waste by the wind, and the presence of pests such as rats and mice.

There are four disposal sites normally operated by ESC, i.e. Venezuela, Malabo, Balut "Smoky Mountain" and Payatas.

The method of solid waste disposal in Metro Manila is open dumping. The incoming trucks dump their refuse load on the ground or on the existing waste and one or more bulldozers spread the waste in the working area. During the dumping and spreading operations, scavengers sort through the waste to find items which can be sold to on-site salvage dealers. There is not application of soil cover on either the active or inactive dumping areas to minimize the odour and vermin problems. The conditions of the access roads and on-site roads is one of the prominent operational problems.

One of the principal causes of air pollution from the existing dump sites is due to the fires that frequently are ignited by spontaneous combustion of the waste.

Case Study 2: Shanghai - China.

The reaction against landfill as the primary method of waste disposal is part of the general upsurge of concern about the state environment. More specific difficulties due to potential shortages of capacity have resulted in Shanghai.

Landfill is still the predominant waste disposal method in Shanghai and in China, but many landfill sites have only a limited life time.

There are several disposal sites normally operated by S.E.S.A.B, those are located near the city.

The method of solid waste disposal in Shanghai is open dumping. The incoming trucks dump their refuse load into little barges, after the barges carry in the first disposal. The first disposal waste is fitted up to receive the wastes for 6 to 7 years and after the waste is brought to final landfill.

In the first disposal the water is collected and mixed again with the wastes, there is no system for the water treatment.

During the first dumping and spreading operations, scavengers sort through the waste to find items which can be sold on-site salvage dealers. After some layers of waste have been agglomerated soil cover is applied, however the amount of soil is very limited which leads to the self ignition of pressed organic material which causes hazardous air pollution.

Table II.15 (see annexe II) gives figures on the disposal routes for municipal waste. Burial in controlled landfills continues to be the most means of disposing of municipal waste in the OECD region; about 70 per cent of municipal waste is disposed of in this way by the USA and by most European countries. However, in Belgium, Luxembourg, France, Italy, Switzerland and Japan more than half of municipal waste receive other treatment than landfill disposal.

V. LEGISLATION.

V.1. The changing regulatory environment.

As landfill capacity in many industrialized countries has decreased and incineration continues to receive a bad press, legislation to reduce the quantity of waste and to encourage reuse and recycling has proliferated. In Annexe I some of the main waste disposal legislation initiates of recent years are developed.

The following points should be noted:

- Some governments (e. g. Canada and Netherlands) have negotiated voluntary agreements with key sectors. This more flexible approach enables industry to choose the most appropriate method to reach agreed targets. Underlying such agreements is the serious threat that failure to observe and reach agreed targets will result in the introduction of legislation.
- The majority of waste disposal legislative initiatives to date have been directed at packaging waste. Packaging is highly visible and has a short life-span. Increasingly, however, legislative attention will turn towards other sectors such as the automobile industry, household goods and electrical and electronic equipment. This is already happening in Germany and Denmark.
- The main thrust of waste disposal legislation to date has been directed towards encouragement of recycling. Other methods of waste disposal are not favoured. Incineration with energy recovery, in particular, is not regarded favourably in some countries despite being preferred in others with good environmental reputations. As the problems of placing all the environmental eggs in the recycling basket become apparent, governments will adopt a more balanced and approach to the whole question.

V.2. Consequence of the industrialized country's legislation on developing countries.

The industrialized countries have created a multitude of various packaging wastes handling systems during the past few years. In principle they all set the same requirements to both domestic and imported packaging. This has been used as an argument proving that is not discriminating against anyone. But is it really so?

Looking at the European situation from the point of view of an exporter e.g. to China, Philippines, Thailand or Malaysia, it seems that a fairly large group of nations in a small area have several different sets of rules. Now this exporter is wondering how

many different sets of packages, markings or contracts does he need to be able to export the same product to Germany, France, The Netherlands and Belgium. In theory, the importers in these countries should take care of the contracts e.g. with the DSD and give the exporters information and instructions on the acceptability of various packaging materials, on the printing of the "Green Dot", the colour for plastic strapping, etc. In practice, some importers don't respect the regulations.

V.3. Some consequences of recycling schemes.

To highlight the confusion - and sometimes ridiculous consequences - that the various systems may create:

Asian textile exporters traditionally use jute as packaging material. Jute is renewable, indigenous, natural material. However German importers of textiles informed the Asian producers that, as recycling is mandatory in Germany and as they do not have a system for recycling jute, the exporters should replace jute by woven polypropylene, as they have a recycling system for this material. Later, this situation has been changed and jute is allowed again.

Exporters of frozen shrimp use mainly waxed cartons for packaging. From France's Eco-Emballages, they could get the "Green Dot", as France allows incineration. France and Germany mutually accept each others "Green Dots". However, Germany does not accept incineration and waxing is undesirable in the recycling process. As a consequence, the exporter could not export directly to Germany, only via France.

Exporters of electronic equipment are using expanded polystyrene for the protection of their equipment. German recyclers have announced that the formed blocks have to be white only. However, the protection of the equipment requires that the EPS be treated with an agent that makes in antistatic. At the same time this agent dyes the EPS reddish and thus unacceptable. In many countries, no alternative cushioning material is produced.

In some cases, packaging material, which would be more economical in the recycling systems of Europe, has to be imported to developing countries which increase their costs a great deal. Already now, the packaging costs for enterprises in developing countries are relatively much higher than for companies in industrialized countries. This is due to the fact that a lot of the packaging materials or the raw materials for packaging have to be imported - mainly from industrialized countries. If the waste handling systems in industrialized countries further increase their packaging costs, it may greatly influence the competitiveness of the exporters in developing countries.

V.4. General problems caused by schemes in industrialized countries.

Many developing countries are in the process of creating their own packaging waste collecting and recycling systems. In fact, developing countries have, for long time been recycling quite more than the industrialized countries - not for environmental reasons but for necessity reasons. In many Asian countries as per example China, India, Malaysia, collecting of glass, plastic or corrugated board has been and is the source of livelihood for a lot of families. It has been economically feasible, because it has replaced the need for imported raw materials. It has basically not been organized by any "umbrella" organization or by the government (except for China where the two systems are used).

Now some of the countries are planning a systematic collection and recycling of used packaging according to their own needs. This is made more difficult by the efforts of Europeans to spread the "Green Dot" system also to developing countries. The marketing of the "Green Dot" has included some unsound features, such as giving it the image of being an eco-label, whether intentionally or not.

European waste handling systems and policies have received wide publicity in the media all over the world. From the European viewpoint it is important to discuss these matters for the obvious reasons that some countries in Europe are producing a lot of waste and having little space for landfills. However, when all this quoted and underlined in developing countries, the results are sometimes unsound: Many countries have started to copy the discussion on packaging waste and being worried about it, although their problem is not packaging waste but waste of food and other products due to the lack or inadequacy of packaging.

V.5.Future issues.

The mandatory and voluntary recycling systems in industrialized countries are really creating new barriers to trade with the developing countries. There are too many different sets of rules. From the viewpoint of the developing countries it would be desirable if:

- the industrialized countries would stop trying to introduce their environmental policies to the developing countries. Usually, directly copying any waste handling systems from one country to another has proven a costly mistake;
- the industrialized countries would instead help the developing countries to create environmental policies and eco-packaging schemes suitable to their conditions;
- the European Union could finally agree on common rules for treating packaging waste. One set of rules, one set of markings would help the trade a lot.
- the industrialized countries would at least inform the exporters in developing countries accurately about their requirements;
- the industrialized countries would understand the difficulties that exporters in developing countries are facing in relation to the availability and costs of packaging materials.

V.6. Policy instrument for waste management.

There are a number of policy instruments which a government can employ to control waste.

The more commonly used, each of which poses different problems for industry, includes:

- Recycling targets: this approach has proved most popular with many governments but the targets, especially for plastics materials which currently have lower recycling levels than most other materials, are often set at levels which are unrealistically high and within impossibly tight time-frames. As the German experience shows, account also needs to be taken of a country's recycling capacity and the availability of markets for recycled goods.
- Re-usability targets.

- Targets for percentage of recyclate in new products.
- Procurement policies which favour recyclable products or products with recycled content: such policies are commonly used to assist the creation of markets for recycled products.
- Mandatory deposit schemes to promote reusable containers, these schemes yield high recovery rates.
- Taxes on certain materials or products: taxes have been used in several European countries and to some effect - the European Commission estimated that the Italian tax on plastic bags resulted in a 40% fall in the consumption of these bags.
- Material and recyclability labelling: commonly to facilitate recycling.

The accumulation of such legislation has important implications for the plastics industry and its end-users. The requirement for recycling is affecting choice of material and product design, while direct bans have obvious consequences for producers of that material and imposing additional costs on industry.

The proliferation of legislation also creates potential trade barriers. Companies subject to tough legislation in their domestic market may find their cost higher than those of their rivals in major export markets. Companies trying to penetrate those markets with higher environmental standards will have to develop different products for different markets, again increasing cost and rendering products un-competitive.

VI. STRATEGY

VI.1. Market and Industrial Surveys on Plastics Industry

As any systematic development of the plastics industry could not be undertaken without a well documented information on the local situation of the plastics industry. In the majority of the cases that information is not available.

A survey on the situation to date regarding the plastic processing, recycling and plastics waste management, including the availability of raw materials, existence of a staff training programmes for the re-utilization of the plastics waste, economic aspects, regulations to promote the development of the waste reclamation industry is necessary.

The survey should enable to determine the different actions to be undertaken in order to improve: the choice of the raw materials origin, the plastic industry, introduction of plastics waste recycling programmes which could have a significant impact on the raw materials imports and on the environmental situation.

VI.2. Education

The population should have to be involved with all the necessary measures which will be required by the selective collection and waste treatment. A special education program will be needed for the population by advertising through the media about the importance of the waste management and means of collection, sorting, recycling and disposal. Special effort will be given in the school to teach the young generation or to encourage and support financially foundations (civic organizations) in charge to teach in schools.

VI.3. Improve actual collection and sorting system.

Throughout all Developing Countries, scavenging of solid waste is widely practiced as a means of making a living. The total number of persons who are dependent on income derived from scavenging is estimated several million of people. These scavengers form the basis of a highly effective and productive recycling system.

An appropriate solution for the treatment in general of the municipal solid waste has to be found especially for large cities where the land filling is becoming critical due to environment and transport problems. New installations have been developed in different cities to improve the selection and sorting of the different items which could be recycled, amongst which the plastic material. Furthermore a process of transformation of the organic component into a compost valid for agriculture is in operation on an industrial scale.

However we must regret that all these developments have been carried out separately in the different cities without any exchange of information to deal the gained experience. In addition some projects could be influenced in their development or delayed at the occasion of changes of municipal political authorities. It should be recommended to have all the information regarding the actual experience gained in this field duly shared with the other municipalities in order to avoid unnecessary loss of time and money.

VI.4. Incineration

The incineration solution cannot be avoided especially for large cities where the disponibility of free land areas will become more and more difficult in a near future and for which the transport costs to outside zones will become prohibitive.

VI.5. Plastic Association

The Associations (processors, recycler,) should have to be the partner with which the Authorities could discuss the new legislation to be prepared and introduced in this matter.

VI.6. Legislation

With this regard, it must be pointed out that a regulation regarding the obligation for the manufacturer to indicate on the bottom of the product his name as well as the type of plastic should have to be introduced.

Other regulations should have to be duly reviewed and eventually recalled and completed to be respected in all country.

VI.7. Human Resources Development in Plastics Industry.

The key to accelerated and sustained industrialization is the development of human skills and resources. Developing countries are fully aware of the critical role of science and technology in their industrialization process and the strengthening of these capabilities remains a challenging task.

It should be recommended to have Plastic Technical Centre to provide all the technical support the companies need to improve their activities. It must be pointed out that these Centre will operate on a non academic way but will provide practical technical support.

VI.8. Market

Regarding the recycled plastic, it must be pointed out that there is a specific market for this material. The products duly manufactured with this recycled plastic could advantageously take for instance the place of wooden products. The road and building construction could be on a large scale a user of these new products.

VI.9. Plastic Industry with the concept of clean production

- Improve the efficiency of the plastics transformation industry;
- Improve the quality and increase the quantity of plastics products;
- Diversify the range of finished and semi-finished manufactured products.
- Reduce the amount of waste generated through better management and recycling.
- Generate an export market on a continuous basis for plastic products as such and as part of other manufactures.

VII. UNIDO PROGRAMME ON POLYMER, RECYCLING AND PLASTICS WASTE MANAGEMENT.

INTRODUCTION.

Developing countries attach the utmost importance to the development of downstream petrochemical industries because the products of these industries contribute directly to the satisfaction of some of the basic needs of their populations. The development of these industries not only helps to strengthen the technological capabilities of the developing countries, but also enhances economic development, generates employment and reduces reliance on imported materials, and thus alleviates poverty. Furthermore, the development of diversified downstream petrochemical industries is a significant factor in increasing the industrial productivity of developing countries by strengthening their industrial structure.

The UNIDO programme contribute to achieving the following development targets for the plastics industry:

- Improve the efficiency of the plastics transformation industry;
- Improve the quality and increase the quantity of plastics products;
- Diversify the range of finished and semi-finished manufactured products.
- Introduction of training courses, as appropriate, for human resource development.
- Reduce external dependence both of imported plastics manufactures and technologies.
- Reduce the amount of waste generated through better management and recycling.
- Generate an export market on a continuous basis for plastic products as such and as part of other manufactures.
- Legal frame

PROJECT AIMS AT:

- ☐ Market and Industrial Survey on Plastic Industries management (Production, Processing, Recycling).
- ☐ Technology acquisition, development, adaptation and transfer.
- ☐ Transfer of the recycling technologies with establishment of pilot plants (small- and medium-scale industries)
- ☐ Plastics waste management

IN THE AREA OF:

- Plastic transformation industry
- Recycling industry

USING VARIOUS TECHNOLOGIES.

The plastic transformation industry use the technologies as follows:

injection moulding, blow moulding, film extruders, pipe & profile extruders, thermo / vacuum forming, rotational moulders for the production of semi-finished or finished products.

In the field of mechanical recycling the following technologies are used: crushing, washing, drying, agglomeration, extrusion, pelletization and packaging.

PROJECT FIELD

Packaging sector:

- Film (packaging): outer wrapping for bottles, cans, and chemical manufacturers products
- Injection and blow moulding: drums and containers for the chemical and food industry
- Film (packaging): covers, drawing, shrinkable film
- Injection moulding: crates,

Agricultural sector:

- Film (packaging): fertilizer bag, shrinkable film
- Film (non-packaging): greenhouse, tunnel films
- Pipe: drainage, irrigation
- Moulded products: trays, pots

Construction sector:

- Film (packaging): covers, drawing film for construction materials
- Film (non-packaging): insulation for foundations, floors, etc.
- Sheets: roofing, flooring
- Injection moulding: drainage, septic tank
- Profiles: windows, doors
- Pipes: sewage, water networks, electrical circuits
- Wire & cable: electrical networks

Automobile sector:

- injection moulding: batteries, other car parts, fuel tanks, bumpers)
- Wire & cables: electrical networks

Electrical and electronics appliances and equipment sector:

- Television sets, refrigerators, freezers, air conditioners

Waste recycling sector:

- The recycling of the majority of end-products produced by all sectors after the life-end of the plastic products.

Public sector

- Including all public authorities such as environmental, sanitation and municipality bureau to establish a legal frame for collection and sorting schemes, international standardization, etc.

LINKAGES

The plastics industry and recycling are linked to the activities of the other units of the Chemical Industries Branch and the others UNIDO Branches.

Of particular note are:

- the use of the multi-layer technology such as paper and plastic in the packaging industries;
- the printing of the plastic products in the packaging sector;
- the recycling of the plastic waste from the municipality solid waste, including paper , glass, organic products, textiles, metals ,

PROJECT EXAMPLES

☐ **Market and Industrial Survey on Plastic Industries management (Production, Processing, Recycling).**

Problem:

Any systematic development of the plastics industry could not be undertaken without a well documented information on the local situation of the plastics industry. In the majority of the cases that information is not available.

Project:

A survey on the situation to date regarding the plastic processing, recycling and plastics waste management. Including the availability of raw materials, existence of a staff training programmes for the re-utilization of the plastics waste, economic aspects, regulations to promote the development of the waste reclamation industry.

Result:

The survey should enable to determine the different actions to be undertaken in order to improve: the choice of the raw materials origin, the plastic industry, introduction of plastics waste recycling programmes which could have a significant impact on the raw materials imports and on the environmental situation.

Country:

Brazil, Philippines, Shanghai-China, Palestine

☐ **Technology acquisition, development, adaptation and transfer.**

Problem:

In many developing countries the utilization of plastic resin to make product with a given end-performance is far higher, sometimes as much as 50% higher than is necessary. This is due to a number of factors such as:

- use of old, badly designed moulds,
- use of bad operating practice,
- lack of quality assurance and quality control
- poor product design

This use of larger quantities of raw materials than necessary leads to unprofitable operation for the plastics transformation industry and increased production of waste.

Source reduction implies the reduction of the total quantity of materials used in the production of an item, this approach should be often placed at the top of the hierarchy of waste disposal methods.

This objective can be attained if the plastic industry has qualified engineers and technicians.

Project:

Assistance with establishment of a Technical Services and Training Centre (through the provision of expert' services and on-site training), including testing, processing, and information service to the plastics industry as well as to their suppliers and products users.

Result:

Reduction of the amount of the waste produced by the plastics industry through management and recycling.

Reduction of the external dependence on both the imported plastics manufacturers and technologies.

Diversification of the range of finished and semi-finished manufactured products.

Improvement of the quality and increase quantity of plastics products.

Establishment of relationships with similar Centres in the industrialized countries.

Country:

Brazil San-Palo (INP) , India, Nigeria, Philippines, Shanghai-China,

☐ **Transfer of the recycling technologies**

A. Industrial plastics waste, recycling in line.

Problem:

A large category of wastes arises during the conversion of the raw plastics into semi-finished (plates, tubes, etc.) or finished products. Often not in-plant

recycling of plastic waste is performed. But in many cases the recycling in line is necessary in order for a process to be profitable with a small investment.

Project:

Assistance with the establishment of scheme recycling in line (through the provision of expert' services and on-site training) including process selection.

Result.

Reduce the import of raw material and the price of the product, increase the efficiency of the process.

Country:

Shanghai-China

B. Pre-treatment of the plastics waste.

Problem.

The technology and the equipment for pre-treatment of plastics waste are presently backward in developing countries. Usually crushing of waste plastics is accomplished with the use of an open mill, and in some cases with the use of a plastics crusher. It has duly noted that these crushing machines are generally in rather bad working condition, which fact significantly increases the energy consumption.

Manual washing is still used in some factories. Mechanical washing production lines have been developed as well. The washing operation is carried out in the flotation basin which only allows the separation by density. No washing by friction such as with screw washing is actually used. There is no rinsing area with clean water before the drying.

The drying process is performed on a discontinuous way by means of a centrifugal dryer. After this operation, no heating by hot air completes the drying process. Therefore the humidity remaining in the material is too high for an appropriate extrusion. An impact is consequently given to the quality of reclaimed plastics and its products. We can say that recycled plastic products of good quality cannot yet be manufactured in developing countries because of the backward pre-treatment.

Project:

Assistance with the establishment of a washing plant (through the provision of expert' services and on-site training) including process selection, plan design, plant construction and equipment.

Result:

Increase the quality of the plastic product manufactured by adequate pre-treatment of the plastics waste.

Increase the number of products that could be manufactured (pipe and film for agriculture).

Reduce the importation of raw material and products.

The successful operation of the pilot plan will serve as a basis to promote the pre-treatment and the recycling in the country.

Country:

Shanghai-China

C. Agglomeration line.

Problem:

In the developing countries, the agglomeration of the plastics is necessary because they do not have the adequate technology to use directly the flacks from the pre-treatement to the extrusion machine. The local equipment is more used as dryer than as it should be, i-e as a plastic densificator. This is due to the fact that the drying is generally insufficient and requires an additional process to achieve this operation. The cost of such a solution is very high as the water is duly transformed in steam under the friction action of the knives of the equipment on the wet plastic material. That type of plant is necessary for agglomerating all films.

Project:

Assistance with the establishment of an agglomeration plant (through the provision of expert' services and on-site training) including process selection, plant design, plant construction and equipment.

Result.

Improve the efficiency of the extrusion line and at the same time save energy.

Reduce the cost of recycling. Facilitate the dosage of additives before the extrusion line to produce pellets and increase the quality.

The successful operation of the pilot plan will serve as a basis to promote the agglomeration of plastic waste and the recycling in the country.

Country:

Shanghai-China

D. Injection line for mixed plastics from post-consumer.

Problem:

In all schemes of plastics collection from the post-consumer or in processing industry. It is still a large quantity of mixed plastics without adequate treatment.

Project:

Assistance wit the establishment of injection plant (through the provision of expert' services and on-site training) including process selection, plant design, plant construction and equipment.

Result:

Produce cheap end products used in agriculture (small container) or in the construction. Reduce the import of raw material.

☐ **Plastics waste management.**

A. Collection scheme, legal, policies, standards

Problem:

At first it must be pointed out that it is not possible to consider the situation in developing countries about the treatment of plastic waste and its recycling disregarding the problem of the treatment of the complete municipal solid waste. Indeed an important part of the plastic waste duly recycled is coming from this municipal solid waste.

This project seeks to promote the development of the waste reclamation industry in an efficient and environmental sustainable manner. Management of Waste Recycling will contribute to the environmentally sound management of solid wastes, the conservation and sustainable use of natural resources, the sustainable development of industry, and sustainable energy production.

Each developing country produces each year waste steel, waste metals, waste plastics, waste rubber. The municipal solid waste also contains valuable plastics. Reclamation of these secondary resources could result in substantial benefits for the country economy, environment and natural resources.

Because the country has not yet established any overall policies, standards or regulations governing waste reclamation, private companies have turned to inexpensive but highly polluting reclamation technologies in order to increase profits, and compete more effectively.

The municipality installations for the treatment of the solid urban waste should be developed to improve the working and sanitary conditions of the scavengers and to increase the percentage of products which could be recycled. Although these units confirm their advantages, some improvements could be introduced. Regarding the treatment of the rejected part of the municipal solid waste, actually no incineration solution has been taken into consideration and developed.

An international cooperation and assistance in order to develop more comprehensive recovery technologies, adopt policies, and regulations to promote waste recycling while ensuring compliance with high environmental standards, and form an orderly, and efficient market system for secondary resources.

Project:

Establish a comprehensive regulatory and management system (collection scheme) to promote the development of the waste reclamation industry in accordance with high environmental standards (through the provision of expert' services, and on-site training), including research the policies, laws, standards, tax policies, and management of secondary resources in other countries,

Result:

This project will promote the reclamation and comprehensive utilization of valuable secondary resources in manner that will benefit the country's economy and environmental, conserve natural resources and save energy.

Country:

Shanghai-China, Palestine in line

B. Sorting plant plastics waste from municipal solid waste.

Problem:

In the most large municipalities in developing countries the disposal of municipal solid waste (MSW) is a major problem. One partial solution to this problem is to collect the plastics waste separable some others solids waste and sorting. This is an attractive alternative to processes such as dumping, landfilling or incineration.

In order to properly asses the feasibility of sorting plant at any particular site, it is necessary to know if the municipality has taken yet in consideration the collection scheme.

Project:

Assistance with the establishment of a sorting plant (through the provision of expert' services and on-site training), including process selection, plant design, plant construction and marketing of the plastic products.

Result:

A more just regulation of scavenging would be more beneficial to all parties concerned with the increasing of the working environment and creating new jobs.

Guarantee availability of sufficient quantities of good quality waste to the recyclers and same time the plastics transformation industry. Reduce the importation of raw material. The successful operation of the pilot plant will serve as a basis for broader-scale application of the technology.

Country:

Palestine in line

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APME Association of Plastics Manufacturers in Europe	Legislation	Applicable packaging	Collection and recovery
Austria	Packaging Ordinance into force October 1993	Transport, sales and secondary packaging	Take-back obligation upon industry: exemption by establishing collection and recovery system - can subcontract to local authorities.
Belgium	Eco-tax law came into force January 1994, voluntary agreements signed in all 3 regions of Belgium. One way beverage containeers not likely to be subject to tax before January 1995. Packaging Ordinace in preparation	Eco-tax applicable to variety of packaging. Voluntary agreements cover all packaging in domestic waste. Voluntary agreements and future Packaging Ordinance will cover all packaging	Industry must be members of recycling organisations recognised by regional governments. Belgian industry and retailers have created Fost-Plus on 28 March 1994. This will be the agreed organisation for packaging in domestic waste
Denmark	Several legislative regulations targeting the banning, restriction, labelling and deposit and taxation of certain packaging	Transport, sales and secondary packaging	The take-back obligation has not been introduced, but an agreement on the recycling of transport packaging was adopted on the 16 August 1994
Finland	Law on waste 1994. Framework legislation without any specific (numerical) targets. Eco-tax for oneway beverage bottles and cans (2 FiM/L). To be doubled in th. future. Government proposal to double current refill/recycling levels	All packaging waste	Local authority (glass), industry (bottles and board)
France	Packaging Waste Decree into force January 1993	Sales and secondary packaging. Household and industry packaging	Conducted by local authorities - industry recovers packaging waste through Eco-emballages
Germany	Topfer Ordinance: targets into force January 1993 and July 1995. Now being reviewed	Transport, sales and secondary packaging	Take-back obligation upon producers - exemption by establishing system outside of local authority network (ie. DSD)
Greece	No legislation in place - the Government is considering a recycling Decree	To be determined by new Decree	To be determined by new Decree
Holland	Voluntary agreement: the Packaging Covenant, into force 1991. Volume reduction by 2000	All packaging placed on the market	Take-back obligation upon industry. Collection and sorting conducted through local authorities
Ireland	Waste Bill in preparation	Used products or their packaging	Proposal that producers and distributors take back used products or their packaging or arrange for their collection and recovery
Italy	Law on liquid containers and plastic shopping bags into force 1990, October 1993 law passed leading to 10% tax on all PE polymer for l/d. This supersedes the carrier bag law	A 10% tax on virgin polymer used to make PE film. Exemption for film produced on-site for ackaging in producing goods and products. Fat bottles set "Funding mechanism"	Local authorities responsible for collection, Consortium for recovery
Norway	Draft law on waste reduction and minimisation, existing tax on certain non-returnable beverage containers	Non-refillable beer, carbonated drinks, wines and spirits containers	Deposit and refund system for refillable glass and PET
Portugal	No legislation in place - discussions between packaging chain and Goverment	To be determined by discussions	To be determined by discussions
Spain	Government preparing solid waste law and series of dicrees on waste streams including packaging. Voluntary agreement between Government and industry on packaging currently exists - pilot schemes to be set up in 3 cities	All packaging wste	Conducted by local authories - industry recovers packaging waste through Eco-emballages-type grouping
Sweden	New Government Manufacturer Responsability Statute September 1994. In force 1 October 1994	All packaging waste	The form collection will take is not yet clear
Switzerland	Law on refillable/recyclable beverage containers - PVC beverage containers banned since November 1991	Soft drinks, water and beer	Separate schemes for HDPE and PET in place based on bring-back system
UK	No legislation in place. Plan presented to goverment by packaging chain in February 1994	All packaging waste	Local authorities responsible for collection. Industry schemes include sponsorship of bottle and vending cup recovery through RECOUP and Save-A-Cup
EU Proposed Directive	Common Position adopted by Member States, December 1993. Conciliation procedure awaited, possibly September 1994	All packaging waste	Principle of share responsibility - no specific requirement

Funding mechanism	Recovery targets	Energy recovery	Deposits on bottles
ARA system for collection and recovery financed by fee-per-kg-package material of OS 11.91 to 17.68	Collection quotas : 40% by 1995, 60% by 1998 and 80% by 2000 Recovery quotas: 80% of the collected quantity	For sales packaging only	Mandatory deposit (Os 4) on refillable plastic beverage containers. All non-refillable beverage containers (not milk and wine) bear and "wastemanagement contribution" of Os 1 for packs larges than 1 L and Os 0.3 for smaller packs
Tax at \beF15/L on drinks containers by suspended if 70% recycling reached for the eco-tax. Funding for Fast-Plus will be via a green dot system	For beverage containers 80% non-refillable glass and metal and 70% non-refillable plastics containers - to be attained gradually over increasing proportion of population - 100% of population by 1998. Targets for all packaging will be set in the Packaging Ordinance	Energy recovery targets will be set in the Packaging Ordinance	From January 1995 possible tax on drinks containers BeF 15/L Exemption for refillables if re-use targets (44% in 1994) and for non-refillable if recycling targets (70%) are met. PVC states to be decided by January 1995
Various taxation of selected packages determined by the material and the size of contents	By 2000: 15% reduction in packaging waste, 80% recycling of transport packaging and a target of 85% reduction of PVC in packaging	62% waste in Denmark is incinerated with energy recovery	Mandatory refillable bottles for domestic production, mandatory deposit and return and recycling system for imports
Eco-tax is fiscal and not used for packaging recovery. Industry is paying for bottle and paper board collection. Glass is practically subsidised by communities. Plastic packaging has no funding system on positive raw material value as waste	70% of all packaging waste by 2000. Government proposal to doble current plastic packaging refill/ recycling levels. The low population density will cause practical difficulties in reaching targets	Government support if refill/recycling targets met. Trials in the use of Packaging Derived Fuel (PDF) in hand to supplement coal/peat	Deposit system exists for glass and refillable bottles. Ministry wants to raise it up to 4 FIM/L. This kind of policy in Finland is considered an enormous trade barrier for soft and alcoholic drinks.
Eco-emballages is financed via a fee-per-packaged unit	Recovery target: 70% of household packaging by 2000, no material at less thatn 60%	All recovery techniques are considered equal	None-covered by fee-per packaged unit
DSD is financed via a fee-per-packaged unit (Weight and volume dependant) the Green Dot	Recycling target for plastics packaging (including feedstock recycling) of 64% by 1995 not subject to review	Not included as a recovery option; under review by the German Government	Mandatory deposit if recyling targets nte achieved and market share of refillbale containers below 72%. Take -back obligation at the counter on containers
To be determined by new Decree	To be determined by new Decree	To be determined by new Decree	To be determined by new Decree
Operating costs divided between participants - industry and local authorities	40% of all packaging by 1995 - 50% plastic bottles adn 50% clean office / shop film	Maximum 40% energy recovery of all packaging waste by 2000	Deposit on all soft drinks imported in glass and plastic bottles
Proposal that producers, retailers and distributors operate deposit and refunding schemes	As yet unspecified targets to be met within a five year period to 1999	Permitted by Government but facilities still need to be developed	To be determined
[illegible]% levy on manufacturers of PE polymer for film and 10% contribution on all polymers for bottles for liquids to pay for recovery.	40% of all plastic containers by 1995 dependent on local authority's ability to collect and recover	Up to 50% of this target (20%) could be met by energy recovery	None, 10% levy on PE polymer for film is not used as a deposit on bottles
Tax on non-refillable drinks containers (milk exempt)	A proposed tax reduction for reverse vending system to meet yet to be defined return rate. Industry to be involved to target setting	Energy recovery not excluded as a recovery option- currently at 8% of MSW	Packaging taxes 3.5 NKr on non-refillable beer and carbonated soft drinks, 2.5 NKr on non-refillable containers for wines and spirits
To be determined by discussions	To be determined by discussions	To be determined by discussion	To be determined by discussions
[illegible] per unit of packaging	Not yet set-interim targets to be set 2 years after the system is set up. Final targets will be those in EU Packaging Directive	Each industry sector will be able to determine which recovery technique to use however, material recycling to be given priority. Energy recovery supported by government.	None
Fibres to pay for collection and recycling through the imposition of duty on packaging	30% of all plastics packaging should be either re-used or recycled by 1 January 2997. (exclusive of PET bottles	56% achieved 1993. Since manufacturers are to be responsible for dealing with sorted waste in an environmentaly acceptable way", incineration for energy recovery could be one such way	Deposit of SKr 0.5 on cans. Non-refillable PET bottles allowed, provided industry puts in place a recyling system - 4SKr deposit in place for returnable PET
Deposit and return system for refillable containers, voluntary levy on plastics beverage containers to fund *infrastructure*	Maximum limites one one way glass, PET, aluminium and ferrous beverage containers in waste	72% achieved 1993	Refillable continers carry a 0.2 SF deposit 60d and 0.5 SF if more, mandatory deposit on one-way beverage containers if reduction targets not met
Recommendation made for industry levy primarily at the stage of sales by converters. Currently voluntary support for schemes such as *RECOUP* and Save-A-Cup	National target to recover 50-75□ of the use packaging by 2000. Packaging Industry assessment 58%. Plastic Industry recovery target 34% Current levels of plastics packaging recycling ca 80 Kts p.a.	Energy recovery supported by government	None
No specific requirements - economic instruments allowed	Recycling targets: 25% minimum, 45% maximum, 15% minimum for eac material in 5 years	Implicit energy recovery band of 15% TO 40% after 5 years	Re-use systems permitted providing they present no barriers to trade

Table II.15. Generation and composition of municipal / household wastes, most recent year available

Region / country	Annual arisings			Composition (% of total weight)						
	Year of data	Total (10^3t)	Per capita (kg /day)	Yera of data	Paper and carboard	Plastics	Glass	Metals	Other	Organic
AFRICA										
Egypt	1990	5,600	0.3 to 0.8	1980	10	1	2		87	
Namibia	1990	44,484		1991	23	11	24	13		29
Nigeria			0.05	1980	15			5	80	
Tunisia		1,200	0.48							
NORTH AMERICA										
Canada	1989	16,000	1.71	1989	36.5	4.7	6.6	6.6	45.7	
Mexico		40.8								
USA	1990	293,613	3.23	1988	40	8	7	8.5	36.5	
ASIA										
China	1987		1						60	
Hong Kong	1990	5,788	0.9							
Israel	1986		1.5	1986	16 to 21	10 to 12	3 to 5	3 to 5		50 to 54
Japan	1988	48,283	1.08	1988	45.5	8.3	1	1.3		43.9
Korea	1989	28,392	2.22	1989	12.3			4.8	82.9	
Pakistan	1978		1.05	1978	15	2	4	5	74	
Singapore	1991	1,247	1.1							
Thailand				1985	18.4	14.5 (incl. rubber)	6 (incl. metals)		60.1	
Turkey	1989	19,500	0.97							
EUROPE										
Austria	1988	2,700	0.97	1986 Vienna	33.6	7.0	10.4	3.7	45.3	
Belgium	1989	3,470	0.96	1989	28.3	7.7	7.6	3.7	5.1	47.6
Finland	1989	2,500	1.4	1985	40	8	4	3	45	
France	1989	17,000	0.83	1989	27.5	4.5	7.5	6.5	54	
Germany, Fed. Rep.	1987	19,483	0.87	1985	17.9	5.4	9.2	3.2	64.3	
Greece	1989	3,147	0.71	1989	20	7	3	4	9	57
Italy	1989	17,300	0.82	1986	22.3	7.2	6.3	3.1	3.2	61.2
Luxembourg	1990	170	1.27	1985	17.2	6.4	7.2	2.6	22.6	44
Netherlands	1988	6,900	1.27	1989	24.2	7.1	7.2	3.2	58.3	
Norway	1989	2,000	1.29	1988	30	5	3	7	55	
Spain	1988	12,546	0.88	1988	20	7	6	4	14	49
Switzerland	1989	2,850	0.87	1989	32	13	7	6	42	
UK	1990	20 000		1990						
USSR	1990	[illegible]0	0.21	1990	32.9	3.3	5.1	3.9	54.8	

Table II.16. Treatment and disposal of municipal wastes in selected countries, most recent year available

Region / country	Annual arisings		Disposal of municipal wastes					
	Year of data	Total (10^3t)	Yera of data	Landfill (10^3t)	Incineration (10^3t)	Incineration with energy recivery (%)	Composting recovery (10^3t)	Other (10^3t)
AFRICA								
Egypt	1990	5,600						
Namibia	1990	44,484						
Nigeria								
Tunisia		1,200						
NORTH AMERICA								
Canada	1989	16,000	1989	13,488	1,416	7.1		242
Mexico		40.8						
USA	1990	293,613	1988	130.6	25.5	96	23.5	
ASIA								
China	1987							
Hong Kong	1990	5,788						
Israel	1986		1986					
Japan	1988	48,283	1987	16,486	32,616	27.4	53	1,454
Korea	1989	28,392	1989					
Pakistan	1978		1978					
Singapore	1991	1,247						
Thailand			1985					
Turkey	1989	19,500	0.97					
EUROPE								
Austria	1988	2,700	1987	1,836	222	9	473	257
Belgium	1989	3,470	1987	1,530	720	29.9		832
Finland	1989	2,500	1985	1,260	540		100	500
France	1989	17,000	1989	7,684	6,970	67	1,207	1,139
Germany, Fed. Rep.	1987	19,483	1987	12,917	5,942		429	195
Greece	1989	3,147	1989	3,084				
Italy	1989	17,300	1989	5,286	2,794	21.2	834	5,052
Luxembourg	1990	170	1990	51	117	100	2	
Netherlands	1988	6,900	1988	3,790	2,555	72	345	210
Norway	1989	2,000	1989	1,500	400	19	100	
Spain	1988	12,546	1989	742			280	1,656
Switzerland	1989	2,850	1989	460	2,270	80	90	30
UK	1990	20,000	1990					
USSR	1990	48,340	1990					