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HAZARDOUS WASTE MANAGEMENT AND POLLUTION PREVENTION

by

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1. Introduction

The management of hazardous wastes is one of the most critical environmental issues that faces many developing countries. It is one of the areas where institutional control and treatment and disposal technology has not kept pace with economic development. This paper reviews the development of hazardous waste management methods over the past decades, and provides the information on the status and trends of hazardous waste management strategy in selected western nations. Several issues pertinent to hazardous waste management will be reviewed, including:

- Definition of hazardous wastes
- Why are we concerned with hazardous wastes
- Aspects of hazardous waste management system
- Prioritization of hazardous waste management options

Due to regulatory and economic pressure on hazardous waste management, pollution prevention has become a very important environmental strategy in many developed countries. Specifically, opportunities for pollution prevention through source elimination, by-product recovery, and recycle and reuse have received increasing attention. In many developed countries, industry is increasingly considering such alternative approaches, and finding many opportunities for their cost effective implementation. This paper provides a review of the status and trends of pollution prevention in selected western nations. The following topics will be discussed:

- Potentials and accomplishments of pollution prevention
- Roles of government and industry to promote pollution prevention concept
- Government programs to promote pollution prevention

2. Definition of Hazardous Wastes

Hazardous wastes are generated from a wide range of industrial, commercial, agriculture and even domestic activities. They may take the form of solids, liquids or sludges. Most definitions of hazardous waste exclude domestic solid wastes and aqueous effluents; however, a major source of hazardous wastes is from the pretreatment of industrial effluents in order to meet water pollution control requirements. Examples include heavy metal sludges from electroplating, sludges from treating petroleum refinery wastes, etc..

In developing an organized approach to hazardous waste assessment and management, a system of waste identification and classification must be developed. In many countries, such a system is a integral part of a legal definition of hazardous wastes. Many countries have used a definition based on an inclusive listing of the following factors:

- Particular types of hazardous waste;
- Industrial processes from which the wastes are defined as hazardous;
- Substances, either specific or classes, the presence of which is indicative of a potential human health and/or environmental hazard.

In some cases, a listing of one or more of the criteria is used as a definition of hazardous wastes. For example, the U. S. Environmental Protection Agency (USEPA) under the Resource Conservation and Recovery Act (RCRA) has adopted two criteria to identify hazardous wastes:

- The inherent hazardous characteristic associated with a waste must be able to be defined in terms of physical, chemical, or other descriptive properties,
- The properties should be measurable by standardized testing protocols.

Testing methodologies, termed "characteristic tests", which meet the two criteria are:

- Ignitibility
- Corrosivity
- Reactivity
- Toxicity

Detailed information on the definition, classification and listing of hazardous wastes is available elsewhere (The World Bank 1989; Wagner 1991).

The nature and degree of hazard posed by hazardous wastes varies widely. A useful distinction is between those wastes which pose a potentially high risk to human health and those wastes where the hazard is much less, but the quantities are perhaps much greater. Typical wastes in the first category might include low flashpoint flammable solvents, highly toxic pesticides or persistent chlorinated materials such as PCBs, while the latter includes such large volume mineral wastes as metalliferous slag, mine tailings, phospho-gypsum or lime sludge.

2. Impacts of Hazardous Wastes

Hazardous waste can cause immediate, short-term, public health problems as well as long-term environmental pollution. They can affect human and animal health through different mechanisms and routes of exposure. The most obvious route is direct contact with the hazardous agents and chemicals during handling, disposal, and/or spills of the waste. Groundwater can be contaminated from waste dumping sites and landfills. Hazardous agents and chemicals can be transported to drinking water wells in this way. Direct discharge of hazardous wastes to surface water could result in rapid and extensive dispersion which can greatly increase the size of the exposed population.

Chemicals in hazardous wastes can be taken up by crops from soil-bound particles or contaminated surface- or groundwaters, or if contaminated water is used for irrigation purposes. The spreading of wastes on agricultural land constitutes other pathways for contamination of vegetation and crops. Consumption of contaminated vegetation by humans and animals can result in the transfer of hazardous substances. Livestock may ingest large quantities of soil when grazing; this is often a significant source of exposure in areas of contaminated soils.

The degree of risk associated with hazardous wastes can be affected by several factors such as: reactivity (fire, explosion, leaching); biological effect (toxicity, acute and chronic); persistence (fate in the environment, detoxification potential); indirect health risks (pathogens, vectors); and local conditions (temperature, soil, water, humidity, light, receiving systems, their use pattern, etc).

Hazardous wastes have only come to be recognized as a priority problem over the past 15-20 years. Action to manage hazardous wastes has often been precipitated by an actual environmental disaster. Japan, for example, introduced comprehensive hazardous waste controls following the Minamata incident in the late 1960s when many people died from eating fish contaminated with mercury which had been discharged to the sea. In the United Kingdom, public outrage arose over the discovery of drums containing cyanide salts on vacant land where children were playing. That incident helped to enact legislation on hazardous waste regulation. Similarly, public outcry over the widespread discovery of pollution caused by past uncontrolled dumping of hazardous wastes has led to the rigid control system on hazardous wastes in the United States since 1976.

3. Aspects of the Hazardous Waste Management System

Every country needs a national control system for hazardous waste management. Such a system must provide four vital components if it is to be successful: (1) Legislation and regulations; (2) Proper implementation and enforcement procedures; (3) Provision of adequate facilities for hazardous waste recycling, treatment and disposal and measures to encourage their use; and (4) Introduction of training schemes for government enforcement officers, plant operators, and managers; and/or public awareness educational programs. Additionally, there are a few general points that may be made regarding the successful introduction of a hazardous waste control system to a country: (1) Good information on present quantities of waste and on present practices is essential so that priorities may be identified; (2) A control system should encompass all aspects of hazardous waste management, from generation through storage, transportation and treatment to disposal; and (3) All parties involved -- generators, transporters, disposers, and government -- have their roles and responsibilities (The World Bank 1989).

Over the last decade, considerable progress has been made in a number of developed countries in controlling hazardous wastes. Progress varies considerably from country to country, but in some countries:

- Effective legislation is in place;
- Effective manifest systems are being introduced to control waste transport;
- An increasing percentage of operators of hazardous waste treatment and disposal facilities have been licensed;
- In some cases, well engineered and well managed facilities have been provided for hazardous waste treatment, incineration, and landfill;
- In a few cases, good collection and transfer systems have been established.

4. Prioritization of Hazardous Waste Management Options

For any particular hazardous waste stream (i.e., type and quantity), it is possible to define a "hierarchy" of preferred management options. These options should be considered to limit as far as possible the quantity and toxicity of hazardous wastes requiring final disposal. In general, the priority of waste management options is given as:

- Waste avoidance or reduction at the source;
- Recycling or resource recovery;
- Treatment by physical, chemical or biological means to destroy, convert or immobilize hazardous constituents;
- Incineration to destroy organic wastes;
- Disposal on land; and
- Disposal at sea.

When waste generation can not be avoided, the selection of appropriate treatment and disposal technologies will depend largely on the types and quantities of the wastes which are generated and on specific local factors. Not all options are suitable for all types of wastes. Detailed consideration must always be given to the composition of the waste and other local factors. Table 1 indicates treatment and disposal methods for 12 generic types of industrial wastes, as recommended by the Environmental Protection Authority of Victoria in Australia (1985). It should be emphasized that these recommendations are for the general situation as pertaining the State of Victoria. In practice, choices will be influenced by the degree of pre-treatment carried out by the waste generator and/or by the availability of suitable facilities for treatment or disposal.

Many western nations have regulatory instruments that set the guidelines for handling and management of hazardous waste. These regulations generally are in the form of "command and control" to regulate hazardous waste management by controlling and restricting pollutant releases to the environment. When these regulations are aggressively enforced, pollution prevention at the source becomes cost-effective. In the United States, hazardous waste management (e.g., land disposal, incineration) has become rather expensive since the enactment of hazardous waste regulations, and it can be a strong incentive for industry to reduce waste generation at source. Governments

Table 1. Recommended Hazardous Waste Management Methods in the State of Victoria, Australia

	Reuse Recovery	Incineration	Physical Chemical Biological Treatment	Solidification Fixation Stabilization Encapsulation	Landfill
Effluents, Wastewaters			•••		
Acids, Alkalis			•••		
Heavy Metals			•••	•••	°°°
Toxic Inorganics			•••	•••	°°°
Reactive Wastes			•••		
Non-toxic Inorganics	•••				•••
Solvents, Oils	•••	•••			
Resins, Paints, Organic Sludg	•••	•••			
Organic Chemicals	•••	•••	•••		
Pesticides		•••	•••		
PCBs, Chlorinated Hydrocarbons		•••			
Putrescible, Biodegradable Wastes		•••	•••		

Notes: ••• = selected options for the waste; °°° = selected options for the treatment residues
Source: Environmental Protection Authority of Victoria, 1985

influence treatment and disposal cost primarily by setting higher regulatory standards for treatment and disposal facilities, by requiring specific waste to be managed using particular methods, technologies or facilities, and by making it more difficult to site and develop new waste management facilities. Governmental influences on treatment and disposal costs are recognized as an important factor in promoting pollution prevention.

5. Benefits of Pollution Prevention

Pollution prevention is a method of multi-media pollution control and management that focuses on reducing the generation and discharge of pollutants (gaseous, aqueous, and solid) at their sources to avoid subsequent handling, treatment, and disposal. The major benefit of pollution prevention is to improve the quality of the environment by reducing the generation and discharge of hazardous pollutants. Pollution prevention programs also offer a multitude of other benefits to companies. These can be classified into one of four basic categories: (1) Economic, (2) Potential Future Liability, (3) Competitive Advantage, and (4) Positive Public Image.

Economic Benefits. The most obvious and quantifiable economic incentive is the reduced pollution control and management costs that can result simply from having less waste to manage.

- Lower on-site handling and treatment costs
- Lower off-site transportation and disposal costs
- Lower paperwork and record-keeping costs

As pollutants are reduced, the proportion of raw material being converted to desired end-products increases. Thus, pollution prevention leads directly to improved operations through yield improvements and increased production capacity.

Future Liability. Perhaps the greatest long-term economic incentive for pollution prevention is to reduce future liabilities and risks. For example, if a waste is not generated, or is generated in smaller quantities, the risk that it might pose to the generator in terms of involvement in a site cleanup or other legal action may be reduced.

Competitive Advantage. By reducing cost, increasing productivity, and reducing long-term liabilities, organizations have the ability to capture market share, increase revenues, and increase profitability. The company that has an economically and environmentally acceptable plan for pollution management may well be the low-cost producer, and hold the key to the success or failure of a business.

Positive Public Image. Pollution prevention is very attractive to the public because of its fundamental benefit -- reducing environmental pollution. It is widely supported and pollution prevention efforts project a positive image of the organization's concern for the community and the environment.

6. Barriers to Pollution Prevention

Although the benefits encourage generators to consider pollution prevention measures, there are numerous factors that may inhibit utilization of these measures. These factors are grouped into those pertaining to technical barriers and financial barriers.

Technical Barriers. These barriers include limited awareness of pollution management issues at the decision-making level in companies, lack of in-house expertise needed to identify and adopt pollution prevention alternatives, and the absence of readily available pollution prevention technologies that could be adopted directly. In addition, attitudes toward changes in industrial processes or practices could affect the implementation of strategies to reduce pollutant generation.

Financial Barriers. Availability of the capital for plant modernization often represents a significant obstacle to plant modernization which, in turn, adversely affects the implementation of source reduction and on-site recycling when these involve process modifications.

7. Estimates of Potential for Pollution Prevention

To plan for developing and implementing strategies to promote pollution prevention, it is useful to learn the range of potential for pollution prevention. Table 2 summarizes the range of estimates -- from 10 percent to almost 90 percent reduction -- by numerous public and private organizations in the United States. Note that almost all these estimates pertain to the period after 1980 -- indicating that pollution prevention (or, more precisely, waste reduction) in the United States began to receive serious attention and produce the results only after the implementation of RCRA in 1981. The wide range of estimates reflects the associated differences in estimating the potentials and the universe of pollutants (mostly hazardous wastes) included in the estimates. Often estimates are quoted out of context or without a full understanding of the factors used to make the estimates (Warren 1990).

To further promote pollution prevention, the USEPA in 1991 set up an Industrial Toxics Project that targeted certain toxic chemicals for which focussed strategies will be developed. The USEPA's goal is to reduce aggregate environmental releases to all media of these target chemicals from industrial facilities, as measured by the Toxics Release Inventory (TRI) in 1988, by 33 percent by the end of 1992 and at least 50 percent by the end of 1995. Under this project, the USEPA will identify 15 to 20 pollutants from the TRI that present both significant risks to human health and the environment, and seek voluntary, measurable commitments from industrial sources of these contaminants to reduce environmental releases (USEPA 1991).

Table 2. Estimates of Potential for Waste Reduction

Source	Year estimate made	Estimated reduction	Comments
Ventura County, California (survey of 75 firms)	1985-1986	30-40%	Ventura County only; not national in scope; focus on reduction in volumes sent to landfills;
U.S. Environmental Protection Agency (1986 Report to Congress)	1986	18-33%	National in scope; aggregated; potential over a 25-year period; source controls only
3M Company (Company Experiences	1985	50% Additional 30%	Over past 10 years Over next 5 years
Office of Technology Assessment (OTA) Industry Survey (99 respondents)	1985	50 to 75% possible 25 to 50% possible <25% possible	11% of respondents 25% of respondents 50% of respondents
OTA opinion (study conclusions)	1985	Substantial opportunities	No specific data available
Congressional Budget Office (CBO)	1985	14% < 1983 amount	Based on model for 24 waste types generated in 1990 by 70 industries
Special firms	1986	Rohm & Haas–10% (1984 to 1985) Exxon Chem.–10% (1984 to 1985) Olin–34% (1981 to 1985) Dupont--35-50% 3M–50% (1975 to 1985) IBM--17% (1984 to 1985) Hewlett Packard –16% (1983 to 1984)	Adjusted for production changes
INFORM	1985	Up to 90%	Based on survey of 29 organic chemical plants
TVA Region	1984	11% for incinerable wastes 33% for landfilled wastes	Changes from 1984 to 2000
Minnesota	1985	47% reduction in 2000 compared with 1984 volumes	RCRA wastes only
U.S. Dept. of Defense	1988	50% reduction in 1992 compared with 1987 volume	RCRA wastes only
Massachusetts	1989	50% reduction in 1997	RCRA wastes only

Source: Adapted from (Warren 1990)

8. Roles of Public and Private Sectors in Promoting Pollution Prevention

There are many players in a society that could contribute to the success of pollution prevention. The following players were identified in a recent conference as ones that may significantly affect the extent to which pollution prevention can be achieved in the United States (Scott et al. 1991).

Industry. Industry includes business that manufacture products and generate wastes. It can contribute to the success of pollution prevention by:

- Eliminating or reducing wastes generated during manufacturing;
- Actively encouraging full cycle raw material/waste management services;
- Funding pollution prevention research and development;
- Establishing incentive programs to actively encourage waste reduction suggestions from employees;
- Establishing pollution prevention training programs;
- Emphasizing the importance of cost-effective solutions for implementing waste reduction alternatives;
- Encouraging pilot demonstrations to implement waste reduction;
- Utilizing process waste assessments as a systematic procedure to assess and identify opportunities for waste reduction.

Individuals. The success of pollution prevention greatly depends on actions by appropriately informed and motivated individuals. Individuals can contribute to the success of pollution prevention by:

- Participating in educational forums to be better informed;
- Supporting the adoption and implementation of pollution prevention;
- Identifying and communicating their motivation through purchasing products;
- Disseminating information throughout communities;
- Demanding environmentally sound products;
- Actively participating in local community programs for solid waste and hazardous material recycling;
- Practicing pollution prevention in the home and workplace;
- Influencing social changes.

Educators. Educators consist of those responsible for kindergartens, grade schools, high schools, vocational schools, universities and colleges, and continuing education instruction. Educators can contribute to the success of pollution prevention by:

- Teaching pollution prevention concepts at each level of education;
- Integrating pollution prevention concepts into each course of instruction so the concepts permeate students' thinking rather than standing alone;
- Providing a consistent thread of pollution prevention reinforcement through continuing education;
- Providing individuals with education that can serve as a basis for rational, informed decision making.

Government. Government consists of two different groups of people: those who develop and enforce regulations and those who provide assistance. Law makers and enforcement agencies can contribute to promoting pollution prevention by:

- Encouraging and actively seeking input from the regulated community prior to implementing regulations;
- "Pushing the edge" in product development and manufacturing methods, which provides a motivation for pollution prevention;
- Providing incentives and assistance to encourage businesses to operate responsibly;
- Forcing industries that do not operate in an environmentally responsible manner out of business.

The second component or role of government -- technical and economical assistance -- can contribute to promoting pollution prevention by:

- Funding and performing research not covered by the other major players;
- Finding and supporting industries willing to perform demonstration projects and making the public aware of the results;
- Encouraging utilization of the results of pollution prevention research;
- Serving as a technical link between industry and regulators;
- Serving as a focal point for comprehensive, multimedia pollution prevention strategies;
- Compiling and distributing cost-effective waste reduction techniques that do not negatively affect process/product performance or production rates.

In addition, government can set standards itself by promoting pollution prevention and thus serving as a role model for other institutions. With its significant purchasing power, the government is capable of creating and developing new markets by its purchasing decisions. Since mid 1970's in some European countries and since early 1980's in the United States, government agencies have been active in designing strategies and implementing programs to promote pollution prevention concepts in

industrial sector. Programs pertinent to promoting pollution prevention can be grouped into three categories: (1) Economic Incentives Programs; (2) Voluntary Compliance Programs; and (3) Mandatory Regulatory Measures. These programs are discussed separately below.

9. Economic Incentives Programs

Economic incentive programs to promote pollution prevention are devised based on the premise that each firm must decide how much output to produce, how to manage pollutants generated in the production process and, implicitly, how much pollutants it will generate. Some major economic measures that could influence pollution prevention include taxes, subsidies, and fines.

Taxes. Taxes affect the firm's pollutant management and production decisions by altering the relative prices of pollution management options faced by the firm or the relative prices confronting consumers. For example, the Netherlands has used this disincentive to waste generation to produce revenues for its waste management regulatory agency (DMHPPE 1985). Some states (e.g., New York, California, Minnesota, Tennessee, Illinois) in the United States tax waste generation (Davis 1988). Another form of financial incentive for pollution prevention involves tax credits. Minnesota allows an income tax credit for five percent of the cost of equipment used primarily for waste reduction. The maximum credit allowed per year was $75,000 (ICF 1985).

Subsidies. Subsidies can take a variety of forms including direct payments, grants, low-interest loans, and tax credits. Subsidies in the form of direct payments or low-interest loans could be used to assist firms in adopting pollution prevention strategies by sharing some of the cost of options such as the modification of existing capital equipment and the installation of new capital equipment. The French National Agency for Recovery and Disposal of Waste (ANRED) provides assistance with the capital costs of full-scale facilities for recycling and waste management (ANRED 1981).

Fines. Imposing fines on firms that fail to comply with specific mandates (e.g., regulations or bans) creates an incentive for compliance by the affected firms. Fines can be used in a different manner to encourage pollution prevention. For example, for firms in violation of pollution control laws, regulatory agencies could reduce fines or other penalties if the firm agrees to pursue pollution prevention activities.

10. Voluntary Compliance Programs

A number of options are available that rely on non-regulatory approaches by government to encourage voluntary efforts by industry to reduce the amount of pollutants generated. These options include: technical assistance programs; technical information exchange programs; research, development and demonstration; awards; and waste exchange.

Technical Assistance Programs. Technical assistance is recognized as a critical element in encouraging industry to improve its waste management practices. It is especially important for smaller firms that lack the information, technical expertise, and financial resources to identify waste management problems and solutions. Technical assistance may take many forms including: expert audits of a firm's waste production and management practices; information on new technologies, sources of equipment, and engineering expertise; assistance in obtaining financing for new capital investment; coordination of efforts by groups of similar small businesses to improve waste management; and production of handbooks, educational materials, newsletters and seminars. In the United States direct technical assistance is becoming popular in state government pollution prevention programs.

Technical Information Exchange Programs. Technical information exchange programs serve a useful purpose by informing industry, policymakers, and the general public about the benefits of pollution prevention, by providing information on the importance of pollution prevention, defining what pollution prevention is, informing individuals about the broadly defined pollution prevention techniques that are available, and informing individuals about the availability of information concerning pollution prevention. In the United States, there are several technical exchange programs pertinent to pollution prevention. For example, the USEPA has maintained a Pollution Prevention Information Clearinghouse (PPIC) system which allows users to access electronically to pollution prevention information summaries on-line (Morse 1989). Other examples are the bibliography listings, seminars and training sessions conducted under the state programs such as those in California, Illinois, Minnesota, North Carolina, and Tennessee, Illinois (U.S. Congress 1986).

Research, Development, and Demonstration (RD&D) Programs. Several western nations provide significant amounts of financial assistance to private industry for RD&D of technologies and methods to avoid or reduce the pollutant generation. Financial assistance is provided as a way of sharing risks with industry. If an RD&D program is successful, the government shares in the benefits by assuring that the new technology will be made available to other industries interested in reducing their waste production. If the technology is incorporated into the ongoing operation of an industry, government may recoup its share of the investment. When a demonstrated technology is patented, the government generally requires the patentee to make the process available to other industries and, in some cases, the government itself may take a patent on the new technology.

Awards Programs. Government agencies often have made use of positive incentives such as public recognition of significant pollution prevention efforts by individual firms and the use of awards to recognize achievements with respect to pollution prevention. Such recognition serves to bolster the firm's public image. In France, the Clean Technologies Mission oversees an annual "Clean Technologies" Award. In the United States, state and local governments reward good performance companies with awards. For example, the Illinois Hazardous Waste Research and Information Center has administered for the past four years the Governor's Pollution Prevention Awards (HWRIC 1990).

Waste Exchange Programs. Waste exchange represents another form of information program that enhances pollution prevention. The waste exchange is a means of connecting waste generators and material users via a matching service that companies can employ to advertise available wastes or to find waste material they can use. In addition to reducing the entry of wastes into the environment, waste exchanges can reduce disposal costs, save raw materials, and save the energy necessary to process those raw materials.

11. Mandatory Regulatory Measures

A number of options that have been used to mandate pollution prevention in the western nations are described below.

Mandatory Pollution Audits and Facility Plans. In the United States, after relying on the use of economic incentive measures and voluntary measures for approximately 10 years, several states (such as California, Massachusetts, Minnesota, New Jersey, New York, North Carolina, Oregon, Washington, and Wisconsin) have developed, or are in the process of developing comprehensive legislation to promote and regulate pollution prevention. State requirements generally take the form of a mandatory plant pollution audit and pollution prevention plan (Sullivan 1990). The idea of mandatory plant pollution audits and pollution prevention plans is developed because many firms do not have complete knowledge of the types and quantities of pollutants they generate. This is especially true of large firms with multiple outputs. For most firms, plant pollution audits and pollution prevention plans are necessary precursors to successful waste reduction efforts.

Banning Certain Chemicals, Products, and Management Practices. Environmental regulatory agencies in certain states in the United States are authorized to ban the production, sale, and use of certain chemicals; the disposal of certain wastes; and the use of certain production processes or waste management practices. The Massachusetts Toxic Use Reduction Act, passed in 1989, is aimed at reducing the amount of toxic material used in the state's industrial processes and discarded in waste streams. The stated goal of this act is to reduce the amount of toxic waste generated by at least 50 percent by 1997 (MDEP 1989). In the Netherlands, under the Chemical Waste Act of 1976, the environmental agencies can adopt rules that prohibit the manufacture or marketing of goods that create particularly hard-to-manage hazardous waste or require that such goods be manufactured or marketed in a certain manner. The Act also grants the environmental agenices the power to order a generator of chemical waste to treat, process or destroy its waste on-site (Davis 1988). Bans on certain waste disposal practices have been employed in several western countries in the effort to reduce adverse impacts on human health and the environment posed by hazardous wastes. One of the stated objectives of Hazardous and Solid Waste Amendments (HSWA) in the United States was to minimize "the generation of hazardous waste and the land disposal of hazardous waste." To this end, the U.S. Congress included a series of provisions in HSWA requiring the USEPA to ban, to the extent possible, the land disposal of individual hazardous wastes. In addition, the USEPA was directed to establish treatment standards for wastes for which there are no practical alternatives to land

disposal.

Mandatory Performance Standards. The German government has recently enacted an amendment to the Waste Law of 1972 requiring that, when technically and economically feasible, the generation of pollution should be avoided and low-waste and non-waste processes should be used. Under this amendment, when licensing new industrial facilities or modifications to existing facilities, state authorities may require the use of pollution prevention measures as a condition of the license. In addition, the amendment employs two specific tools for enhancing pollution prevention. It authorizes the Federal Ministry of the Environment and Nature Protection to require that certain waste be separated from other waste for the purpose of recycling. Moreover, it specifies that producers or sellers of certain products be required to accept their return after use (FRG 1986b). Both these tools can be used to increase the prospects of reuse considerably. The German government has proposed application of these tools to mercury batteries and certain packaging materials as a first step (FRG 1986a) and is considering an order making manufacturers of halogenated organic solvents responsible for the management of waste solvents (Davis 1988).

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