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ANALYSIS OF INDUSTRIAL POLLUTION PREVENTION PROGRAMS IN SELECTED ASIAN COUNTRIES*

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ABSTRACT

Industrialization in developing countries is causing increasing environmental damage. Pollution prevention (P2) is an emerging environmental concept that could help developing countries achieve "leapfrog" goals, bypassing old and pollutive technologies and minimizing traditional control practices.

The current P2 promotion activities in Hong Kong, the Republic of Korea, the Philippines, Singapore, Taiwan, and Thailand are discussed. These programs, generally initiated in the last 5 years, are classified into five categories: awareness promotion, education and training, information transfer, technical assistance, and financial incentives. All important at the early stages of P2 promotion, these programs should inform industries of the benefits of P2 and help them identify applicable P2 measures. Participation in these programs is voluntary. The limited data indicate that adoption of P2 measures in these countries is not yet widespread.

Recommendations for expanding P2 promotion activities include (1) strengthening the design and enforcement of environmental regulations; (2) providing P2 training and education to government workers, nongovernmental organizations and labor unions officials, university faculties, and news media; (3) tracking the progress of P2 programs; (4) implementing selected P2 mandatory measures; (5) identifying cleaner production technologies for use in new facilities; (6) implementing special programs for small and medium enterprises; and (7) expanding P2 promotion to other sectors, such as agriculture and transportation, and encouraging green design and green consumerism.

BACKGROUND

Many developing countries in Asia and the Pacific Basin are experiencing rapid industrialization. Among the consequences are potentially serious environmental and health problems resulting from highly pollutive industries commonly found in these countries, such as chemical, electroplating, tanning, paper and pulp, and food processing. The majority of these industries are still being run with little use of environmental control. To alleviate these problems, some countries have begun to develop and enforce environmental regulations that resemble those of the developed nations decades ago — by focusing on treating effluents and

emissions after they are generated. The concept is known as "end-of-pipe" (EOP) treatment. Although EOP treatment is a proven effective method of protecting the environment, it has some disadvantages. It is costly to control pollutants after they are generated; moreover, it can transfer pollutants from one medium to another, thereby resulting in no net environmental benefit. In some instances, for example, improper disposal of highly concentrated sludge produced from treatment of industrial wastewaters can actually increase the risk to human health and the environment.

The limitations of EOP treatment have caused environmental decision makers in many developed nations to consider alternative methods of pollution control. Because it is clearly preferable to avoid producing pollutants in the first place, rather than treating effluents prior to discharge, EOP treatment is being replaced, where practical, by a preferred method of environmental management. This concept, called "industrial waste minimization" (IWM), "pollution prevention" (P2), and more recently "cleaner production" (CP), now pervades environmental programs for protecting air, water, and land in many developed nations.

What Is Pollution Prevention?

P2 is a method of multimedia pollution control and management that focuses on reducing the generation and discharge of pollutants (gaseous, aqueous, and solid) at their source to avoid subsequent handling, treatment, and disposal. P2 encourages industry to reduce its hazardous pollutants at the source and recycle, rather than to treat and dispose of pollutants in the environment. This preferred strategy for addressing chemical pollutants is often referred to as the "environmental management option hierarchy." This hierarchy ranks source reduction and source elimination as the highest priority; recycling and reuse are next, followed by treatment of effluents and emissions to reduce volume and/or toxicity. Finally, legally permitted disposal (e.g., putting waste-filled barrels in secured landfills) is the least desirable waste management technique. This environmental management hierarchy has been adopted by the United Nations, the U.S. Congress and U.S. Environmental Protection Agency (USEPA), Greenpeace International, the Chemical Manufacturing Association (of the United States), and many other organizations.

Source reduction practices include those that reduce the amount or toxicity of any pollutant entering any waste stream (or otherwise released to the environment) before external recycling, treatment, or disposal. They generally fall into four main categories: (1) design of environmentally friendly products; (2) substitution of higher-purity and/or less-toxic material; (3) adoption of new production technologies, increased automation, and improved material handling, operating conditions, and equipment; and (4) improved operating practices by providing proper training, requiring waste stream segregation and inventory control, and changing operating and maintenance procedures.

The general category of recycling is a broad one that encompasses options with varying degrees of transportation, handling, or processing. Some recycling options can be listed in order of decreasing preferability: (1) on-site reuse or recovery, (2) reuse in an off-site process, (3) off-site recovery, and (4) energy recovery. In this ranking, on-site options are preferable to off-site options, as the latter options incur greater risk and liability because materials must be transported and because generators generally do not control recovery and subsequent reuse.

Adopting P2 as a way of doing business can provide a number of significant benefits. The quality of the environment will be improved by reducing the generation and discharge of hazardous pollutants, and substantial savings of direct pollution management costs will be achieved through P2 practices. Depending on the individual site and its operations, these savings might be achieved through (1) lower on-site waste handling and treatment costs, (2) lower off-site waste transportation and disposal costs, and (3) lower paperwork and record-keeping costs. As pollutants are reduced, the proportion of raw material being converted to desired end-products increases. Thus, P2 leads directly to improved operations through yield improvements and increased production efficiency. The economic savings obtained through even simple efforts can be substantial, often resulting in capital investment recovery in just a few months. These savings can be even more impressive when calculated on a long-term basis, including lower future liability cost.

All of these economic incentives can combine into a single, powerful result that is universally understood in business: increased 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 acceptable P2 plan may well be the low-cost, high-efficiency producer and hold the key to the success of a business.

Why Pollution Prevention Now?

Although P2 has numerous advantages, it has not attracted substantial attention from the public until recently. When environmental pollution became an important issue in the late 1960s, many developed nations adopted command-and-control policies that force pollutant generators to employ EOP control to treat pollutants. Ideas of source reduction and P2 became attractive only after the mid-1970s, when limitations on EOP control became apparent. Developed nations have demonstrated different levels of awareness and resultant actions toward P2. For example, in parts of Europe, interest in source reduction and low-waste technologies has been evolving over the last 10 to 20 years. Results of industrial firms in Germany, Sweden, and the Netherlands have demonstrated benefits of P2 approaches. Many laws and social attitudes have already made the transition from EOP control to P2, and some even focus on product design and utilization optimization.

In the United States, IWM and P2 received serious attention only in the 1980s, following the promulgation of the Resource Conservation and Recovery Act (RCRA) and the Superfund Act. The landmark in the U.S. P2 program was the passage of the Pollution Prevention Act of 1990. With this Act, the U.S. Congress declared P2 to be the preferred strategy for dealing with pollution problems. The USEPA, along with many state and local agencies and private organizations, has developed numerous voluntary and mandatory programs to promote the P2 concept. The results thus far have been quite positive. The success stories of 3M, Dow Chemicals, and DuPont, as well as many small and medium enterprises (SMEs), are well known. Most industrial firms in the country have adopted P2 techniques; many of them have also established specific programs to implement P2 measures over the long term.

Encouraged by the results in western nations, many Asian countries have initiated activities to promote the P2 concept and encourage domestic industries to adopt P2 measures. The information presented here on P2 programs in Hong Kong, the Republic of Korea, the

Philippines, Singapore, Taiwan, and Thailand was collected from open literature. Table 1 summarizes individual countries' P2 programs; the programs are described in detail in the following sections.

P2 PROGRAMS IN SELECTED ASIAN COUNTRIES

Hong Kong

Hong Kong, a small city-territory, has four major manufacturing industries that account for about 74% of the total domestic export: clothing and textile, electronics, watches and clocks, and plastics. About 50,000 industrial establishments are located in Hong Kong; 95% of these are SMEs employing less than 50 workers, and 11,500 are considered to be potential pollutant generators.

The Hong Kong government has not yet formulated policies or strategies specific to promoting cleaner production technologies. However, following completion of a government-launched consultancy study on the support to industry on environmental matters, the government recently established a working group on CP to look into possible actions that could facilitate and enhance the development of cleaner technologies for local industries. The working group comprises representatives from government departments (i.e., the Environmental Protection and Industry Departments), academic institutes (i.e., University of Hong Kong, Hong Kong University of Science and Technology, Chinese University of Hong Kong, Hong Kong Polytechnic, and City Polytechnic of Hong Kong), and private organizations (i.e., Private Sector Committee Environment Center and Hong Kong Productivity Council).

The Hong Kong Environmental Protection Department (HKEPD) has formed a Cleaner Technology Special Interest Group (CTSIG) to serve as a focal point in HKEPD for collecting and disseminating local and overseas CP information. As one information source, CTSIG has established a connection to the International Cleaner Production Information Clearinghouse set up by the United Nations Environment Programme (UNEP). HKEPD also set up a waste recycling hotline to answer questions from the community about the waste recycling activities in Hong Kong (Leoung, Ching, and Li 1995).

The Hong Kong Productivity Center (HKPC) was established in 1967 to provide technical support, research and development, and training to Hong Kong's industry. One of its major activities has been in the area of environmental protection. Its role has been to identify solutions to environmental problems for Hong Kong businesses. In some cases, this has involved on-site technical services to identify environmental problems and assist in selecting and implementing pollution control and prevention measures. Other cases have involved research and development of special equipment to meet specific needs. Equipment that fits into very tight space restrictions has been a major area of effort. HKPC also conducts training courses for industrial operators on environmental control and compliance with environmental laws and regulations.

HKPC has been playing an active role in developing and promoting cleaner technologies. Under funding support by the Hong Kong government, HKPC is undertaking research and development studies on CP for specific industries, including low-waste electroplating and

Table 1. Summary of P2 Programs in Selected Asian Countries[a]

	Hong Kong	Korea	Philippines	Singapore	Taiwan	Thailand
Status	Active	Active	Active	Active	Active	Active
Established	N/A	1992	1991	1980	1989	1986
Legislation	N/A	N/A	N/A	N/A	Executive Order	N/A
P2 Annual Budget (million U.S.$, 1995)	N/A	> $1	$2.4[b]	N/A	$3	N/A
Funding Source(s)	Hong Kong Gov't	Korean Gov't	Philippine Gov't, USA	Singapore Gov't	Taiwan Gov't	Thai Gov't, UN, USA, Germany, Denmark
P2 Project/Team	CP Working Group	HAN Project	IEMP	WMD PUB	JWRTF	CDG-SEAPO, IEMP, ASEAN/EIP, USAEP, DANCED
Performing Organizations	CTSIG and HKPC	IESE/ SNU	PRC	WMD PUB	CTCI, FTIS, ITRI	TDRI, AIT, TEI, Louis Berger Int.
Activities						
Awareness Promotion	X	X	X	X[c]	X	X
Awards		X	X		X	
Training and Education	X	X	X	X[c]	X	X
Technical Information Exchange	X	X		X[c]	X	X
Waste Exchange			X	X	X	
Technology Development and Demonstration	X	X			X	X
On-Site Technical Assistance	X		X	X[c]	X	
Financial Incentives		X	X[d]		X	

[a] N/A = not available; USA = United States of America; UN = United Nations; P2 = pollution prevention; CP = cleaner production; IEMP = Industrial Environmental Management Project (Philippines); WMD = Waste Minimization Department (Singapore); PUB = Public Utilities Board (Singapore); JWRTF = Joint Waste Reduction Task Force (Taiwan); CDG-SEAPO = Carl Duisberg Gesellshaft - South East Asia Program Office; ASEAN-EIP = Association of Southeast Asian Nations - Environmental Improvement Project; USAEP = U.S. Asian Environmental Partnership; DANCED = Danish Cooperation on Environment and Development; CTSIG = Cleaner Technology Special Interest Group (Hong Kong); HKPC = Hong Kong Productivity Center; IESE = Institute of Environmental Sciences and Engineering (Korea); SNU = Seoul National University; CTCI = China Technical Consultants, Inc. (Taiwan); FTIS = Foundation of Taiwan Industry Services; ITRI = Industrial Technology Research Institute (Taiwan); TDRI = Thailand Development Research Institute; AIT = Asian Institute of Technology (Thailand); TEI = Thailand Environment Institute.

[b] Including budget for non-CP components.

[c] P2 activities thus far limited to solid waste reduction and energy and water conservation.

[d] One-year moratorium for participating firms from issuance of cease-and-desist order by the Department of Environment and Nature Resources (Philippines).

electrophoretic painting technologies for local surface-finishing applications, recycling of wastewater for the local electroplating industry, and a plating process for electroplating and printed circuit board (PCB) industries. An assessment by HKPC indicates that some CP technologies have been successfully implemented, including nickel recovery from nickel-bearing rinsing wastewater, use of drainboards to reduce dragout loss, use of countercurrent/reactive rinsing to reduce water consumption and wastewater volume in electroplating and PCB industries, and recovery of caustic soda from mercerizing wastewater and waste heat from hot effluents for reuse in the textile bleaching, dyeing, and finishing industry (Leoung, Ching, and Li 1995).

HKPC is also active in providing technical assistance to domestic industry on achieving environmental control and green productivity and in raising public awareness of CP. Some examples of HKPC's related activities are (1) publishing a quarterly journal, *Green Productivity*, informing the public of the importance of sound environmental management; (2) arranging a series of cleaner technology seminars, meetings, and workshops between overseas CP technology suppliers and local industries since 1993; (3) conducting a study mission on cleaner technologies in Canada in March 1994; and (4) participating in the CP technology assessment and demonstration sponsored by the Asian Productivity Organization (APO), aimed at promoting CP in SMEs in APO's member countries (Leoung, Ching, and Li 1995).

The Republic of Korea

Through implementing seven economic development plans since 1962, the Republic of Korea (South Korea, hereafter called Korea) has been transformed from an essentially agricultural economy into a newly industrialized, export-oriented one. The leading manufacturing industries in Korea include steel, automobiles, shipbuilding, electronics, petrochemicals, and textiles. The rapid pace of development and industrialization has caused increasing environmental problems.

Actions to promote public awareness of CP started almost 5 years ago. In 1990, a symposium on CP was held at Seoul National University (SNU) for the first time in Korea to introduce the CP concept to the Korean industry. In 1992, a CP Symposium sponsored by the World Health Organization and the United Nations Development Programme was held at SNU and attended by local and foreign experts on policies, strategies, and technologies. An undergraduate course in SNU's Chemical Technology Department has been developed to introduce the CP concept to students (Lee 1994).

In 1993, a study group for CP was organized that comprises representatives from industries, universities, and research institutes. The group gathers information on CP technologies and disseminates it to industries. An award program sponsored by the Ministry of Environment (MOE), Chosun Daily Newspaper, and Samsung Electronics Company is being planned by the study group; organizations will be selected to recognize their outstanding achievements in CP (Lee 1994).

In 1992, MOE, which has primary responsibility for Korea's environmental policies and their implementation, and the Ministry of Sciences and Technology, Ministry of Trade and Energy, and Ministry of Construction initiated a 10-year "HAN Project for Development of

Environmental Technologies." Coordinated by the National Institute of Environmental Research, the HAN Project is designed to accelerate national development of environmental sciences and technologies, minimize the impact of international environmental management standards, and foster the export of Korea's environmental technologies. The total budget of the HAN Project is estimated at U.S. $300 million over 10 years from 1992 to 2001. It comprises seven major programs: air pollution control technologies, water treatment technologies, waste treatment technologies, marine pollution control technologies, CP, global environmental technologies, and environmental health and risk assessments. The HAN Project will emphasize development of EOP treatment technologies in the first phase (1992-97) and CP technologies in the second phase (1998-2001) (Lee 1994).

Coordinated by the Institute of Environmental Sciences and Engineering of SNU, the CP program under the HAN Project is presently the major initiative to develop and demonstrate CP technologies in Korea. It had a budget of U.S. $260,000 and $330,000 for 1992 and 1993, respectively, and more than U.S. $1 million for 1994. Under this program, specific source reduction and waste recycling technologies are being studied for steelmaking, dyeing, fine chemicals, crystal glass, electroplating, metal processing, food processing, and PCB manufacturing industries. CP technologies for each of these industries are selected, assessed, and demonstrated; depending on their technical and economical feasibilities, they are recommended for use in domestic industries (Lee 1994).

Under independent efforts, industries in Korea are also active in developing CP technologies. For example, the Korea Research Institute of Chemical Technology (KRICT), an organization formed in 1991 to serve the chemical industry in process research and development, has specific programs to develop environmentally friendly chemical processes. The CP technologies currently being developed at KRICT include recovery and reuse of organic solvents, chlorofluorocarbon substitutes, biosurfactants, and supercritical water oxidation (Kim 1994).

The Korean government has implemented financial assistance to industries adopting CP. If a company wants to build a new plant or modify an existing process based on CP technologies developed through the HAN Project, the MOE will provide a low-interest loan to help the company purchase the technologies (Lee 1994).

The Philippines

More than 15,000 industrial and manufacturing plants currently operate in the Philippines. These plants are diverse both in terms of size and activities undertaken. The Philippines' industrial sector can be described by the following structural characteristics: (1) the presence of a broad range of industries — from the large-scale petroleum refining operations to the food industry, which ranges in size from very large to very small; (2) a large concentration of manufacturing activities in Metro Manila and surrounding core regions; and (3) a large number of small, diverse, and unregistered establishments that make up the informal industrial subsectors and that contribute significantly to total output — around 40% of the gross national product.

Industrial pollution in the Philippines has escalated significantly during the past decade, adversely affecting human health and environmental quality. In response, the government initiated the Industrial Environmental Management Project (IEMP) through the Department

of Environment and Nature Resources (DENR). This project, funded by the U.S. Agency for International Development (USAID) at a total budget of U.S. $12 million over 5 years from 1991 to 1996, consists of three major components: P2 initiatives, capability building, and policy studies (USAID 1991).

Under the P2 initiatives of IEMP, industries are provided with technical support and encouraged to change from traditional EOP treatment to the P2 approach. An environmental risk assessment was conducted at the start of the project to identify and rank more than 3,000 industries nationwide based on their relative potential risk to health, welfare, and the environment. Industry was ranked nationally and regionally based on the results of this study. Target industries were identified on a regional basis for receiving technical assistance to implement P2.

The core of the P2 initiatives is pollution management appraisal (PMA), which is a plant-audit procedure that identifies financially sound opportunities for waste reduction; 150 firms will be selected for voluntary participation in PMA. To overcome resistance by firms to participate in the PMA process, IEMP provides a number of incentives: (1) free PMA consulting services; (2) seminars for senior executives that highlight P2 success stories in their industries and demonstrate the benefits of practicing P2 in their facilities; and (3) a 1-year moratorium for participating firms from issuance of cease-and-desist orders by DENR (Araza et al. 1995).

In the first 2 years of IEMP (as of December 1994), 80 PMAs were conducted in six regions in the Philippines. These PMAs covered numerous industrial sectors, including poultry and piggery, coconut processing, fish canning, fruit preservation and canning, food processing, beverage manufacturing, slaughtering, chemical processing, pulp and paper, wood product processing, metal fabrication and finishing, and leather. Varying degrees of success were experienced by these facilities. More than 500 P2 options were implemented from a survey of 62 firms. More than 90% of the firms implemented some or all of the PMA team's recommendations, 85% of the firms have a waste minimization program, 88% realized cost savings, 85% realized a reduction in pollution load, and 73% reported improvements in the quality of their emissions and effluents. Aggregate investment made by these firms in P2 projects totaled U.S. $1.5 million, resulting in a gross annual savings of U.S. $6.3 million (Araza et al. 1995).

The success of PMA activities is being promoted through national recognition awards given by the DENR, by developing linkage with industrial and professional associations, and by training more local technical expertise in P2. Additionally, under IEMP, training workshops are provided for government and industry to improve and expand technical capabilities on pollution management, monitoring, and regulatory enforcement (Araza et al. 1995). As a part of IEMP, about 10 policy analyses will be completed to support advances in regulatory, fiscal, and administrative dimensions of pollution issues. Training programs will be provided for approximately 200 professionals in pollution management appraisal, 60 in environmental risk assessments, 700 in environmental impact assessments, 200 in compliance audits, 200 in compliance monitoring, and 300 in data collection/analysis (USAID 1991).

An Industrial Waste Exchange, Philippines (IWEP) project was initiated in 1988 to promote waste exchange and recycling among industries. The project was first implemented by the Environmental Management Bureau of DENR under a grant from the International Development and Research Center (IDRC) of Canada. In 1993, the Philippine Business for the

Environment (PBE), with funding support from several private companies and international organizations, continued operating the IWEP project. PBE uses numerous approaches to reach industrial companies throughout the country to encourage them to participate in the program. The key mechanism is the IWEP Bulletin published in PBE's bimonthly magazine, *Business and Environment*. Waste exchange information is also being transmitted electronically through the Philippine Sustainable Development Network (Favila 1994).

Singapore

Singapore, one of the smallest countries in the world, has achieved a level of economic success that classifies it as a high-income economy. The industrial sector makes up slightly more than one-third of Singapore's economy. Presently, more than 3,800 manufacturers are operating in the country. The major industries in terms of sale volumes are of food and beverage, apparel, paper products and printing, chemical products, petroleum, rubber and plastic products, non-metallic minerals, fabricated metal products, machinery and appliances, and transportation equipment. Most of the heavy industries (including major petroleum operations) are located in the western part of the country, including some offshore islands. Medium-sized industries are located in outlying areas, and smaller industries are distributed throughout the rest of the country.

The Ministry of the Environment is responsible for all environmental matters in Singapore. The key strategies in managing the environment comprise prevention, enforcement, and monitoring. Preventing pollution requires proper land use planning and provision of environmental infrastructure. Once preventive measures are established, controls are stringently enforced to ensure that pollution control equipment is properly maintained and operated. The ministry has promulgated specific regulations requiring industries to control air and water pollution and solid and hazardous wastes.

The government agencies of Singapore have sponsored programs to campaign for certain elements of P2 measures. The Ministry of Environment has a Waste Minimization Department (WMD), established in 1991, which develops, promotes, and oversees implementation of programs in waste minimization and recycling. Its focus has been on consumer waste. Some of WMD's current efforts to reduce solid waste generation in industry are (1) waste exchange, facilitating the exchange of waste material such as demolition waste for uses within the construction industry; (2) minimal packaging for industrial products, including the sale of suitable products in refill packs to promote the reuse of metal and glass containers; (3) product identification, labeling of material used such as steel and aluminum cans to facilitate identification for recycling; (4) waste audit, provided to organizations generating large quantities of wastes, including recommending IWM measures; and (5) green labeling, helping consumers identify environmentally friendly products, including recycled paper, dry-cell batteries, compact fluorescent lamps, detergents, and washing machines (Tan 1994).

The Public Utilities Board (PUB) of Singapore has conducted an annual campaign on water and energy conservation since 1979. Over the past 15 years, the engineers from PUB worked with academic and research institutions to provide seminars, workshops, and training courses for industries to improve energy and water-use efficiency. Most of the companies in the country now have implemented water and energy conservation programs in their plants. A utilities

controller is generally appointed in every large manufacturing facility to take overall responsibility for utilities management (Tay 1995).

However, process engineers or environmental engineers in industrial facilities typically do not have sufficient training on P2 measures pertaining to manufacturing processes. No core group of experts exists in Singapore to provide technical assistance on P2 for industries. Except for solid waste minimization efforts by WMD and water and energy conservation promotion activities by PUB, neither the government agencies nor private organizations have a specific program to provide technical information or consultation on industrial P2 measures. The engineering and environmental consulting firms are generally focused on EOP control projects; specific programs to promote P2 measures have not been developed.

Taiwan

Over the last three decades, Taiwan has changed from an agricultural economy to a newly industrialized, economically prosperous, export-oriented one. At the early stages of industrialization, development focused on labor-intensive industries, such as garments, textiles, shoes, toys, and sundry goods. Amid concerns that increasing labor costs and an appreciated local currency were making Taiwan less competitive in foreign trade, the trend has been to move into higher-quality and value-added products, including those in the high-technology and chemical sectors. SMEs — those firms with capital investment less than U.S. $1.5 million and total assets less than U.S. $4.5 million — make up 96% of the business enterprises and produce about 50% of the gross product of the entire business enterprise in Taiwan.

The environmental damage from industrial sectors has been very serious in Taiwan. In April 1989, recognizing the potential benefits of IWM, the Ministry of Economic Affairs (MOEA) and the Environmental Protection Administration (EPA), under an executive order of the Executive Yuan, jointly initiated programs to promote IWM in the country. Under this effort, the Joint Waste Reduction Task Force (JWRTF) was established and given responsibility to formulate and implement plans to promote the IWM concept in Taiwan. JWRTF is headed by the Industrial Development Bureau of MOEA, with oversight provided by a group of individuals selected from environmental agencies, research organizations, academia, and industry. It is assisted by consultants, research institutions, and universities to plan and implement specific tasks to promote waste reduction in the industrial sector in Taiwan. The annual budget of the JWRTF is approximately U.S. $3 million.

A first 5-year IWM plan was approved in July 1990, which called for an aggressive program to demonstrate IWM technologies and to provide technical assistance and consultation on the use of IWM technologies to the industry. From 1991 to 1995, the effort to promote IWM reduced waste generation in numerous industrial sectors. The results are reported in an *Industrial Waste Minimization White Paper of the Republic of China* (Chinese version) (MOEA 1994) and subsequently summarized in a recent article by Chen et al. (1995). Specific IWM promotion activities provided in these publications are briefly described below.

To promote the P2 concept to the public, the Taiwan government sponsored numerous workshops designed to provide training courses for managers and technical staff of private enterprises. From 1991 to 1993, 76 workshops were conducted; 7,119 individuals received

training in the IWM concept. The Taiwan government also sponsored large-scale annual conferences focusing on IWM. Beginning in 1991, each annual conference drew more than 300 local and overseas participants from industries, academia, and research institutions. Additionally, as a part of the IWM promotion program, individuals, factories, and trade and research organizations were selected to recognize their outstanding achievements in IWM. By the end of 1994, 89 parties received IWM awards.

As part of an information transfer effort, numerous IWM-related technical guidance manuals, booklets, videos, posters, and journals have been published and provided free of charge to the public. Among the guidance manuals published are (1) two IWM opportunity assessment guidances prepared for general application and (2) industry-specific technical guidance prepared for PCB paper manufacturing, textile weaving and dyeing, paint manufacturing, printing, and dyestuff industries. Two P2 periodicals are also published: *Pollution Prevention for Sustainable Development* and *Waste Minimization Information Exchange*. All these publications are prepared in Chinese to suit the needs of user communities.

Additionally, China Technical Consultants, Inc. (CTCI), has been commissioned to establish IWM databases and serve as an information clearinghouse. One database contains IWM technological information. A computerized data system has been implemented to contain data from broad categories, including P2 promotion policy and strategy, IWM techniques for specific industries, and case studies. By the end of 1994, more than 1,400 entries were collected in the database. Another data system being implemented at CTCI is the human resources information database that collects data from individuals regarding IWM experiences. The system will be useful for industry to identify individuals with specific IWM expertise. By the end of 1994, more than 420 entries were stored in the system.

Under the on-site technical assistance programs, a number of industrial facilities are selected each year and provided assistance in developing and implementing IWM plans. Two private nonprofit organizations, CTCI and Foundation of Taiwan Industry Services (FTIS), are commissioned by the JWRTF to provide technical assistance without charge to the firms selected for service — most of them small- and medium-sized, privately owned enterprises.

To qualify for on-site assistance services, the firms must demonstrate a strong interest in and potential for IWM and possess excellent technical, administrative, and financial resources. These firms receive management and technological consultation to set up IWM programs, identify IWM options, analyze the technical and economic feasibility of IWM options, and implement and assess the benefits of the selected options. Those that do not qualify for on-site assistance may apply for "general waste minimization consultation" to meet their specific and immediate needs on IWM implementation and environmental regulatory compliance.

From 1989 to mid-1994, a total of 93 firms received on-site technical assistance for implementing IWM measures, resulting in savings of more than U.S. $115 million from higher energy and process efficiency and reduced EOP treatment costs. These firms encompass various industries, including PCB, pesticides, leather, paper, textile weaving, textile dyeing, electroplating, brewery, pharmaceuticals, chemicals, seafood, food processing, rubber/plastics, painting and paint manufacturing, electronics, pottery, and defense.

Under the financial assistance programs, MOEA, in cooperation with banking institutions and nonprofit organizations, provides subsidies to encourage P2 and pollution control by industry.

Subsidies take a variety of forms, including direct payments, grants, and low-interest loans. Priority is given to small- to mid-sized firms in selected industries, including metal finishing, textile dyeing, pulp and paper, tannery, and steel, as well as chemical manufacturing. Typical low-interest loans allow for 70% of ongoing commercial loan rates for a maximum of 80% of capital investment need per case. From 1991 to 1993, MOEA approved 260 low-interest loan applications totaling U.S. $86 million for purchasing waste reduction and pollution control equipment. In addition to low-interest loans, the government also offers investment tax credit through corporate income-tax deductions and accelerated depreciation of equipment to firms that can document successful efforts to control pollution or reduce pollutant generation through capital equipment improvements.

To develop suitable P2 technologies for the domestic industry, MOEA sponsored more than 55 IWM technology research projects from 1989 to 1994. These projects are funded under numerous research and development initiatives, including "Textile Process Modification for Pollution Control," "Five-Year Plan for Automation Control Technology Development," "Five-Year Plan for Metal Processing Plant Automation Technology Development," and "Five-Year Plan for Development of Rational Water Usage for Industrial Processes." The IWM technologies developed under these programs have been transferred for application in more than 20 industries.

To enhance off-site waste reuse, Taiwan has had an industrial waste exchange program since 1987. The program is supported by MOEA and operated by the Union Chemical Laboratories of the Industrial Technology Research Institute (ITRI). The supply and demand information is listed in the bimonthly journal *Waste Minimization Information Exchange*. Between 1987 and 1993, 157 waste exchanges amounting to 160,000 tons of waste were accomplished. The types of waste that have been exchanged include organics, inorganics, solvents, grease, wax, acids, and alkalis.

The Taiwan government is presently formulating the second 5-year IWM plan, which will be implemented beginning in 1996. Most of the activities under the current 5-year plan will continue. Demands from the industry on technical and financial assistance in IWM is expected to increase as enforcement of environmental regulations will tighten in 1998. Financial assistance will be provided in favor of IWM-oriented projects and less for EOP control projects. Additionally, specific financial incentive programs will be designed to encourage more small-scale industries to adopt IWM. A National Clean Production Center will be established at the Union Chemical Laboratories, ITRI, beginning in 1996 to conduct technical and policy research aimed at promoting, among other things, multimedia P2 concepts, sustainable development, and green consumerism based on life-cycle assessments.

Thailand

Thailand is a rapidly industrializing country. Industry in the country accounted for 25% of the gross domestic product in 1970 and 36% in 1990. The number of government-registered factories grew by a factor of more than 80, from 631 to 51,500, in the 20 years from 1969 to 1989. The largest components of Thailand's industrial sector are food processing, transportation equipment, fabricated products, and machinery parts. In the 1980s, high growth was seen in machinery production, leather goods, electronics, plastic products, rubber products, toys, transport equipment, paper products, and chemicals. The seventh 5-year national

economic and social development plan, covering 1991-1996, emphasizes the continued development of six industries: agro-industry, textiles, clothing, electronics, petrochemicals, and basic metals (East-West Center 1992).

In Thailand, as in many developing Asian countries, EOP treatment to conform to effluent standards is still the norm. The P2 concept, however, is slowly emerging. One example is the organization of the Thailand Business Council for Sustainable Development (TBCSD), which presently comprises 56 representatives from business firms. The objective of the council is to promote sustainable development approaches among members through, among other means, the promotion of energy conservation, waste minimization, and the use of cleaner technologies. For the current year, members are required to develop their corporate environmental policy in conformance with TBSCD's agenda, conduct environmental audits, and publicize their environmental activities.

Over the last 10 years, several projects have been conducted in Thailand under multilateral or bilateral assistances that are devoted entirely or partially to P2 promotion. The key donors for these projects are UNEP, United Nations Industrial Development Organization (UNIDO), German Agency for Technical Cooperation (GTZ), Danish Cooperation on Environment and Development (DANCED), and USAID through IEMP, the Association of Southeast Asian Nations (ASEAN) Environmental Improvement Project (EIP), and U.S. Asian Environmental Partnership (USAEP) initiatives.

In the mid-1980s under the sponsorship of UNEP, Thailand Development Research Institute (TDRI) evaluated the feasibility of applying 13 CP technologies in pulp and paper production, textile production, and metal coating and finishing industries (TDRI 1986). The study verified that, with cost-effectiveness and product marketability, Thailand is ready to accept 5 of the 13 proposed P2 technologies and concluded that time has not yet come for wholesale promotion of P2 technologies.

Under an ongoing GTZ-sponsored project, specific manufacturing plants are selected from industries of high pollution potential for techno-economic studies and demonstration of appropriate P2 technologies. These industries include distilleries, tanneries, palm oil, fish canning, textile dyeing, electroplating, and chicken slaughterhouses. Additional international cooperation programs designed to provide information transfer, technology transfer, and/or policy study support for promoting P2 in Thailand include the following (Phantumvanit and de Mesa 1995):

- The ASEAN EIP, funded by USAID and involving Louis Berger International and Chemstar Laboratories, to promote environmental policy and institutional development and provide technology transfer and training (ongoing).

- Demonstration and implementation of CP technologies and wastewater treatment in the tannery sector, funded by UNIDO and involving the Department of Industrial Works (DIW) and the Tanning Organization, to introduce CP by designing a full-scale, hair-saving demonstration unit (1995-1997).

- A program sponsored by DANCED and involving the Thailand Environment Institute, the Federation of Thai Industries, and the Energy Conservation Center

of Thailand to promote CP in the electroplating, textile, and food industries and to serve as a CP information center (1995-1997).

- A program involving the European Union, the Thailand Environment Institute, and the Regional Institute of Environment Technology (Singapore) to reduce industrial pollution in the province of Samutprakarn, with particular emphasis on applying CP by conducting technology demonstration studies (expected to start in early 1996).

Education and publicity campaigns have been active in promoting public awareness of the P2 concept in Thailand. Numerous international cooperation projects involved universities and research institutes where researchers, students, and faculty members were given exposure to P2 information and hands-on training in the challenges posed by actual industrial pollution control and manufacturing process demands. The seminars and workshops that were organized at the completion of various technology evaluation/demonstration programs provide opportunities to raise public awareness on the importance and benefits of P2.

Thailand has an information clearinghouse system that provides P2 technical information to industries. From 1991 to 1993, UNIDO's Environment Programme commissioned a study in Thailand focusing on energy and environment information available to small- and medium-sized industries. In response to the findings and recommendations of the study, UNIDO's Industrial and Technological Information Bank (INTIB) has started to support a pilot phase of the Energy and Environment Information System (EEIS) to be maintained at the Library and Regional Documentation Center, Asian Institute of Technology, Bangkok. When implemented, the EEIS will serve as an information clearinghouse, delivering industrial energy and environmental (including P2) information to industries in the country. A network of about 10 to 15 secondary contact points is being developed to expand the outreach of EEIS (Phantumvanit and de Mesa 1995).

SUMMARY AND DISCUSSIONS

Program Period and Legislation Basis

Most of the P2 programs in the six selected Asian countries were generally developed in the last 5 years. These programs were established through executive order (Taiwan), bilateral agreements (Thailand, the Philippines), general departmental authorities (Hong Kong, Singapore), or executed as part of a larger project (Korea).

Program Funding Level and Sources

Funding levels for P2 programs vary from "not available" in Hong Kong and Singapore to millions of dollars for Korea (more than U.S. $1 million/year) and Taiwan (U.S. $3 million/ year). Sources of funding for P2 programs in these countries are mainly government agencies. Funding for P2 programs in Thailand and the Philippines is generally donated from foreign countries or international organizations. The funding levels for P2 programs in the Philippines

and Thailand are uncertain as these programs are being performed as part of larger programs that include other non-P2 components.

Program Locations

The sponsoring agencies of P2 programs in most cases are the country's environmental management regulatory agency, such as Hong Kong's HKEPD and the Philippines' DENR. The P2 program in Taiwan is jointly sponsored by the EPA and MOEA, with the latter playing the leading role. The HAN Project of Korea is jointly funded by the MOE, Ministry of Sciences and Technology, Ministry of Trade and Energy, and Ministry of Construction. The bilateral or multilateral assistance programs in Thailand in many cases involved participation of government agencies, such as DIW of the Ministry of Industry.

With few exceptions, the P2 programs are performed mostly by organizations outside of the sponsoring agencies. In Taiwan, these include CTCI, FTIS, and ITRI; in Hong Kong, the HKPC; and in Thailand, the Thailand Environment Institute, Federation of Thai Industries, Energy Conservation Center, and TDRI. Academic organizations are also involved, such as SNU in Korea and Chulalongkorn University, Prince of Songkla University, and Asia Institute of Technology in Thailand. In several cases, particularly under bilateral assistance programs, consulting firms such as PRC and Louis Berger International in Manila, and Carl Duisberg Gesellschaft-South East Asia Program Office and Louis Berger International in Bangkok, are the performing organizations.

Program Activities

Programs that are implemented to promote P2 are grouped into five categories: (1) awareness promotion, (2) training and education, (3) information transfer, (4) technical assistance, and (5) financial incentives. These programs are discussed separately below.

Awareness Promotion. Awareness promotion is the first and least-expensive step among many different programs to encourage adoption of P2 measures in any country. Almost all countries in this analysis have specific programs designed to educate the industry and the general public about the concept of P2. The promotion is being done generally through distribution of booklets, journal and newspaper articles, posters, and videos. These tools are designed to define what P2 is, explain its importance, and inform individuals about sources of P2 information. Another form of awareness promotion is to present awards to organizations with outstanding achievements in P2. Korea, the Philippines, and Taiwan currently present such awards.

Training and Education. The P2 concept is relatively new in many developing Asian countries. Training and education are important for industry workers and government officers. Specific programs are being implemented in almost all study countries to provide education and training on P2 techniques for industry workers. These programs are generally implemented in classrooms. In certain cases, training is brought to firm managers as well as in-plant workers at their work facilities. Under the IEMP program in the Philippines, training and education of P2 are also being provided to government workers. Additionally, P2 courses are being introduced in higher education in Korea and Thailand.

Information Transfer. General information on the nature and benefits of P2 technologies for specific industrial sectors is necessary for user communities, particularly case examples that illustrate technical methods and economic benefits. This type of information, commonly found in P2 guidance manuals, fact sheets, and computer databases, is available from international organizations such as UNEP and certain developed countries such as the United States, Germany, and the Netherlands, and is being made available to many developing countries. In Taiwan, guidance manuals and fact sheets have been developed that are tailored to its language and cultural conditions.

Industrial waste exchange programs are another form of information transfer. The approach of waste exchange is to match the generators of waste with potential users or buyers of the same waste through listing waste in newsletters, magazines, and/or electronic mail. Industrial waste exchange programs in the Philippines, Singapore, and Taiwan appear to work quite well, contributing to waste reduction and environmental protection.

Technical Assistance. Substantial attention has been given in many Asian countries to develop detailed case studies illustrating which P2 technologies suit domestic conditions and how P2 projects have been successfully implemented in the country. Most of these projects emphasize testing imported CP technologies at domestic firms. In some cases, research and design of special equipment are performed to meet specific needs. For example, equipment that fits into very tight space restrictions has been a major area of development efforts in Hong Kong. Development and demonstration studies generally also include financial information on costs and benefits of projects. Table 2 shows industries that have local case studies of P2 performed.

Still another form of technical assistance is to provide on-site service, especially to small- and medium-sized firms, to collect detailed data on the sources, amounts, and composition of waste (or pollutant), as well as information on raw materials (energy, water, and chemicals) and manufacturing processes. The purpose is to identify cost-effective P2 opportunities. When identified P2 opportunities involve large projects, such as changing a unit process or designing a new one, technical assistance also provides a detailed feasibility study for a company. In-plant audit services are being provided in Taiwan and the Philippines, where in the past several years 93 and 80 companies, respectively, have received such services to identify and implement P2 options.

Financial Incentives. Under the financial incentive programs, government agencies in the Philippines, Singapore, and Taiwan provide free on-site technical assistance services to industries implementing P2 programs. Taiwan and Korea provide additional financial incentives for implementing P2 and EOP projects. These incentives may take a variety of forms that include grants, low-interest loans, investment tax credit, or accelerated depreciation of equipment. In the Philippines, a different incentive program is being implemented. All firms that volunteered to participate in IEMP's PMA program are allowed a 1-year moratorium for issuance of cease-and-desist orders. This directly encourages adoption of P2 measures by the participating firms.

Table 2. Industrial Sectors that Have Cleaner Technologies Tested, Demonstrated, or Applied

Country	Industry
Hong Kong	Electroplating, surface finishing, PCB, textile
Korea	Fine chemicals, textile dyeing, steel, glass, electroplating, metal processing, food processing, PCB
Philippines	Sugar milling, pulp and paper, vegetable and animal oil processing, tanneries and leather, food and beverage, fish canning, industrial chemicals, pig and poultry farming, meat processing, cement, metals, mining, wood, electroplating
Taiwan	PCB, pesticides, leather, paper, textile weaving, textile dyeing, electroplating, brewery, pharmaceutical, chemical, seafood, food processing, rubber/plastics, painting and paint manufacturing, electronics, pottery, defense
Thailand	Pulp and paper, textile, metal coating, electroplating, food processing, tanneries and leather

RECOMMENDATIONS

Implementation of Effective Environmental Regulatory Systems

In the history and development of P2 activities in Europe, the United States, and Japan, aggressive enforcement of pollution control regulations has been the major driving force for P2 programs. Industrial firms generally would be less likely to invest in new equipment or procedures to reduce waste generation if they were allowed to illegally dispose of waste in the environment, which is why aggressive pollution control monitoring and enforcement activities are necessary for P2 to make economic sense.

With some exceptions, developing countries are often deficient in designing and implementing environmental laws. Governments in these countries should review their existing environmental regulatory structure and identify the most effective ways to improve the environmental regulatory systems. It is beyond the scope of this paper to delineate how to develop comprehensive environmental regulations and how to effectively enforce these regulations in any country. However, it is important that environmental regulations and their enforcement be improved in a manner that encourages industry to adopt more P2 measures. Specific lessons are being learned in some countries. For example, some environmental regulations are being adjusted in the United States, allowing industries the flexibility to meet emission and effluent control goals. The regulatory measures being considered include (1) addressing all pollutants and all media from any one facility together, rather than addressing sources or pollutants individually; (2) managing total emission quantity in a geographical area, rather than just individual plants or sources, thus making it possible for firms to reduce emissions on the basis

of the lowest marginal costs; and (3) placing higher priority on preventing pollution rather than EOP treatment and disposal.

Implementation of Additional P2 Programs

Promoting P2 in a country is highly complex. The extent of P2 that a society can achieve depends on many factors. To expand the impact of P2 programs, their scope should be broadened beyond strengthening the environmental regulatory framework. The following areas of expansion are suggested.

Training and Education. Existing P2 training and education programs in developing countries are in most cases conducted for managers and engineers in industrial sectors. These programs should be expanded to other audiences to accelerate P2 promotion. It is critically important to provide P2 education and training to people in government agencies, including but not limited to environmental and industrial development agencies. Such programs must focus on the intrinsic difference and benefits of P2 versus EOP control. The goal of such training should be to help government personnel understand those circumstances that are best addressed by EOP methods versus those that should be seen as fast-payback, lower-cost P2 opportunities. P2 education should also be targeted to officials in nongovernmental organizations, labor unions, financial and commercial service institutions, university faculties, and news media. Such training should have the goal of broadening understanding and public support for P2 solutions to environmental problems.

Tracking Progress of P2 Programs. Data on P2 accomplishments in specific companies that participate in on-site waste audit programs have been made available in certain countries, such as the Philippines and Taiwan. Data are lacking on the progress of P2 programs in specific sectors or entire countries. Unless countries obtain comprehensive data on the generation and impact of environmental pollutants, there is little driving force for P2. Each country must collect data on amounts and types of wastes and pollutants being generated by different sectors and on specific health and environmental impacts. Such data should be collected regularly and assessed for P2 program progress and for identification of priority areas.

Mandatory P2 Measures. Because P2 measures are in many cases process-specific and their selection can be subjective (involving company secrecy), it is considerably more difficult to incorporate P2 into regulations than traditional EOP controls. Despite this difficulty, certain mandatory measures can be designed to encourage adoption of P2. For example, regulations have been implemented in the United States requiring industries, especially large-quantity waste generators, to report essential information on P2 progress and/or to submit detailed P2 plans that reveal exactly what companies expect to do in the future. Some states have just begun to implement these requirements; their initial results are still being assessed. Another mandatory measure implemented under the U.S. Right-to-Know Act is that firms are required to provide the general public with data about the usage and releases of toxic chemicals at specific industrial facilities. Public disclosure of these data has pressured American industry to make explicit commitments to P2.

Identification of CP Technologies. Incorporating P2 measures into production processes can be most effectively achieved with new facility construction or plant/process renovation. Rapid industrialization in many developing countries will require new manufacturing

technologies in the next decade. Additionally, many developing countries are planning to upgrade industry and to promote industrial efficiency and productivity. A most challenging but potentially highly rewarded task is for government to identify the best-available CP technologies in numerous sectors and to ensure the maximum use of these technologies in the new or renovated facilities. It may be possible to develop specific technical criteria to use in assessing CP technologies. Another possibility is to develop a list of "hazardous" technologies that should be avoided. Candidates for such a list, such as mercury-cell chlor-alkali production and chlorine bleaching of pulp and paper, could be identified from those technologies that have been regulated out of existence in one or more countries for environmental or health reasons and those facing opposition due to their inherent hazards.

Special Programs for SMEs. In many developing Asian countries, a large segment of industrial production comes from small- and medium-sized plants, workshops, and cottage industries. These industries supply a large portion of their jobs and country's gross national product. Though small in pollutant generation on a per-facility basis, the gross amount of wastes and their total impact on health and the environment are substantial. Moreover, the owners and operators of these industries in general have no capacity — either financial or technical — to implement environmental measures through either waste reduction or EOP control. To promote P2 in SMEs, special measures may have to be devised, in addition to providing training, information service, technical assistance, and financial incentives. One possibility is to require (or attract) SMEs operating with hazardous technologies to relocate to designated centralized areas such as industrial parks to facilitate effective environmental management. Another possibility is to establish central waste-treatment facilities and require all firms to ship their waste there for disposal, at costs. The latter approach, being implemented in Hong Kong, is expected to encourage industries to adopt P2.

Expansion beyond Manufacturing Industry Sectors. Promoting the P2 concept should not be limited to private manufacturing industries. Rather, it should be expanded to agriculture, forestry, transportation, construction, and mining industries as well as government-owned facilities such as munitions plants, military bases, and public utilities. Another possible area of expansion lies in promoting green design of consumer products by encouraging or requiring industries to make changes in the design and packaging of consumer products, aiming at waste reduction and increased recycling and reuse. Many industries in the United States, Japan, and Europe have actively pursued designing products that are environmentally responsible, friendly, and conscious. Government agencies in these countries have also derived specific mechanisms such as eco-labels to help consumers identify environmentally preferred products.

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ACRONYMS AND ABBREVIATIONS

AIT	Asian Institute of Technology (Thailand)
APO	Asian Productivity Organization
ASEAN	Association of Southeast Asian Nations
CP	Cleaner Production
CTCI	China Technical Consultants, Inc. (Taiwan)
CTSIG	Cleaner Technology Special Interest Group (Hong Kong)
DANCED	Danish Cooperation on Environment and Development
DENR	Department of Environment and Nature Resources (Philippines)
DIW	Department of Industrial Works (Thailand)
EEIS	Energy and Environment Information System (Thailand)
EIP	Environmental Improvement Project (ASEAN)
EOP	End-of-Pipe
EPA	Environmental Protection Administration (Taiwan)
FTIS	Foundation of Taiwan Industry Services
GTZ	German Agency for Technical Cooperation
HKEPD	Hong Kong Environmental Protection Department
HKPC	Hong Kong Productivity Center
IDRC	International Development and Research Center (Canada)
IEMP	Industrial Environmental Management Project (Philippines)
IESE	Institute of Environmental Sciences and Engineering (Korea)
ITRI	Industrial Technology Research Institute (Taiwan)
IWEP	Industrial Waste Exchange, Philippines
IWM	Industrial Waste Minimization
JWRTF	Joint Waste Reduction Task Force (Taiwan)
KRICT	Korea Research Institute of Chemical Technology
MOE	Ministry of Environment (Korea)
MOEA	Ministry of Economic Affairs (Taiwan)
P2	Pollution Prevention
PBE	Philippines Business for the Environment
PCB	Printed Circuit Board
PMA	Pollution Management Appraisal
PUB	Public Utilities Board (Singapore)
RCRA	Resource Conservation and Recovery Act (USA)
SMEs	Small and Medium Enterprises
SNU	Seoul National University
TBCSD	Thailand Business Council for Sustainable Development
TDRI	Thailand Development Research Institute
TEI	Thailand Environment Institute
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization

USAEP	U.S. Asian Environmental Partnership
USAID	U.S. Agency for International Development
USEPA	U.S. Environmental Protection Agency
WMD	Waste Minimization Department (Singapore)