FOREWORD

The Asian Productivity Organization has been conducting various activities related to the environment over the past ten years with a view to increasing environmental consciousness and promoting policy, technology and knowledge on the protection and improvement of the environment among its member countries. However, measures taken by factories and farms in the region are often not satisfactory for solving environmental problems in spite of ever-growing awareness on the issue. The reasons for this are probably because conventional waste treatment technologies tend to impose a net cost on industries and thus erode their competitiveness.

Inspired by the developments during 1992 such as the Earth Summit in Rio and the Agenda 21, the APO launched its Special Program for the Environment in 1994 under a special grant from the Japanese government. In an endeavor to find practical and attractive approaches for industries to deal with both productivity and environmental protection for sustainable development, the APO has decided to tackle the issue with the concept of Green Productivity (GP). In concrete terms, GP aims at instituting a better environment in the process of increasing productivity thus lending a competitive edge to the businesses in the age of globalization.

To substantiate the GP concept, the APO has adopted a multi-dimensional micro-to-macro approach to promote GP practices. It focuses on the enterprise level through the applications of productivity and management tools (such as TQM, 5S, TPM etc.) that are in tandem with waste and emission prevention, energy conservation, pollution control, and Environmental Management Systems (EMS). Initially taking off from the industrial sector, the GP is now being increasingly applied to agriculture, service industry and the even communities. GP is thus evolving as a drive with comprehensive strategies for sustainable socio-economic development.

Over the last several years, the APO has actively promoted the concept of Green Productivity throughout the region through the forms of demonstration projects, information dissemination, and promotional missions. APO has established partnerships with NPOs and various industrial development organizations around the region.

The APO initiated a research survey in late 1998 to study the state of GP implementation in Singapore, Malaysia, Taiwan, Thailand, the Philippines, and Japan. The specific research goals were to review the existing national efforts to promote GP and GP-related approaches; compile case studies of GP implementation in SMEs and analyze barriers to further adoption of GP practices; and provide recommendations on how to further develop GP in the region.

I am very pleased to present the results of this research. By publishing these survey results, the APO hopes to stimulate further discussion on strategies for GP promotion and dissemination in its member countries.

Takashi Tajima
Secretary-General

Tokyo, December 2001

INTRODUCTION

Shen-Yann Chiu Ph.D., and
Sean Gilbert
International Green Productivity Association

THE CHALLENGE

Environmental problems have become increasingly apparent around the Asian region in the wake of the dramatic increase in industrial activity over the last three decades. From deteriorating urban air quality to polluted rivers, countries are finding themselves under growing pressure to improve their controls on pollution. At the same time, however, economic growth still remains a central goal for almost every country.

In response to the growing pressures, countries across Asia have established detailed regulatory frameworks to address environmental concerns. Many laws follow the traditional command-and-control models established by Europe, the United States, and Japan, but several countries have also begun to incorporate newer ideas in pollution regulation. For example, Thailand's Factory Act allows the Department of Industrial Works to create guidelines for manufacturing processes to ensure incorporation of cleaner technologies. Taiwan has already instituted a system of emissions fees from stationary emissions sources of NO_x and SO_x, and is considering expanding the system. Public disclosure strategies are being reviewed or implemented by the Philippines, Thailand, Indonesia, China, and Japan among other countries. The list goes on.

In addition to establishing regulations, several Asian countries have begun to actively promote industrial environmental management tools. As will be seen in the coming chapters of this book, most countries have developed active outreach and guidance programs based on concepts such as Green Productivity (GP), Pollution Prevention (P2), Cleaner Production/ Cleaner Technology (CP/CT), and other basic management tools. The reaction from larger companies has generally been favorable as industry has found ways to dramatically reduce pollution output while simultaneously lowering costs.

However, despite vigorous efforts to promote new legislation and concepts, small to medium-sized enterprises continue to pose a challenge. The countries included in this book all boast upwards of 70,000 SMEs, many of which rely on outdated technology and contribute significantly to the overall pollution loading of their countries. At the same time, however, SMEs contribute the bulk of employment and output to the countries' economies. Efforts to encourage SMEs to improve environmental performance typically encounter the same barriers around the region: lack of financing, poor understanding of environmental regulations, inadequate technical skills, lack of awareness regarding the need for environmental protection, and employment of high-polluting, low-tech manufacturing techniques. Perhaps most important, SMEs believe that they cannot afford to make the necessary investments to remove these barriers to improving environmental performance without sacrificing their competitiveness.

Despite the perception of most SMEs, there is a growing body of case studies and other research indicating that implementing certain basic environmental practices does lead to both lower pollution and significant cost savings for SMEs. Getting this message across to SME managers in a convincing manner has become one of the main challenges for industrial agencies around Asia. Given the general skepticism amongst SMEs towards environment issues, it is essential to convince them that environmental practices will not only save them money, but will actually enhance their business position. The most effective way to communicate this message is to link sound environmental practice to improvements in product quality (and market) or overall productivity. To this end, the Asian Productivity Organization (APO) has initiated the Green Productivity program.

THE ORIGINS OF GREEN PRODUCTIVITY

Green Productivity was first introduced as a concept by the Asian Productivity Organization (APO) in 1994. In response to the need to link economic development strategies with environmental preservation, the APO established a working group on Productivity and Environment to conduct research in 10 Asian countries, including Taiwan, Hong Kong, India, Indonesia, Japan, the Republic of Korea, Mongolia, Nepal, Singapore, and Thailand, from 1993 to 1994. The working group's research focused on applications and opportunities for cleaner production as the cornerstone for guiding Asian countries towards a more environmentally friendly industrialization.

Following the working group's survey, APO gradually began to broaden the scope of Green Productivity to incorporate a wider variety of tools and techniques. The ultimate goal –balancing economic needs and environmental needs– remained the same, but APO saw a need for a strategy that targeted SMEs and sought to promote more environmentally friendly management techniques through the medium to which they would be most receptive: productivity improvement. In addition, APO saw that national productivity organizations were often bypassed by the numerous initiatives to promote cleaner production, pollution prevention, and many of the other new environmental management techniques. Given the high level of access and credibility of national productivity organizations (NPOs) amongst SMEs, APO believed that NPOs should be directly engaged in promoting improved environmental efforts. As a result, APO began developing the concept of Green Productivity as a component of productivity improvement programs.

In 1996, APO organized a three-day international conference on Green Productivity to discuss the many aspects of balancing economic growth and environmental protection. The result of the conference was the Manila Declaration (see appendix) that has provided the framework for APO efforts since the conference. Work has focused on developing a network of NPOs and GP resource people throughout the region and training them in the basics of environmental management and pollution prevention practices, starting with the simplest principles such as good housekeeping and waste minimization techniques. The goal has been to establish a base level of knowledge that can serve as a platform for developing the next generation of tools and techniques.

WHAT IS GREEN PRODUCTIVITY?

Broadly speaking, Green Productivity is a concept that can help companies to identify ways to strengthen business performance either through or in conjunction with better environmental management. The formal definition of Green Productivity is:

> *A strategy for enhancing productivity and environmental performance for overall socio-economic development. It is the application of appropriate techniques, technologies and management systems to produce environmentally compatible goods and services. GP can be applied in manufacturing, service, agriculture, and communities.*

While GP is applicable to a range of different types of organizations, this publication focuses primarily on its relevance to SMEs.

In the context of SMEs, Green Productivity approaches productivity improvement through or in combination with environmental performance improvement. In its simplest form, productivity is a measure of efficiency or output per unit of input (material, labor, capital). SMEs typically demonstrate low levels of manufacturing efficiency due to lack of expertise or access to suitable technology. Poor efficiency means high wastage and lost profits. Green Productivity for SMEs is posited partially on the assumption that introduction of good housekeeping techniques and waste minimization practices will lead to improvements in productivity (and therefore profit) as well as reductions in environmental impact.

GP implementation among SMEs relies primarily on tools that can instill good fundamental management practices within the company and typically show a quick return on investment. Furthermore, Green Productivity emphasizes the productivity benefits of implementing the systems rather than the environmental benefits. In general, SMEs are much more receptive to programs introduced to improve their bottom line than initiatives to improve environmental performance.

In practice, GP implementation relies primarily on basic environmental management concepts to improve overall environmental performance, including: waste minimization/pollution prevention techniques (source reduction, recycle/reuse opportunities), life cycle assessments, and environmental management systems. For companies just starting to address environmental issues (such as the typical SME), a GP program typically focuses on approaches to improving material productivity. As companies become more advanced in their approach, their GP programs may expand to utilize more complex environmental management tools such as environmental management systems or life cycle assessment.

Over the medium to long term, GP will seek to incorporate environmental criteria directly into cost- and quality-control methodologies used by productivity improvement programs. Ultimately, Green Productivity aspires to develop into a comprehensive management system that helps a company maximize product quality, minimize costs, and maintain minimal environmental impact. The system would integrate existing quality, cost, and environmental management methodologies and would also develop ways to drive productivity improvement strategies towards those options which maximize environmental benefits.

BACKGROUND TO THIS BOOK

Over the last six years, APO has actively promoted the concept of Green Productivity throughout the region through demonstration projects, information dissemination, and promotional missions. APO has established partnerships with NPOs and industrial development organizations around the region and the year 2000 saw the establishment of the first national-level GP organizations. Through the APO's efforts, a regional network of GP experts is beginning to emerge, along with a growing number of GP programs. This publication is the result of a research project initiated in late 1998 to study the state of GP implementation in Singapore, Malaysia, Taiwan, Thailand, the Philippines, and Japan. Specific research goals were to:

1. Review the existing national efforts to promote GP and GP-related tools such as pollution prevention, etc.;
2. Develop case studies of GP implementation in SMEs and analyze barriers to further adoption of GP practices; and
3. Provide recommendations on how to further develop GP in each country.

In publishing the results of the research, APO hopes to stimulate further discussion on strategies for encouraging SMEs to improve environmental performance.

FORMAT

This book is divided into six chapters, each summarizing the research results for one country (Malaysia, the Philippines, Singapore, Taiwan, Thailand, and Vietnam). Each chapter begins with an overview of the political and economic structure of the country. The overview is followed by an environmental profile of the country, introducing the key regulatory agencies, major laws, and general status of industrial compliance. Major program initiatives based on the preventative strategies and concepts are also introduced. The section concludes with an analysis of the SME sector's environmental performance and the level of adoption of environmental practices.

Following the environmental profile, the performance of the industry sector of the case study is reviewed. Major environmental aspects for the sector's standard production process are discussed, as well as the typical environmental loading/performance data for the sector (where available). The section provides an analysis of current GP-related efforts within the sector.

The next section is the case study. The case studies provide a detailed profile of the efforts of a single company to implement GP-related initiatives. A detailed description of the production process, modifications, and impact on performance are provided. The case studies are summarized with a cost-benefit analysis of the effort to identify cost savings or earnings from the projects.

Lastly, each chapter concludes with recommendations from the authors on future strategies for promoting GP in their respective countries.

CONCLUSIONS FROM THE RESEARCH

There are a number of common themes that run throughout the reports from the different countries. One of the most prominent themes is the issue of priority – SMEs must be convinced that improving environmental performance should be a business priority. Once top management commits to a program, many of the barriers related to internal culture and human resources can be resolved, and, at a minimum, basic options which often lead to significant returns can be implemented. One route to securing management's attention is through regulatory pressure, as demonstrated in the Thailand case study. However, regulations only function to the extent that they are enforced and, as several reports mention, many SMEs manage to avoid the attention of environmental inspectors. An alternative to regulation is to rely on market forces, such as in the Taiwan case study, where the key motivating factor was management's belief that improved environmental performance would help secure the company's competitive position. More direct appeals can be made to the potential of GP programs to improve product quality which relates directly to profitability and competitiveness with other products in the market.

Even after top management becomes interested in environmental improvement, other tangible barriers such as financing and access to technical expertise still must be resolved. Most countries have now developed various outreach programs that offer training in the technical aspects of strategies to prevent or minimize pollution. In addition, many countries also offer tax incentives for equipment purchases. While these efforts are generally viewed as positive, it is likely that more are still needed, particularly in the area of financing improvements within SMEs.

Another theme that appears in many of the studies is the need for new regulatory approaches to deal with SMEs. Most countries surveyed already have extensive regulations and standards to control pollution. While the laws have been effective in managing the performance of larger companies, SMEs are still often outside of the system. Many SMEs are unaware of their regulatory obligations and view meeting standards as a burdensome, costly activity. Equally important is that, to the extent that they do impact SMEs, regulations tend to encourage end-of-pipe solutions rather than pollution *prevention*. The outreach programs developed to promote environmental management tools are a step in the right direction, but further incentives are needed to encourage SMEs to actively pursue Green Productivity and even to seek a higher standard than the law requires.

Perhaps the best strategy for promoting Green Productivity or any other environmental management strategy lies in making "the business case" for pursuing the initiative. As the case studies in this book demonstrate, improving material productivity can quickly bring benefits to the bottom line and also significantly improve environmental performance. Many of the options adopted in the case studies are simple housekeeping changes or low-tech alterations to the production process. In addition to highlighting cost savings, it is also important to point out any gains in productivity. In several of the case studies, much of the benefit of the project came from the improved productivity rather than cost savings. In the Philippines' case study, the participant's interest in Green Productivity stemmed from the program's potential value as a complement to the existing productivity improvement program and the possibility of creating a higher value-added product.

In some cases, SMEs may also be practicing Green Productivity unknowingly. The changes documented in the Malaysian case study brought significant environmental benefits, but the company's actions were not originally motivated by concern for the environment. The experience suggests that outreach initiatives may be able to find a potential host of new and highly persuasive case studies if environmental assessments can be incorporated into productivity improvement programs. Demonstrating that programs designed to improve productivity can also bring environmental benefits will likely make it easier to convince SMEs that the reverse is also true.

Perhaps the biggest challenge that shines through in all the papers is the question of how to effectively reach the majority of the SME community. There are literally tens of thousands of SMEs in every country, the largest proportion of which lack the basic skills and knowledge to undertake Green Productivity and other environmental programs. Due to the significant amount of resources required to help a single SME, most technical extension programs are only capable of supporting a few hundred SMEs per year. As a targeted approach seeking to change influence a specific sector, current strategies may be effective, but their reach will always be limited by the amount of resources the government is willing to invest.

The immediate recommendations from the researchers for spreading the application of GP primarily centered around improving the depth and scope of outreach programs. Specific suggestions included:

- Establishing networks of GP advocates and practitioners to facilitate the exchange of information;
- Increasing the number of demonstration projects and encouraging intra-industry exchange;
- Strengthening the knowledge and skills of environmental consultants; and
- Disseminating the results through university engineering programs.

Over the long term, however, any government seeking to reach SMEs on a national scale will need new strategies that are not based solely on enforcement and technical extension programs. Most SMEs don't place a priority on environmental improvements because they believe their capital (human and financial) is better invested in other areas of their business. Poor enforcement of regulations only further reinforces such SME priorities. To change this perception, governments and outreach agencies must seek to weave incentives for better performance into the fabric of the market environment through the use of market instruments and, more important, by encouraging large customers to demand that SME suppliers achieve minimum levels of environmental performance. When SMEs see that environmental performance is a direct component of their profitability and sustainability as a company, environmental programs will become the first priority.

Regardless of the specific promotion strategy, the case studies in this book demonstrate that approaches such as Green Productivity have much to offer the SME community. At the same time, there are still numerous barriers in terms of introducing GP-related techniques, convincing management that they merit investment, and ensuring that SMEs have the resources to undertake the effort. However, as the case studies also show, the process has been started. The remainder of this book provides snapshots of the situation in seven countries around Asia.

FUTURE GP EFFORTS

The year 2000 marked a new phase in the GP programs around the region. As mentioned, several national level GP Associations were formed and the International Green Productivity Association (IGPA) has been established in Taipei, Taiwan ROC. The IGPA will serve as a coordinating body for international GP efforts. The first step will be the development of further guidance materials and training units on GP practices. Over the next few years, IGPA will seek to facilitate the exchange of information and experiences amongst GP practitioners throughout the region. For further information on publications and activities, please contact the IGPA or one of the national associations listed in the appendix.

MALAYSIA

Phang Siew Nooi
Professor
Department of Administrative Studies and Politics
Faculty of Economics and Administration
University of Malaya, Kuala Lumpur
Lee Kiyau Loo
Head, Green Productivity Project Management Unit
Centre for Economic Development and Policy Management
National Institute of Public Administration
Kuala Lumpur
Foo Hee Boon
Researcher
Faculty of Economics and Administration
University of Malaya, Kuala Lumpur

COUNTRY PROFILE

Introduction

Malaysia is comprised of two major land masses –Peninsular Malaysia and Sabah/Sarawak– separated at the nearest point by 500 km of the South China Sea. Peninsular Malaysia (which has a land mass of 132,750 sq. km) consists of the states of Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Perak, Perlis, Penang, Selangor, Terengganu and the Federal Territory (Wilayah Persekutuan) of Kuala Lumpur. Across the South China Sea are Sabah, including the Federal Territory of Labuan (63,620 sq. km) and Sarawak (123,985 sq. km).

Structure of Government

The head of state in the Malaysian constitutional monarchy is the Yang DiPertuan Agong, a ceremonial ruler elected by rotation amongst the hereditary ruling houses of nine Malaysian states. The Westminster-styled form of government has the Prime Minister as the leader of the executive branch of government. He is assisted by a Cabinet drawn from the party that holds the majority in the elected Dewan Rakyat (House of Representatives). Ultimate legislative power resides in the Parliament, which comprises the Dewan Rakyat and the Dewan Negara (Senate).[1]

[1] Asia Pacific Centre for Environmental Law Report on Malaysia at *http://sunsite.nus.sg/apcel/dbase/malaysia/reportma.html*, Dec. 13, 1998.

Each of the 13 states has a state Constitution, a state legislature and a state government headed by the Menteri Besar (Chief Minister). As with typical federal structures, the states retain authority over numerous sectors. However, decisions by the federal government are binding upon the states and the federal government also exercises indirect control over state matters through national policies and fiscal measures.[2]

The Economy

Malaysia is classified as a middle-income country. In recent years, Malaysia has been transformed from an agro-based economy to a manufacturing economy. Its per capita Gross Domestic Product (GDP) was estimated to be RM12,000 in 1997 (approximately US$3,200).[3] The Malaysian economy grew quickly until mid-1997, with GDP growth peaking at 8.5 percent in 1996 before moderating to 8 percent in the early half of 1997 (Economic Report 1997/1998). Along with the downturn of the economies in Asia, beginning with the devaluation of the Baht in Thailand, the Malaysian economy slowed towards the end of 1997. By early 1998, the impact of the economic slowdown resulted in reduced growth in manufacturing and service industries. Given the continued recessionary trend in Asia, productivity was expected to grow at a slower rate in Malaysia in 1999. The effects of these recent economic upheavals upon the economy of Malaysia have been profound. In terms of sectoral performance, output growth decelerated for 1998. Recent figures indicated a drop of 9.2 percent in manufacturing output, 14.8 percent in domestic demand, and 20 percent in construction (The New Straits Times, 28 August 1998).

For the foreseeable future, prospects for the Malaysian economy will hinge greatly upon external factors and global trends. Being an open economy, Malaysia's macroeconomic performance and its capacity to maintain growth will be influenced by its ability to quickly adapt and adjust to these developments. With most of Malaysia's trading partners expected to record a moderately slower rate of growth, competition in the global and domestic markets will become more intense. Malaysia's economic performance will increasingly depend on its capability to compete in the global market, not only in terms of goods and services, but also in attracting capital flows. It is timely to look into strategies for further improving productivity to support Malaysia's international competitiveness. A key focus should be reducing economic wastage by increasing resource efficiency.

In this context, government programs to develop and promote investment in the key sectors of agriculture, manufacturing, and services will need to be dealt with in a holistic manner. However, the issue of sustainable development should not be neglected in the pursuit of further development and growth within these sectors. It has been alleged that in times of recession, scant attention is paid to the need for protecting environmental quality and ecological concerns, vis-à-vis the pursuit of profits. Therefore, it is important that the status of environmental compliance among the key sectors not be neglected, but rather, maintained and enhanced as part of the overall economic strategy. Thus far, the government's environmental controls are primarily exercised through regulations supported by enforcement activities. The Department of Environment (DOE) under the

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[2] Ibid.

[3] Malaysia (1998), *Economy Report 1997/98*.

Ministry of Science, Technology and Environment has been given the onus of monitoring and enforcing environmental standards in Malaysia.

Key Economic Policies & Agencies

The Ministry of International Trade and Industries is responsible for overseeing implementation of the Second Industrial Master Plan, 1996-2005 (IMP2) which utilizes a two-prong strategy of a Manufacturing-Plus-Plus orientation combined with a cluster-based industrial development approach. Under the Manufacturing-Plus-Plus orientation, existing manufacturers operating in Malaysia and new companies investing in Malaysia will be encouraged to move beyond mere assembly and production to include research and development (R&D), product design, distribution and logistics, and marketing. The goal is to enhance industrial linkages and increase Malaysia's overall productivity and competitiveness.[4]

Two ministries govern the use of Malaysia's natural resources: the Agriculture Ministry and the Ministry of Primary Industries. The Agriculture Ministry is responsible for agricultural, livestock, and fishery activities. The National Agriculture Policy (1998–2010) sets the strategic direction for agricultural and forestry development to the year 2010 and incorporates two new strategic policy approaches. The first is the promotion of the agro-forestry concept in which agriculture and forestry are viewed as mutually compatible and complementary. The second is the product-based approach that reinforces and complements the cluster-based agro-industrial development as identified in the Second Industrial Master Plan 1996-2005.[5]

The Ministry of Primary Industries (MPI) oversees the development of the primary commodity sector covering R&D, production, processing, and marketing of timber, palm oil, rubber, cocoa, pepper, pineapple, tobacco, tin, copper, and other minerals. The Department of Forestry under this Ministry oversees the management of forestry resources under the guidance of the National Forestry Policy.[6]

In 1997, productivity increases contributed 70 percent to GDP growth. This was the result of an emphasis on innovation, high technology, and efficient utilization of human resources. Tables 1 and 2 offer breakdowns of the contributions by various sectors to growth in the economy and overall productivity.

Manufacturing

By the end of the Sixth Malaysia Plan (1991–1995), the manufacturing sector's output accounted for 33.1 percent of GDP. Growth in manufacturing output increased at an average annual rate of 13.3 percent.[7] In 1997, this sector constituted 34 percent of Malaysia's GDP and accounted for 81 percent of total exports.[8]

Among the domestic market-oriented industries, fabricated metal products, basic iron and steel, and nonmetallic products registered the highest rate of growth in terms of output.[9]

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4 Ministry of International Trade and Industry at *http://www.miti.gov.my/mnfp/mpoli.htm*, Dec. 20, 1998.
5 Ministry of Agriculture at *http://agrolink.moa.my/dpn/dpn3*, Dec. 20, 1998.
6 Malaysian Timber Council at *http://www.mtc.com.my/policy/synopsis.htm*, Dec. 20, 1998.
7 *Seventh Malaysia Plan*, CD-ROM edition, Percetakan Nasional Malaysia Berhad.
8 National Economic Recovery Plan at *http://thestar.com.my/archives/neac/nerp/welcome.html*, Dec. 20, 1998.
9 *Seventh Malaysia Plan*, CD-ROM edition, Percetakan Nasional Malaysia Berhad.

In export-oriented industries, electrical and electronic products, rubber products, wood products, and textiles continued to be the leading sectors.[10]

Table 1. Sector Contribution to the Economy

	GDP		Employment		Productivity growth	
	1996	1997	1996	1997	1996	1997
Agriculture	12.27	11.60	16.99	16.58	4.68	4.57
Mining & quarrying	6.89	6.52	0.51	0.49	1.99	0.98
Manufacturing	33.28	34.38	26.43	26.85	5.83	5.73
Construction	4.35	4.42	8.72	9.07	2.05	1.88
Electricity	2.32	2.35	0.91	0.97	2.58	2.51
Transport	7.46	7.58	5.14	5.06	8.27	8.42
Commerce and trade	12.04	12.01	16.73	16.59	8.32	6.36
Finance	10.59	10.80	4.87	5.06	6.20	5.82
Government	8.86	8.45	10.74	10.59	4.11	3.23
Other services	1.94	1.89	8.97	9.02	0.91	-0.10
Aggregate services	43.21	40.73	46.45	26.69	30.38	26.24

Source: Adopted from NPC, *Productivity Report 1997*.

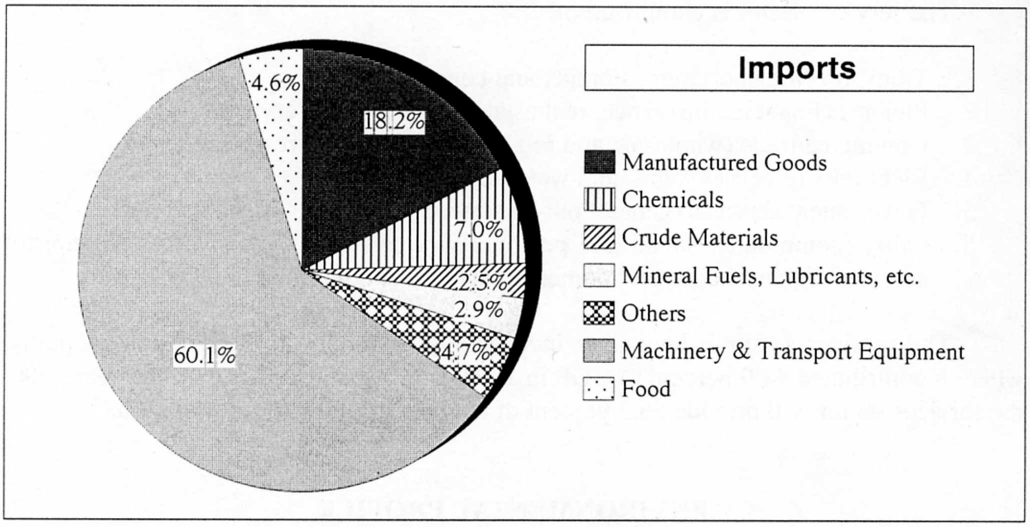
Table 2. Sector Contribution to Productivity Growth

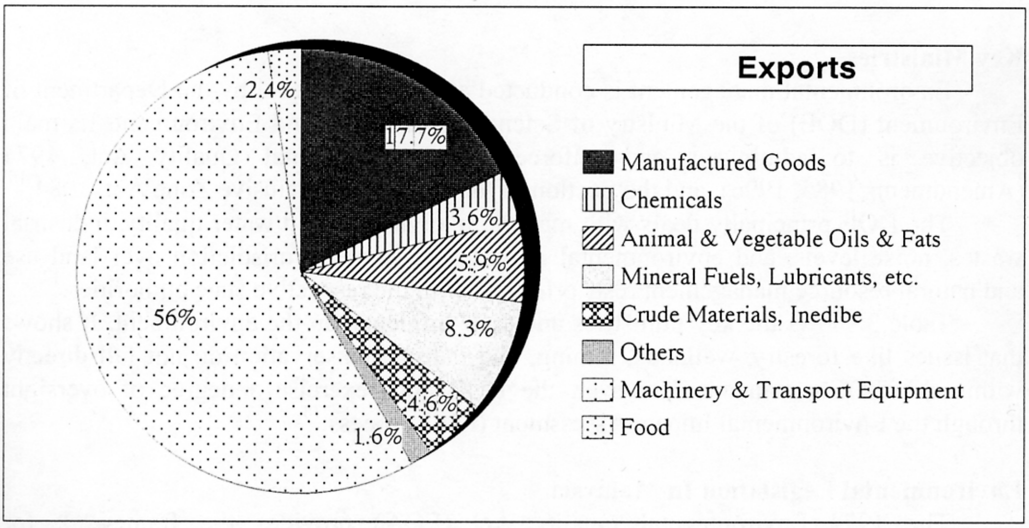
Sector	1996	1997 *(estimated)*
Manufacturing	48.00	51.25
Commerce/Trade	15.24	11.49
Transport	12.96	9.46
Finance	13.20	14.00
Construction	5.47	5.43
Electricity	2.58	2.83
Government	2.29	2.10
Other services	0.65	1.03
Mining & quarrying	2.56	0.85
Agriculture	.-2.92	1.56

Source: NPC, Productivity Report 1997.

[10] Ibid.

Figure 1. Imports and Exports by Commodity Sector, 1997





Agriculture

The agriculture sector is comprised of commodity crops, food crops, livestock, fishery products, and sawed logs. In the period of the Sixth Plan (1991–1995), the agriculture sector grew at 2.0 percent per year, lower than the revised target of 2.1 percent. The sector's share to GDP declined from 18.7 percent in 1990 to 13.6 percent in 1995.[11]

During the Seventh Plan (1995–2000) period, the agriculture sector is projected to grow at 2.4 percent per year.[12] Focus will be given to processing activities that add value, particularly those involving the production of finished products. This is in line with the objective of the Industrial Master Plan to promote resource-based industries, as well as improve inter-sector linkages.[13]

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[11] Ibid.
[12] Ibid.
[13] Ibid.

Services

The services sector is comprised of:

1. Transport (transportation, storage, and communications);
2. Finance (financial, insurance, real estate, and business services);
3. Commerce/trade (wholesale and retail trade, hotels and restaurants);
4. Electricity (electricity, gas, and water services);
5. Government services (general public services, defense, and others); and
6. Other (community, social and personal services, provision of private nonprofit services to households, and domestic services of households).

The services sector is becoming increasingly important in the national economy, where it contributed 44.9 percent to GDP in 1997.[14] It is envisaged that by the year 2000, the services sector will provide 55.3 percent of the new jobs created in Malaysia.[15]

ENVIRONMENTAL PROFILE

Key Ministries

Environmental management is conducted at the federal level by the Department of Environment (DOE) of the Ministry of Science, Technology and Environment. Its main objective is to administer and enforce the Environmental Quality Act, 1974 (Amendments 1985, 1996), and the Section of the Economic Exclusive Zone Act, 1984.[16]

The DOE principally deals with matters involving air and water quality, industrial wastes, noise levels, and environmental impact assessments. Jurisdiction over land use and natural resource management rests primarily with the respective state authorities.[17]

Table 3 shows the key ministries and their influence on the environment. It shows that issues like forestry, wetlands, mining, and marine conservation do not fall directly within the DOE's mandate. However, the DOE does exercise a degree of oversight through the Environmental Impact Assessment (EIA) process.[18]

Environmental Legislation In Malaysia

The 1974 Environmental Quality Act (EQA) provides the framework for environmental regulation in Malaysia. The EQA framework is based upon the issuing of licenses and the prescription of premises to be regulated. The Minister, in consultation with the Environment Quality Council, may prescribe the occupation or use of specific premises to be an offence unless the occupant is the holder of an appropriate license. Conditions for the occupation and use of "prescribed premises" are attached to the license by the Director General the licensing authority.[19]

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[14] National Productivity Corporation, *Productivity Report 1997*, Malaysia, 1998, p.118.
[15] MIDA-Business Times, *Malaysian Service Industry*, BT Information Sdn. Bhd. p. 10, 1994.
[16] DOE at *http://www.jas.sains.my/doe/mobjective.html*, Jan. 4, 1999.
[17] Asia Pacific Centre for Environmental Law Report on Malaysia at *http://sunsite.nus.sg/apcel/dbase/malaysia/reportma.html,* Dec. 13, 1998.
[18] Ibid.
[19] Ibid.

Table 3. Key Ministries and Their Influence on the Environment[20]

Ministry	Influence
Ministry of Science, Technology and Environment • Department of Environment • Department of Wildlife and National Parks	Environmental quality Wildlife and national parks
Ministry of Agriculture • Agriculture Department • National Rice and Padi Board • Fisheries Department	Agriculture Fisheries
Ministry of Primary Industries • Federal Forestry Department • Malaysia Timber Industry Board • Forest Research Institute of Malaysia • Mines Department	Forestry at national level Mining
Ministry of Transport • Marine Department Peninsular Malaysia • Marine Department Sabah • Marine Department Sarawak • Port Authorities nationwide, several of which are incorporated	Marine affairs Port operations
Ministry of International Trade and Industry (MITI) • Malaysian Industrial Development Authority	Foreign investment
Ministry of Energy, Telecommunications and Post • Jabatan Bekalan Elektrik • Tenaga Nasional • Sabah Electricity Board	Energy provision
Ministry of Housing and Local Government • Local Government Department • Sewerage Department • Solid Waste Management Department • Town and Country Planning Department	Local government Sewerage services Pending privatization Land use planning
Ministry of Land and Cooperative Development • Land and Mines Department • Federal Land Development Authority • Sarawak Land Development Authority	Land use and mines
Ministry of Rural Development (through several regional development authorities)	Land development
Orang Asli Affairs Department	Indigenous people

Source: Asian Pacific Centre for Environmental Law.

EIAs have become a key part of Malaysia's efforts to prevent or minimize pollution and other environmental impacts through projects design. Malaysia requires EIAs for more than thirty-five different activities, including energy, transportation, infrastructure, agro-industries, waste treatment, and disposal projects.[21]

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20 Ibid.
21 Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987.

Strategies for Environmental Improvement

Within the EQA, there are several progressive provisions that can contribute to pollution prevention:[22]

- The prescription for the reduction, recycling, recovery, or regulation of specified hazardous substances (EQA (1974) Act 127, Part IV, section 30A);
- The prescription of minimum percentages of recycled substances for specified products, and the labelling of such with declarations on recycled constituents as well as methods of manufacture and disposal (eco-labelling) (EQA (1974) Act 127, Part IV, section 30A);
- The prescription of rules on deposit and rebate schemes to ensure environmentally sound recycling or disposal of specified products (EQA (1974) Act 127, Part IV, section 30B);
- The provision for environmental audits to be conducted, irrespective of whether the operator is operating out of prescribed premises (EQA (1974) Act 127, Part IV, section 33A); and
- The right to impose a "research cess" on wastes to finance research into any aspect of pollution or prevention (EQA (1974) Act 127, Part VA, section 36A).

Environmental management awareness and action within the industrial sector are led by the large companies. This is due to several factors: (a) rising standards for clean air that are even higher than in the West; (b) concern for corporate image by managers, both as a matter of policy and as a response to increasing negative media coverage on polluters; and (c) rising tariff rates for electric power that have increased substantially and are expected to increase more. Enforcement has not been as significant a motivator for large companies as the above–mentioned factors. Some negative incentives such as the current below-marketprice for water (M$1.3 per cubic meter) still exist.[23] However, the National Economic Recovery Plan (NERP)[24] calls for a revision of the current water supply pricing system to reflect its actual cost.

The Standards and Industrial Research Institute of Malaysia Berhad (SIRIM) is one of the major certification bodies for ISO 14000 in Malaysia. SIRIM invited more than thirty companies to participate in a pilot scheme for ISO 14000 certification in 1996, and by 1998 a total of 70 companies had received ISO 14001 certification from SIRIM. SIRIM also has a program (funded by DANCED) concerning clean technology for SMEs in the electroplating, food, and textile industries.[25]

Malaysia has a total of 165 industrial estates occupying a total of 16,000 hectares. Industrial growth is projected to cover an additional 25,490 hectares by the year 2000, of which 11,000 hectares are to be developed under the Seventh Malaysia Five-Year Plan.[26]

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[22] Asia Pacific Centre for Environmental Law Report on Malaysia at *http://sunsite.nus.sg/apcel/dbase/malaysia/reportma.html*, Dec. 13, 1998.

[23] US-AEP Country Assessment-Malaysia at *http://www.usaep.org/country/malaysia.htm*, Dec. 9, 1998.

[24] NERP was formulated by the National Economic Action Council (NEAC). NEAC is a high level council that oversees strategies to revive the Malaysian economy during the current economic crisis. See *http://thestar.com.my/archives/neac/nerp/chapter6.html*, Dec. 20, 1998.

[25] SIRIM website at *http://www.sirim.my/~rtech/environment/danced.htm*, Jan. 4, 1999.

[26] Ministry of International Trade and Industry, International Trade and Industry Report 1997/98, Kuala Lumpur, Malaysia, 1998.

There are also special estates for SMEs developed jointly by SMIDEC and the Malaysian Industrial Estates Sdn. Bhd. By March 1998, eight SME industrial estates had been established.[27] Required EIAs[28] can help in planning industrial areas by focusing on clean technology opportunities, appropriate industrial combinations for cost-effective waste management, programs for toxic release inventories, and risk management approaches.[29] The DOE Guidelines for the Siting and Zoning of Industries has recommendations for buffer zones for different types of industries.[30]

The Malaysian Industrial Development Authority (MIDA) is the key agency within MITI that is responsible for promoting and coordinating industrial development. Under the Promotion of Investments Act (1986), MIDA gives tax holidays and allowances to encourage proper storage, treatment, and disposal of hazardous waste. Waste generators establishing storage, treatment, or disposal facilities may receive an initial 40 percent and annual 20 percent allowance for all capital expenditures during five years.[31]

Companies directly engaged in hazardous waste management are eligible for "pioneer" status and are therefore only required to pay taxes of 30 percent of their income (or 15 percent in specified locations) for five years. MIDA also extends import duty and sales tax exemptions for machinery, equipment, raw materials, and components for the storage, treatment, and disposal of hazardous waste.[32] The DOE Advisory Unit at MIDA provides foreign and local investors with information and advice.

Consistent with Malaysia's commitment under the Montreal Protocol to phase out the use of ozone depleting substances (ODS) by the year 2000, ODS-consuming industries, particularly SMEs, can obtain funding from the Multilateral Fund set up under the Montreal Protocol to install ODS-free technologies in their facilities.[33]

Currently, environmental concerns are being addressed and enforced in broad terms: air quality, river quality, solid waste management, hazardous substances, and industrial wastes, etc. In order to tackle pollution issues and enhance overall environmental quality, it is important for DOE to consider the inter-sectoral activities of each sector and consider establishing different environmental standards within a given sector.

Presently, regulations divide the manufacturing sector into resource-based and non resource-based industries. The DOE should consider establishing different pollution control standards for sub-sectors within the two industry classifications. Taking resource-based industries as an example, data on specific environmental performance could be gathered to establish standards for sub-sectors within the industry, such as food and beverage or chemical products. As it stands at the moment, there is very little, if any, effort directed to evaluating and monitoring environmental performance of industry sub-sectors. The Environmental Quality Act (1974) and its supporting regulations define requirements and guidelines broadly, irrespective of sub-sector activity or performance.

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[27] Ibid., p. 218.

[28] Department of Environment, Ministry of Science, Technology and the Environment, *Environmental Impact Assessment Guidelines for Industrial Estate Development*, Kuala Lumpur, 1994.

[29] US-AEP Country Assessment-Malaysia at *http://www.usaep.org/country/malaysia.htm*, Dec. 9, 1998.

[30] DOE Zoning Guidelines.

[31] Malaysian Industry Development Authority website at *http://www.jaring.my/mida/policy/chapter3.html*, Jan. 4, 1999.

[32] Ibid.

[33] Ministry of International Trade and Industry, *International Trade and Industry Report 1997/98*, Kuala Lumpur, 1998, p. 246.

Regulatory Compliance by Industry

Industrial development is relatively new and, due to planning, is concentrated into specially designated zones where infrastructure support can be provided. The concentration of these industries near coastal areas and rivers, together with the inadequate waste management and treatment facilities, has resulted in serious environmental problems in the areas surrounding industrial estates. A study found that liquid wastes (88 percent) were most frequently treated, followed by solid wastes (46 percent), and gaseous wastes (39 percent). Among the reasons for failure to treat wastes include: companies failing to perceive waste problems as serious, economic viability, and perceived lack of legal requirements.[34]

While a number of appropriate measures were taken by the government over the last few years, the number of offences prosecuted under the Environmental Quality Act and related regulations has seen steady increases over the period from 1980 to 1996. In 1984, there were 14 prosecutions, but this number increased to 130 in 1992. By 1996, the figure stood at 256. The large increase in the number of SMEs over the period would naturally contribute to the increase in companies which are ignorant of environmental requirements and therefore, have a higher likelihood of committing environmental violations. The situation would be further exacerbated if enforcement also tightened over the same period. On the other hand, the large number of offences would also suggest that environmental quality is steadily deteriorating despite growing efforts by the enforcement agencies. Enforcement activities have been backed by new environmental legislation to cover sewerage, natural resources, management of hazardous chemicals, the use of chlorofluorocarbons (CFCs), and occupational safety and health. The type of industrial pollution for industrial sub-sectors is outlined in Table 4.[35] General compliance data for certain sectors are provided in Tables 5 and 6.

Scheduled Waste Management[36]

Malaysia's first integrated hazardous waste management plant started its test-run during the third quarter of 1997. By March 1998, 360 companies had contracted with the operator of the plant to dispose of their wastes at the facility. The integrated scheduled waste management system comprises the waste management centre in Bukit Nanas, Negeri Sembilan, transfer stations, and a transportation network to cover the Peninsula. The waste management centre has four major facilities to treat and dispose of waste: an Incineration Plant, a Physical/Chemical Treatment Plant, a Solidification Plant, and a Secured Landfill.[37]

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[34] Lim, P.E., Y.K. Leong and Teng, Evelyn, *Environmental impacts of Industries in Malaysia***,** Proceedings of the State of the Environment in Malaysia Conference, Consumer Association of Penang, 1996, p. 332.

[35] US-AEP Country Assessment-Malaysia at *http://www.usaep.org/country/malaysia.htm*, Dec. 9, 1998.

[36] "Scheduled wastes" are defined under Malaysian Environmental Quality Regulations. The term refers to any waste falling within the categories of waste listed under the 'first schedule' of the regulations. Examples include cyanide, PCB, PCT, heavy metal sludge, latex effluents, etc.

[37] Kualiti Alam Sdn. Bhd. website at *http://www.uem.com.my/kalam*, Dec. 24, 1998.

Table 4. Industry and Type of Industrial Pollution

Industry	Industrial pollution
Rubber products processing	Issues include contaminants such as hydrogen sulfide in wastewater, odor control, and stack emissions.
Palm oil industries	Anaerobic ponds are the most common means of wastewater treatment. Enhanced wastewater treatment is needed near municipalities and catchment areas, as well as noise control technologies, sludge treatment, air pollution (stack) control systems, and waste recycling technologies to convert fiber and trunk wastes into value-added products.
Oil, gas, and petrochemicals	The main pollution problems include radioactive sludge disposal, recovery of used oils, and ship-based sludge treatment and disposal.
Electronics/Electroplating	The majority of electroplating and metal-finishing industries are small- to medium-sized enterprises. Wastewater effluent with heavy metal contaminants is routinely disposed of in domestic sewage systems without prior treatment. Cost-effective wastewater systems, technology to recover heavy metals from wastewater effluent, and toxic sludge treatment and recycling technologies are needed.
Food and beverage processing	A large percentage of the country's total wastewater effluent is released by food processing companies. Noncompliance is a direct result of the lack of appropriate treatment technology, overutilized capacity, and poor maintenance of the treatment systems. The wastewater stream has high levels of biochemical oxygen demand, chemical oxygen demand, oil and grease, and suspended solids.*

Note: * Further details are discussed on page 20.

Table 5. Notification Compliance as Required Under Regulation 3 of the EQ (Scheduled Wastes) Regulations, 1989[38]

Scheduled waste generators			
Industry/ Activities	**Regulation**	**Compliance status**	**Comments**
All facilities that generate, store, transport, treat, or dispose of scheduled wastes	• EQ (Scheduled wastes) Reg. 1989 (Reg. 3) • EQ (Prescribed Premises) (Scheduled Wastes Treatment & Disposal Facilities) Order 1989 • EQ (Prescribed Premises) (Scheduled Wastes Treatment & Disposal Facilities) Regulations 1989 • Customs (Prohibition of Export) Order (Amendment) (No. 2) 1993 • Customs (Prohibition of Import) Order (Amendment) (No.2) 1993	• 59.4 percent compliance as mandated under EQ (Scheduled wastes) Reg. 1989 (Reg. 3) • The number of waste generators in compliance has increased from 2,252 in 1996 to 3,103 in 1997	Total quantity of scheduled waste generated in 1997 was 279,510.9 metric tons

[38] Department of Environment; Ministry of Science, Technology, and Environment, *Environmental Quality Report 1997*, Kuala Lumpur, 1997.

Table 6. Environmental Performance by Industry Sector[39]

Agro-based prescribed premises					
Industry / Activi-Ties	**No. of premises**	**Regulation**	**Pollutant loading (BOD)***	**Compliance status**[40]	**Com-ments**
Crude Palm Oil (CPO) Mills	309	• Environmental Quality (Licensing) Regulations 1977 • Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order 1977 • Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 (Amendment) 1982	6,800 kg/day	• 76% compliance • 2 CPO mills had their licenses temporarily suspended • 40 CPO mills compounded for various violations • 27 CPO mills taken to court for not complying fully with the effluent discharge limits stipulated in their licenses	
Raw Natural Rubber (RNR) Pro-cessing Factories	144	• Environmental Quality (Licensing) Regulations 1977 • Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Order 1978	1,640 kg/day	• 90% compliance • 1 RNR factory compounded • 1 RNR factory taken to court for not complying fully with effluent discharge limits stipulated in its license	

Note: * BOD = biological oxygen demand.

[39] Department of Environment, Ministry of Science, Technology, and Environment, *Environmental Quality Report 1997*, Kuala Lumpur, 1997.
[40] Based on enforcement visits by DOE State officials in 1997.

Table 6. Continued

Non–Prescribed Premises[41]				
Industry/ Activities	**No. of premises[42]**	**Regula- tion**	**Compliance status[43]**	**Comments**
All manufac- turing industries	5,290	EQ (Sewage & Industrial Effluents) Regula- tions, 1979	• 83.2 percent compliance • The lowest compliance comes from metal finishing and electroplating, food and beverage, paper and petroleum refineries with 69 percent, 70 percent, and 79 percent compliance respectively	Based on 4,932 questionnaires returned, significant water pollution sources are food and beverage (20 percent), paper (13 percent), electrical and electronics (10 percent), and metal finishing (9 percent).[44] The parameters that are most difficult for the industries to comply with were BOD, chemical oxygen demand (COD), suspended solids (SS), oil and grease, and heavy metals such as nickel, copper, and lead. Among the main reasons for noncompliance were: inefficient operation or absence of effluent treatment plants (especially for SMEs).
All manufac- turing industries	7,660	EQ (Clean Air) Regu- lations, 1978	• 89 percent compliance • The lowest compliance comes from nonmetallic mineral industry, rubber-based industry, and quarries with 56 percent, 64 percent, and	The nature of noncompliance included: excessive dust emissions due to lack of or poor maintenance of air pollution control equipment, black smoke emissions, foul odours, operation of fuel burning equipment, chimneys, or incinerators without prior written approvals from the Director General of

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[41] Department of Environment, Ministry of Science, Technology, and Environment, *Environmental Quality Report 1997*, Kuala Lumpur, 1997, p. 41.

[42] Number of premises were based on number of enforcement visits relating to each regulation.

[43] Based on enforcement visits by DOE State officials in 1997.

[44] Department of Environment, Ministry of Science, Technology, and Environment, *Environmental Quality Report 1997*, Kuala Lumpur, 1997, p. 72.

…continued

			76 percent compliance respectively.	Environment, and open burning of waste materials. 212 factories and 41 quarries are carrying out regular self-monitoring of key parameters such as total suspended particulates (TSP), hydrogen sulphide, lead, dust, nitrogen dioxide, sulphur dioxide, sulphur trioxide, chlorine (CL2), and hydrochloric acid (HCL). Results are submitted to the DOE on a monthly or quarterly basis.

Contravention License

The Environmental Quality Act provides for contravention licenses to be issued to industries under certain situations, such as genuine difficulties in complying with discharge standards and other stipulated conditions of the Act. The contravention licenses were mostly given to companies in the food, rubber- based, and textile industries.[45]

Impact of Agriculture on the Environment

Some of the major environmental impacts of agricultural activities include biodiversity loss, soil loss, air pollution from open burning, and agro-chemical residues. Impact on biodiversity was extensive from 1968 to 1981, during which time large tracts of mostly undisturbed forest and swamp land were developed to resettle hundreds of thousands of people.[46]

In 1997, agriculture-related activities were the cause of nearly four percent of the complaints received by DOE.[47] Complaints typically concerned open burning or odors arising from animal husbandry. No thorough studies have been done in Malaysia on the effects of agro-chemicals on marine or riverine systems.[48]

Impact of the Service Sector on the Environment

Essential environmental services such as sewerage maintenance and solid waste management have suffered in the past from lack of funding and resources. Now, the government has embarked on a national privatization drive to upgrade the effectiveness and efficiency of these services. Sewerage services were privatized in 1993 with a

45 Department of Environment, Ministry of Science, Technology, and Environment, *Environmental Quality Report 1997*, Kuala Lumpur, 1997, p. 42.
46 Caufield, Catherine, Masters of Illusion, Pan Books, London, 1998.
47 Department of Environment, Ministry of Science, Technology, and Environment, *Environmental Quality Report 1997*, Kuala Lumpur, 1997.
48 Proceedings from Biodiversity Policy Reform Workshop, 16–18 December 1997, Kuala Lumpur, Pg 61.

US$2.4 billion investment from a private consortium. The privatization of solid waste management is still pending.

DOE's data on environmental impacts arising from the transportation sector cover both commercial and private vehicles. Vehicular emissions are regarded as a major source of air pollution, especially in urban areas.[49] In 1997, 23 cases of oil pollution by sea transport were reported, out of which five cases were prosecuted in court.[50]

Small and Medium Enterprises (SMEs) in Malaysia

An SME in Malaysia is defined as a "company with annual sales turnover of not exceeding RM 25 million and full-time employees of not more than 150 workers." Administratively, the demarcation between small and medium is[51]:

- Small Company: a company with full-time employees of not more than 50 and with an annual sales turnover of not more than RM 10 million; and
- Medium Company: a company with full-time employees between 51 to 150 and with an annual sales turnover of more than RM 10 million to RM 25 million.

Out of a total of 111,855 SMEs, 88 percent are small companies and 12 percent qualify as medium companies.[52]

SMEs are concentrated in food and beverages, fabricated metal products, machinery and equipment, wood and wood products, textile, apparel, and leather sectors.[53]

Although SMEs represented the majority of manufacturing establishments in Malaysia, their contribution to total value-added and employment was about 28 percent and 33 percent. On a per company basis, they contribute less to total value-added and employment than larger companies. This is due primarily to their size, which limits their ability to adopt advanced technologies, employ more skilled workers, increase their production capacity, expand their market, or enjoy economies of scale. SMEs primarily manufacture finished products for the larger companies rather than intermediate products, reflecting the lack of strong industrial linkages within the manufacturing sector.[54]

The Small and Medium Industries Development Corporation (SMIDEC) was established on 2 May 1996 to assist SMEs. SMIDEC will serve as a national focal point on overall development programs for SMEs in Malaysia.[55] It will address issues such as lack of financial assistance, technological capabilities, and skilled workers.[56] Among its goals is the development of linkages between SMEs and larger companies; a key feature of the Second Industrial Master Plan (IMP2).[57]

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49 Department of Environment, Ministry of Science, Technology, and Environment, *Environmental Quality Report 1997*, Kuala Lumpur, 1997, p. 69.
50 Ibid., p. 49.
51 SMIDEC website at *http://www.jaring.my/smidec/*, Jan. 4, 1999.
52 Ibid.
53 National Productivity Corporation, *Productivity Report 1997*, Malaysia, 1998, p.139.
54 *Seventh Malaysia Plan,* CD-ROM edition, Percetakan Nasional Malaysia Berhad.
55 SMIDEC website at *http://www.jaring.my/smidec/*, Jan. 4, 1999.
56 Ibid.
57 National Productivity Corporation, *Productivity Report 1997*, Malaysia, 1998, p.139.

The DOE will target SMEs in 1999, as they are the country's main polluters. A prime target will be the metal-finishing industry, which pollutes the rivers with toxic heavy metals. The DOE is drawing up standards for the SMEs to meet. The standards will be introduced in a staggered manner like the standards for the palm and rubber industries in the 1970s. The World Bank is studying funding mechanisms by which SMEs can apply for special loans to implement pollution abatement measures.[58]

Significance of SMEs

In Malaysia, the majority of SMEs are owned by Malaysians, with foreign ownership accounting for 23 percent of medium-scale establishments and three percent of small-scale establishments.[59] Most local SMEs are labor-intensive and rarely employ up-to-date management systems, technology, or equipment. Due to the nature of their organizational capacities and production operations, the majority of SMEs do not have the ability to sustain competitiveness and simultaneously implement environmental management practices without the aid of outside agencies. Current regulatory practices have biased SME efforts in environmental management towards compliance with standards set by the DOE through end-of-pipe solutions. Noncompliance can result in legal prosecutions, fines, and even work suspension orders. Due to DOE's perceived preference for penalty for noncompliance rather than incentives to encourage cleaner production, many SMEs tend to interpret end-of-pipe techniques as the industry's panacea in environmental management. Relatively little knowledge about up-stream process for pollution control or waste management (in essence GP best practices) is known or utilized as a solution for environmental loading, compliance, or even cost savings.

Thus far, local SMEs have been reacting to environmental legislation, rules, and compliance by following relevant guidelines provided by the DOE. Endorsement by the DOE that SMEs are in compliance with regulations allows them to believe that they have achieved a desirable environmental standard. This is essentially a wrong perception as it lulls most SMEs into a false sense of security that compliance is the best level of performance that can be achieved and that there is no justification for further improvements.

Under the IMP2, the Malaysian government has placed a strong emphasis on export-led growth through industrial diversification, the provision of a liberal investment climate, and the promotion of intra-industry linkages. In order to sustain this high rate of growth, public policies and strategies were formulated under the Seventh Malaysia Plan (1996–2000) to accelerate the diversification of industries and develop a more resilient industrial base towards the achievement of Vision 2020.[60] In line with this target, concerted approaches were taken to expand and upgrade small and medium enterprises. In 1994, there were 12,108 SMEs with a paid-up capital of about RM 2.5 million and employing between 5 and 75 full-time workers. SMEs consisted of 10,400 small-scales enterprises and 1,708 medium-scale enterprises. The food manufacturing and beverages industry sectors had recorded an average annual growth rate of 8.7 percent and 2.3 percent respectively for the period 1991–1995. While efforts have been undertaken to

[58] *The New Straits Times*, Nov. 20, 1998.
[59] Ibid. Also, *Productivity Report, 1997*.
[60] Vision 2020 calls for Malaysia to achieve developed-nation status by 2020.

further broaden and strengthen the manufacturing base of these industries through research and development, parallel actions in environmental management by the SMEs have been slow. This is reflected in terms of patterns of formal environmental complaints, 70 percent of which were related to SMEs in 1997.

ENVIRONMENTAL PERFORMANCE OF THE FOOD AND BEVERAGE INDUSTRY

Food and Beverage Industries

The number of approved manufacturing projects for the food and beverage industry under the 6th Malaysia Plan, 1991–1995 were as follows:

Number of food manufacturing factories	216
Number of beverage and tobacco factories	21
Total capital investment of food manufacturing industries	RM 2,422.0 million
Total capital investment of beverage and tobacco industries	RM 500.5 million

During the first year of the Seventh Malaysian Plan, the number of food and beverage and tobacco projects approved in 1996 was 33, with a proposed capital investment totaling RM 405.1 million. This increased to 60 projects, with a total capital investment amounting to RM 1,042 million in 1998 (see Tables 7 and 8).

Wastewater Treatment

Under the Environmental Quality (Sewage and Industrial Effluents) Regulations of 1979, there are two effluent standards: Standard A and Standard B. Standard A is generally applicable to activities and industries that are sited within, or in the near vicinity of, cachement areas and is more stringent. Standard B is generally applicable to both industrial and development activities throughout the country. The parameters for Standard B are as following:

Temperature	40^{o} C
pH Value	5.5–9.0
BOD at 20^{o} C	50 mg/l
COD	100 mg/l
Suspended solids	100 mg/l
Oil and grease	10 mg/l
Cadmium	0.02 mg/l
Mercury or Chromium	0.05 mg/l
Other heavy metals	range from 0.1 to 5 mg/l

Source: DOE.

Normally, a detention lagoon of 6–8 hours is required to achieve a BOD suspended solids in the ratio of 20:50 (Standard A effluent under the Malaysian Standards MS 1228-1991). An efficient anaerobic process (e.g., the up-flow anaerobic sludge blanket, UASB) reactor system would have 70–75 percent BOD removal efficiency in wastewater treatment.

Like many other sectors, wastewater is one of the key environmental impacts for food and beverage manufacturers. Based on DOE Environmental Quality Report 1996 findings, the water quality of most of the river systems in the country suffered from high levels of suspended solids. The food and beverage industries (together with other sub-sectors such as rubber-based, metal finishing, and paper industries) had difficulties in complying with the requirements of the Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979. In fact, in 1994, only 64 percent of this sub-sector complied with this regulation. The food and beverage sub-sector also accounted for seven percent of water pollution complaints. The most common reason for failure to comply with regulations was the absence or lack of a proper wastewater treatment system. Most SMEs do not have treatment equipment installed. Those who have treatment systems face operation and maintenance problems and the systems often do not work efficiently.

Table 7. Approved Manufacturing Projects

	No. of approvals				Total no. of approvals	
	1985	1990	1995	1998	5MP (1985–90)	6MP (1991–95)
Food manufacturing	57	36	37	48	200	216
Beverage and tobacco	5	3	2	12	16	21
Total for manufacturing sector	625	906	898	844	3,210	4,297

Source: Sixth Malaysia Plan 1991–1995 and *Seventh Malaysia Plan 1996–2000*.[61]

Table 8. Capital Investment

	Capital Investment				Total Capital Investment	
	1985	1990	1995	1998	5MP (1985–90)	6MP (1991–95)
Food manufacturing	579	571	499	769	3,887	1,467
Beverage and tobacco	29	39	6	273	89	170
Total for manufacturing sector	5,687	28,168	20,869	26,352	58,575	54,566

Source: Seventh Malaysia Plan 1996–2000.[62]
Unit = RM m.

Air Quality

Air quality varies depending on local activities and surrounding topography. There is an absence of a specific measurement to indicate the food and beverage industry's contribution to the levels of lead, SO_x, NO_x, or the total suspended particulates (TSP).

[61] *Sixth Malaysia Plan 1991–1995*, p. 133.
[62] *Seventh Malaysia Plan 1996–2000*, p. 272.

However, in the Klang Valley where the majority of food and beverage industries are located, the average concentration of Total Suspended Particulates (PM10) is about 50 ug/m^3 which is well below the recommended Malaysian Guideline for PM10 at 150 ug/m^3. This is also reflected in term of the overall level of compliance with Environmental Quality (Clean Air Regulations) Act. In 1994, the food and beverage sector had achieved 91 percent compliance. Compliance rates further improved to 96 percent in 1996.

Noise Monitoring

In general, noise levels recorded at the boundaries of the various types of manufacturing facilities/industrial premises exceeded 65 dB(A)Leq, the guideline value recommended by the DOE. The range of measurements for premises of light, medium, and heavy industries were respectively 51.7–80.9 dB(A)Leq, 52.9–81.5 dB(A), and 56.4–76.9 dB(A)Leq. in 1994.

Environmental Programs Implemented

Like most other countries, Malaysia has enacted a series of laws and regulations to stimulate pollution abatement based on end-of-pipe treatment. As discharge standards have become more stringent over the last two decades, the cost of end-of- pipe treatment has increased to the point of impacting the economic viability of companies in Malaysia. SMEs are particularly strongly impacted by rising costs due to their limited technical and financial resources. Equally important, the end-of-pipe approach does not eliminate pollutants, but merely transforms them from one medium to another. Therefore, it is crucial for Malaysia to begin looking beyond the end-of-pipe methods to resolve pollution control problems.

Over the last 10 years, the trend has clearly been towards preventative strategies, starting with the pollution prevention concept (P2) and later, expanding into strategies such as cleaner production (CP). A common theme is the recognition that pollution or wastes are a sign of inefficiency in industrial production, and reduction of waste can lead to higher profitability.

In the case of Malaysia, statistics have indicated that a large portion of the country’s environmental problems are associated with the activities of SMEs. SMEs attribute their difficulties in compliance to their numerous constraints, such as: lack of access to new technologies, lack of skills, low capital investment, low profit margins, small and variable scale of operation, and low productivity.

However, with environmental standards and enforcement becoming more stringent, activities related to pollution prevention, control, and waste minimization are steadily gaining momentum and attracting interest in Malaysia. Several programs that are relatively new in terms of concept and practice have been introduced and implemented on an ad hoc and piecemeal basis. Some of the environmental programs or activities that have been launched in Malaysia are cleaner technology, cleaner production, pollution prevention, adoption of the Environmental Management System (EMS), and the ISO 14000 certification.

In so far as Green Productivity (GP) is concerned, it is a very new concept that has been introduced by the APO through the NPC Malaysia. The proposed strategy seems to be promising as a two-pronged approach where productivity is enhanced with better environmental performance. GP allows for greater flexibility in the use of productivity tools in combination with environmental management tools depending on the objective that has to be achieved. It is expected that SMEs will be more open to such an approach than a system based purely on environmental management.

In mid-1997, an agricultural project called the Model Vegetable Production Farm was implemented in Cameron Highlands using GP practices. The project is sited on 1.25 acres of a vegetable farm and specializes in growing leafy vegetables and sweet potatoes. The main objectives of this first Malaysian GP project are to:

- Demonstrate technical applicability, environmental desirability, and economic viability of Green Productivity principles and approaches in intensive vegetable production in Malaysia; and
- Disseminate results of the demonstration to other vegetable farmers in Malaysia and APO member countries.[63]

Cleaner Technology (CT) promotion has been sponsored by DANCED with SIRIM as the implementing organization. The application of CT is also relatively new in this country, having begun in 1996 through a series of demonstration projects with a few selected SMEs. The projects promoted CT through activities such as environmental and energy audits, demonstration sites, and information dissemination. Under this program SIRIM offers two types of services i.e., Cleaner Technology Extension Services (CTES) and Cleaner Technology Information Service (CTIS).[64]

Under a program supported by the United Nations Environment Program (UNEP) and Swedish International Cooperation Development Agency, the concept of Cleaner Production (CP) was introduced to Malaysia in 1996. However, promotion was limited to paper mills where improvement of "raw material procurement, storage, and preparation was measured in terms of monetary benefits."[65]

A CP project sponsored by the APEC–HRD through the Research Institute for Asia (RIAP) and the University of Sydney was implemented in Malaysia and other APEC countries in 1997. The project involved a case study on a meat processing factory which ended in 1998 and the findings will be published as part of the HRM training manual on CP needs in APEC countries.[66]

There are also other environmental programs such as MAWAR (Malaysian Agenda for Waste Reduction) that are currently carried out for specific functions or areas such as waste reduction, under the auspices of DOE. More specifically, some Malaysian companies are already implementing ISO 14001, especially those linked to multinational companies (see Table 9).

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[63] Teng, Evelyn, Fong Lin, and Dzulkifli Sipon, "Country Paper: Malaysia," in *Workshop on Green Productivity For NPOs*, March 22–26, 1999, Taiwan.
[64] Ibid., p. 9.
[65] Ibid., p.11.
[66] Phang, Siew Nooi and Kiyau Loo Lee, *Human Resource Management For Cleaner Production Needs in APEC–A Malaysian Case Study,* May, 1998.

Table 9. Companies with MS-ISO 14001 by SIRIM *(December 1998)*[67]

Sector	Number	%
Electrical/Electronics	44	61
Scientific	16	23
Engineering	8	11
Service	3	4
Total	**70**	**100**

In the area of pollution prevention (P^2), the Palm Oil Research Institute of Malaysia (PORIM) is actively involved in applying P^2 methodologies to its 282 crude palm oil (CPO) mills in Malaysia. PORIM has managed to reduce pollution from a population equivalent of palm oil mill effluent pollution of 15.9 million people in 1978 to only 1.6 million in 1989.[68]

At the same time, the role played by many NGOs in Malaysia in promoting environmental practices is significant. NGOs are particularly important in highlighting the concepts of cleaner production, green productivity, cleaner technology, and pollution prevention.

The above programs have created a measure of interest amongst businesses, especially SMEs. However, for any of the environmental programs to be sustainable in the long run, there is a need to follow through with intense promotion supported by government agency and industry participation.

CASE STUDY OF GP IMPLEMENTATION

Company Profile

Name:	Fika Foods Corporation Sdn. Bhd.
Type of Organisation:	Private Ltd.
Nature of Business:	Food Sub-sector (frozen meats)
Market:	Local
Type of Service:	Manufacturing and Distribution
Products:	Sausages, burgers, shredded chicken and cold cuts
Production Capacity:	100 tons annually (estimate)
Approx. No. of Staff:	50 employees (see Figure 2)

Company Background

Fika Foods Corporation Sdn. Bhd. began its operation in 1985 as a family business on Old Klang Road, Kuala Lumpur producing sausages and chicken ham. In December 1993, Fika Foods Corporation Sdn. Bhd. relocated to Subang Light Industrial Park. Since then the company's product range has expanded to include frozen frankfurters, frozen burgers, chicken sandwiches, and shredded chicken. The company employs approximately

[67] Teng and Sipon, op. cit., "Country Paper Malaysia", p. 13.
[68] Ibid., p.13.

50 people for the manufacturing and distribution of its products. All frozen meat products are produced in the halal way and have been awarded halal status. The company supplies its meat products throughout Peninsular Malaysia and Sabah.

Environment Profile

In terms of the presence of any environmental management systems in this factory, it can be noted that only very basic methods are employed, as is demonstrated in the disposal of waste products by the factory. The company has a limited level of awareness and concern regarding its environmental practices and performance. The factory disposes of both liquid and solid wastes via the methods described below:

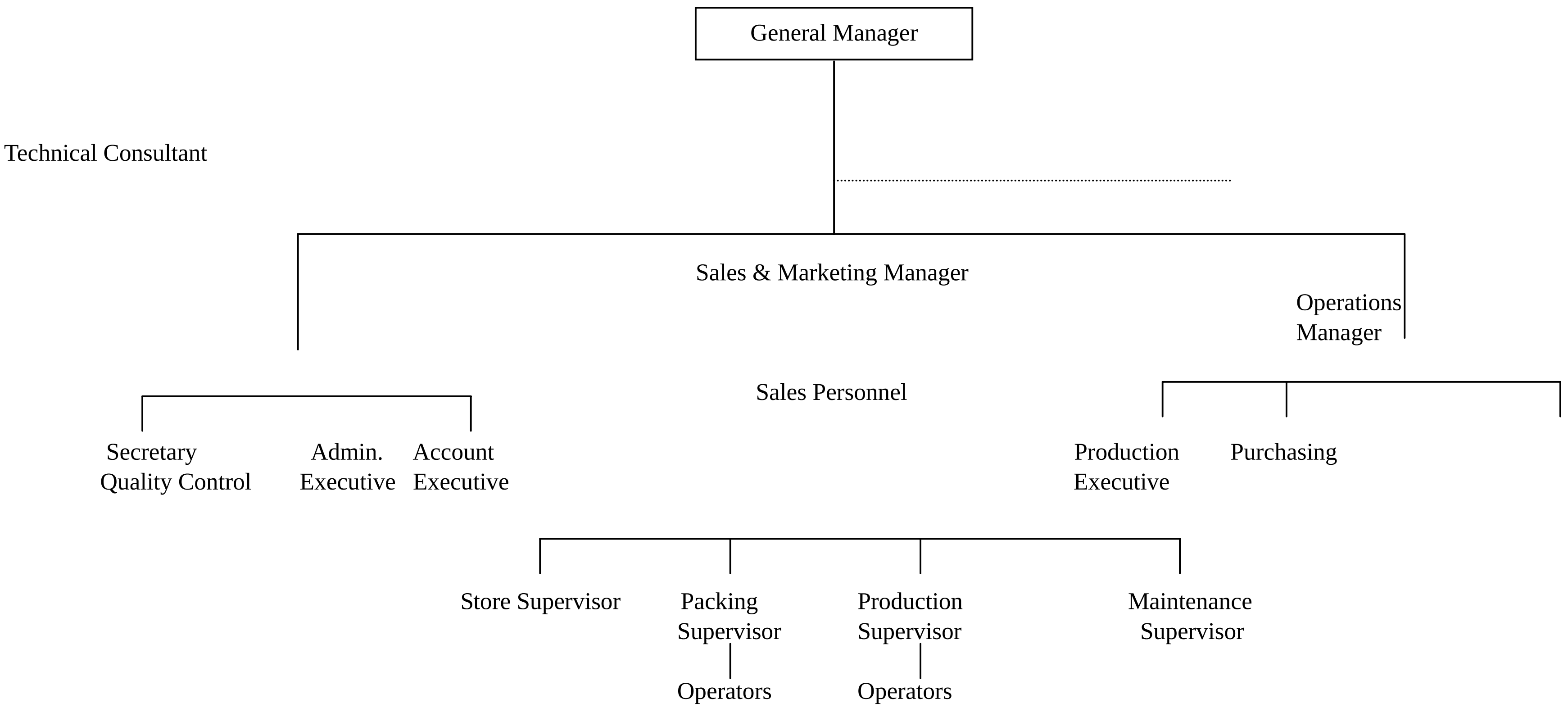
Wastewater

The wastewater that is discharged during the production process contains meat particles, fats, and oils. These solids are separated from the wastewater stream through filters placed at vertical points at the internal drains of the factory. The wastewater is then discharged into external drains outside the factory through the factory's main drain outlet.

Solid wastes

The factory's solid waste ranges from damaged materials/goods, unwanted packaging materials/items, and chicken bones. The waste items (with the exception of the bones) are collected in garbage bags, neatly tied, and put into larger garbage bags. The bags are then placed in a covered garbage disposal tank outside the factory. The solid waste is collected daily by garbage collectors hired by the industrial park management. The chicken bones are collected separately and sold by the factory for recycling into fish meal daily.

Figure 2. Organizational Chart of Company: Fika Foods Corporation Sdn. Bhd.



The Case Study

In Malaysia, although the GP and other related concepts such as CP or CT are not unknown in the industrial circuit, conscious practice of GP amongst SMEs is virtually nonexistent.

Bearing this situation in mind, the selection of a case study on GP implementation by the food industry in Malaysia encountered certain challenges. The concept of environment as interpreted by the majority of those in the food industry pertains to pollution and health controls. The majority of the food factories try to stay within the standards established by the DOE and will not openly breach the environmental and health guidelines of the respective Ministries. Efforts to comply are merely reactions to policies laid down to show some semblance of environmental consciousness and are not the sign of keen interest in environmental performance. The response to voluntary promotion of environmental management practices has not been very encouraging thus far.

With this background, the search for a food factory that has implemented and practiced GP as a case study for this project had to be focused accordingly. The understanding and interpretation of the practice of GP had to be redefined for its suitability as a case study to reflect the practicality and advantages of GP.

Going by the definition of GP given by the APO (i.e., GP is a practical means of socio-economic development aimed at efficiently producing goods and/or services which are profitable yet environmentally compatible, and involves the adoption of management strategies, activities, and technologies to achieve such sustainable objectives – APO 1997), the activities undertaken by Fika Foods can be interpreted as reflecting the practice of GP.

According to the above understanding of the practice of GP, Fika Foods' activities in reducing wastes (water and solids) through enhancing human resource management and technological improvement are GP efforts, although the factory is not conscious that it is practicing GP. Under such circumstances, data collection and analyses were not conducted by the factory, and figures on environmental practices were seldom recorded and kept. Inadvertently, the basis for comparison of the "before and after" in undertaking GP for this case study has been constrained by the absence of data for the "before" period. While a definitive year cannot be determined as to when the company embarked on GP practices, it can be assumed that from the mid-90s, after the company's relocation to the Subang Industrial Park, a series of environmental practices had been implemented by the company. Due to financial constraints, improvement on equipment and machinery was postponed until 1998 when the company installed a peeler machine for peeling the cellulose casings off the sausages. Previously, this was done manually. A meat processor was also acquired for grinding the meat for the sausages and burgers. Previously, the factory purchased processed meat. The machinery not only improved production and quality of the finished product, but also reduced the usage of water and the total wastewater output. The machinery purchases were motivated by a desire to improve overall productivity and efficiency.

Production Process and Waste Generation

The company produces four types of processed food (i.e., sausages, burgers, shredded chicken, and cold cuts for sandwiches). The production process is described in Figures 3 and 4, which illustrate the flow process and the final waste output.

Figure 3 shows the product output (foods) from the manufacturing process, as well as the wastes generated. Reviewing Figure 4, it can be seen that the major wastes associated with the process are wastewater, fats and oils, and cellulose casings. On-site observations noted large quantities of water used in the production process, thereby resulting in large volumes of wastewater. As the processed meat constitutes the main raw material, fats and oils are inevitable components of the wastewater.

Another waste product is cellulose casings which are removed (peeled) after the sausages are cooked. The biodegradable cellulose casings are disposed of as part of the factory's garbage. The weight of the discarded cellulose casings is estimated at approximately 990 kg per month. Plastics and papers form another part of the factory's solid waste stream with estimates shown in Table 10.

While the practice in the past was to buy only deboned chickens, the factory at present buys some dressed chickens that have not been deboned. Due to improvement in workers' skills, the factory can now perform the task of deboning and resell the bones at 13¢ per kilogram for use as fish meal.

Figure 3. Production Process and Outputs

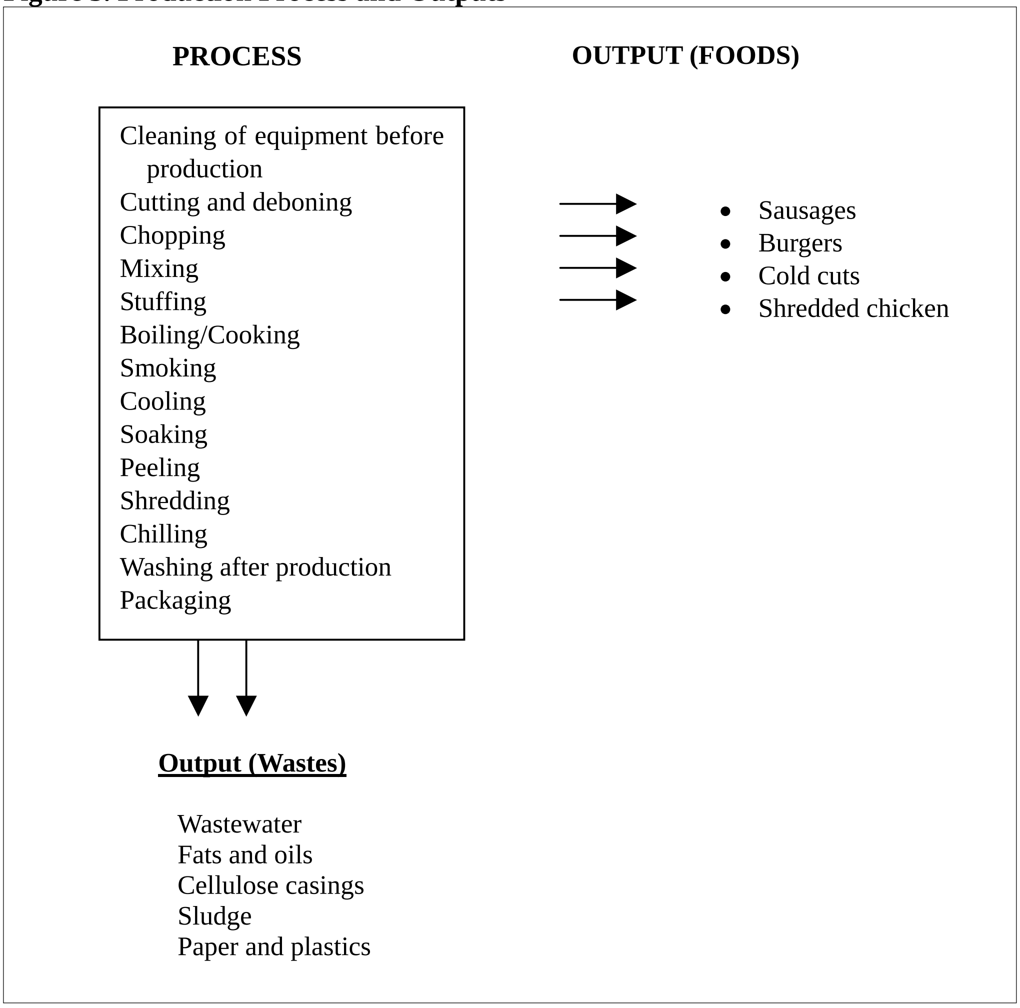


Figure 4. Wastes from Production Process

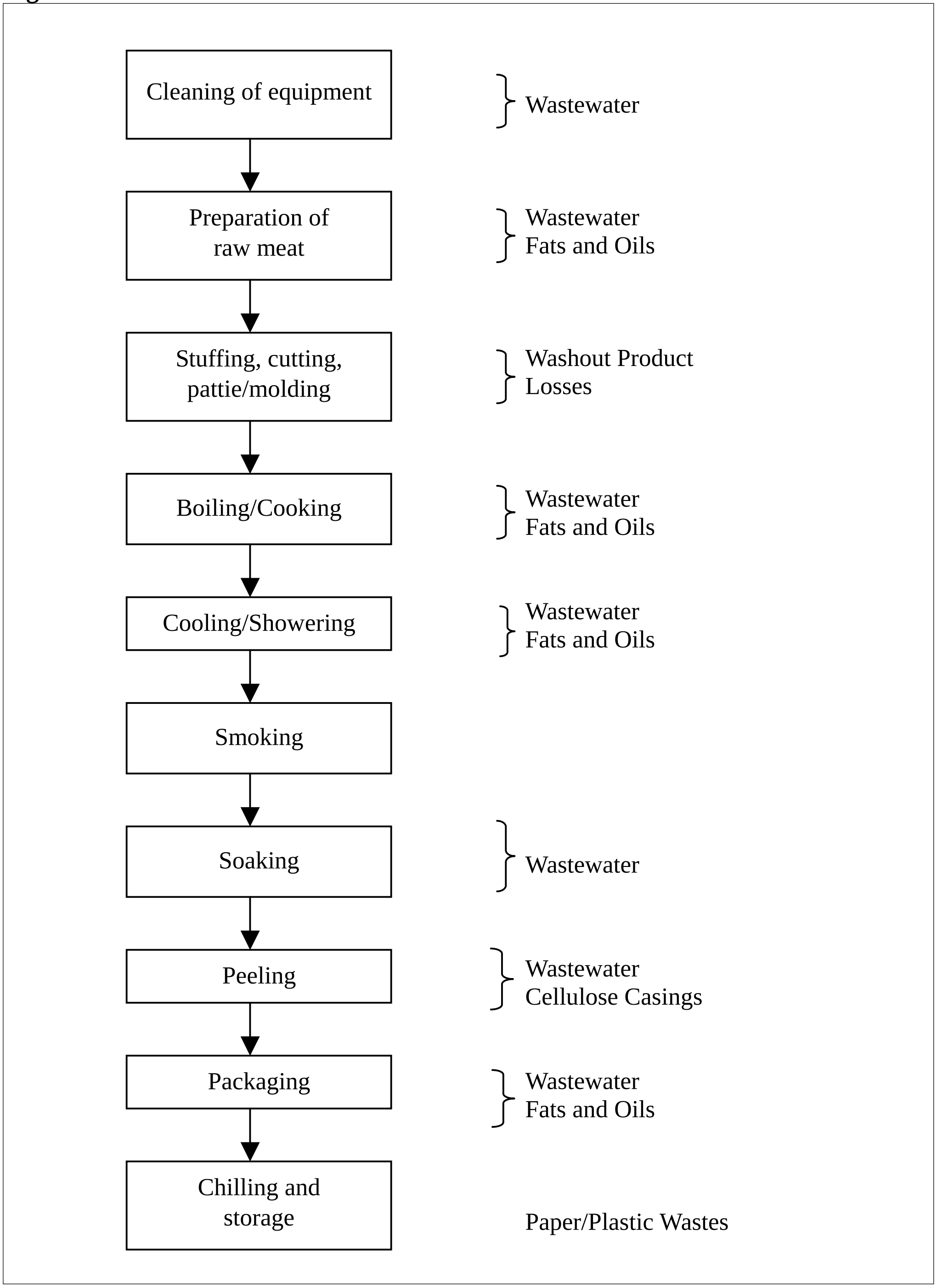


Table 10. Solid Waste Generation

Type of waste product	Source	Average output/ month	Disposal method
1. Cellulose casings	Peeling machine	990 kg	Industrial garbage collector
2. Plastics and paper	Packaging process	250 pcs	As above
3. Chicken bones	Deboning of dressed chickens	20 tons	Sold as fish meal

Source: Fika Foods Corporation.

Wastewater

Analysis was undertaken of the wastewater generated at each step in the production process. Altogether, there are eight basic steps for which the wastewater characteristics are tabulated (see Table 11). The first seven processes continued as standard process after the factory was renovated. Having purchased the peeling machine and modified the overall process, the eighth step of soaking the sausages after manually peeling has been eliminated, thereby reducing process time as well as wastewater and its contents (see Table 11).

Wastewater is generated from the moment the factory begins its production for the day with the rinsing of equipment and machines. The machines are used for the preparation of raw meat, deboning, cutting, pattie moulding, and stuffing. The wastewater was measured and gauged according to the DOE's Standard B Limit (see Appendix A). The samples were collected on different dates (i.e., January 15, 1999 and January 22, 1999) for each process.

Piped water is used for rinsing or cleaning the equipment before the production begins. The pH of the resulting wastewater was measured and recorded to be 7.80 and 8.55 respectively, indicating the wastewater to be slightly alkaline. The BOD concentration was measured to be 19.8 ppm and 5.4 ppm and total solids (TS) were recorded at 108 ppm and 141 ppm. Similarly, the oil and grease levels were very low, comparatively at 3.6 ppm and 1.0 ppm (Table 11).

The second type of wastewater came from the boiling and cooking processes. After the sausages have been stuffed and linked, they are boiled, cooked, and when required, smoked. The wastewater from the boiler indicated a neutral pH of 7.0 with the BOD level of 28.8 ppm. The TS were measured at 130 ppm, which is considerably low as compared to the other processes. Oil and grease were negligible at less than 0.1 ppm. One possible reason could be the natural consequence of the oil and grease being neutralized in the process of boiling. Another factor could be due to the use of vegetable oil in the product, which is a relatively volatile oil and easily "lost" in analysis procedures.

Immediately after the sausages have been cooked, they must be cooled down by a showering process. This procedure consumes much water, thereby generating a high volume of wastewater that drains into the main outlets. This process takes place in another section of the factory that has a room temperature of 24^{o} C, as compared to the previous processes where the room temperature averaged 15^{o} C. The wastewater from cooling the sausages was measured to have a high acidic content with a pH measured at

Table 11. Analysis of Wastewater from Each Process

Process	Volume per day (litres)	Average temperature 0^{o} C		pH unit		BOD unit: ppm		Total Solids (TS) unit: ppm		Oil and grease unit: ppm	
	1/15/99	Before renovation 1997	After renovation	1/15/99	1/22/99	1/15/99	1/22/99	1/15/99	1/22/99	1/15/99	1/22/99
1. Rinsing of equipment before production	3,000	190C	150C	7.80	8.55	19.8	5.4	108	141	3.6	1.0
2. Cooking water (boiler)	300	190C	150C	7.00	NA	28.8	NA	130	NA	<0.1	NA
3. Cooling of sausages (showering)	2,560	240C	240C	3.73	3.82	8.31	1,158	1,781	1,690	8.5	23.4
4. Soaking of unpeeled sausages	3,500	240C	240C	3.81	4.08	7,406	3,906	11,155	8,784	31.4	11.2
5. Cleaning of equipment after production	16,000	190C	150C	4.60	6.05	5,026	840	2,565	567	529	364
6. Floor cleaning (packing area)	300	190C	150C	6.84	6.33	394	128	151	252	6.1	13.9
7. Discharge outlet	-	300C	300C	4.55	3.92	588	3,290	1,519	4,637	25.8	298
8. Soaking of peeled sausages	3,250	240C		4.03		1,568		495		9.3	

3.73 and 3.82 consecutively on two occasions. The BOD measurements ranged from 1,158 ppm–831 ppm which were relatively low as compared to the other processes. The TS ranged from 1,690 ppm–1,781 ppm. Oil and grease concentrations ranged from 8.5 ppm to a high of 23.4 ppm.

The next process involves soaking, cleaning, and washing of the unpeeled sausages before processing in the peeling machine to remove the sausages' cellulose casings. The measurement readings for the wastewater appear high as compared to the other processes and are also above the DOE's guidelines. The wastewater from the container of unpeeled sausages had a pH reading of 3.81–4.08 and a BOD level of between 3,906 ppm–7,406 ppm. Similarly, the TS measurements were also high at 8,784 ppm–11,155 ppm. The oil and grease contents were 11.2–31.4 ppm on both occasions. Once peeled, the sausages are sealed, packed, and frozen for sale.

At the end of the day, the production area has to be cleaned. First, the equipment and machinery are washed. The wastewater from this process had a moderately high acidity of 4.6–6.05 pH. The BOD level ranged from 840 ppm to 5,026 ppm. At this stage, most of the solids would have been collected through sieves placed strategically at the drains within the production area. By the time the wastewater is discharged to the main outlets, much of the TS would have been collected, but smaller particulate would have escaped into the main drain located outside the factory. The oil and grease contents in the water from cleaning the equipment were high with readings of 364 ppm–529 ppm. This was due to the machinery retaining volumes of raw meat from the process of cutting, mincing, and molding. Comparatively, the packing area produces less grease and oil as well as TS and BOD. The wastewater analysis from this section of the factory revealed a pH of 6.33–6.48 with the BOD content measuring 128 ppm–394 ppm. This is much lower than the BOD content of the other processes with the exception of rinsing the equipment prior to operation. Even the oil and grease content of 6.1 ppm–3.9 ppm appears to be within the acceptable limits of the DOE.

Finally, at the discharge outlet located outside the factory, the wastewater still has a fairly high acidity with pH of 3.92–4.55. This was not surprising however, since the company does not employ any processes to neutralize the wastewater. The BOD level seemed to be moderately high with a measurement of 588 ppm–3290 ppm comparatively. The oil and grease contents were especially high on the second collection at 298 ppm. The untreated wastewater is discharged directly into the main drain located outside the factory.

The process of soaking the peeled sausages as shown in Table 11, was eliminated following the acquisition of the peeling machine after the renovation of the factory. This is the only data collected from the "before" GP practice period and the figures show the measurement content for each parameter. Prior to renovation, the factory room temperature ranged between 19^{o} C–24^{o} C as opposed to a cooler environment today of 15^{o} C–24^{o} C.

The wastewater from the manual process was acidic with a pH of 4.03 which was high as compared to the other processes. The BOD level was 1,568 ppm and the TS was measured at 495 ppm. The oil and grease content was at an acceptable level of 9.3 ppm.

By introducing the peeling machine, the process of soaking the peeled sausages could be eliminated. By gauging the effects of this equipment upon the production process for sausages and interpreting this as implementation of a part of the GP practice, some comments can be made on environmental performance for the period before and after.

By dispensing with this one process and going directly from peeling to packaging, certain elements had been either saved or reduced. Consumption of water for soaking the peeled sausages had been reduced by at least 3,250 litres a day. Subsequently, wastewater was reduced and with it the related pollutants and chemicals. For instance, the water discharged into the drains should have reduced levels of pH by 4.03 ppm, BOD by 1,568 ppm, oil and grease by 9.3 ppm and TS by 495 ppm on a daily basis. With less manual handling of the finished product, it can be logically assumed that the hygiene standard improved. Needless to say, with less contact, the potential incidence of product contamination was reduced.

In terms of human resource management, since this process was previously performed manually, the factory has deployed the workforce to other sections to enhance productivity. With one less process to operate, the factory has saved time spent on that particular process, as well as other factors such as energy, space, and, most of all, decreasing the output of pollutants into the environment.

Cost-Benefit Analysis of Purchase of Peeling Machine

The company purchased a peeling machine to replace the manual procedure of removing the cellulose casings from the sausages. The cost of the machinery, inclusive of installation, labor, and materials, was RM 70,000. The company paid for the peeling machine without obtaining any bank loans or financing.

From the available cost figures provided by the company, a simple cost-benefit analysis was prepared based upon a monthly projection (see Table 12). With the use of the peeling machine, production of sausages increased by one ton (from 3.5 tons to 4.5 tons) per month. At the same time, labor cost was reduced as only one worker needed to be employed to operate the machine (as opposed to three workers for the manual process). The wages for the operators were RM 600 per month, which led to a savings of RM 1,200 per month or RM 24,000 per year. While water intake is now negligible, consumption of electricity increased by at least RM 300 per month or RM 3,600 per year. On the whole, the usage of the peeling machine is economically viable as increased production allows for higher sales output and more income. Details of the analysis are illustrated in the following cost-benefit and Net Present Value (NPV) analysis section. Also presented is an alternative scenario assuming that the machine had been purchased or financed through a bank loan.

NPV analysis of purchase of peeling machine

To determine whether a project (buying a new machine) is practical or not, we need to use the Net Present Value method. The NPV of a project is found by subtracting the initial investment (I) from the present value of its cash inflows (CF), discounted at a rate equal to the firm's cost of capital (i).[69]

[69] Lawrence J. Gitman. (1997). *Principles of Managerial Finance,* 8th Edition, Addison Wesley.

Table 12. Simple Cost-Benefit Analysis of Sausage Production

Production cost prior to purchase of peeler machine	RM	Production cost after purchase of peeler machine	RM	Savings/Outflow	RM
1. Machine cost (NA)		**1. Machine cost** (RM 70,000)		Cash outflow (calculated per month)	–5,833
2. Labour cost		**2. Labour cost**			
3 employees@RM 600/month	1,800	1 employee@RM 600/month	600	Cost savings (1,800-600)	1,200
3. Cost of raw materials (estimation)		**3. Cost of raw materials (estimation)**		Excess production capacity	
Cost of raw materials=RM 1.50/kg 3,500 kg×RM 1.50=RM 5,250 RM 5,250×30 days = RM 157,500 per month	157,500	Cost of raw materials =RM 2/kg 4,500 kg×RM 2=RM 9,000 per day RM9,000×30 days = RM 270,000 per month (RM 270,000–RM 157,500 =RM 112,500)	270,000	(4,500–3500) 1,000kg/hr	–112,500
4. Energy (electricity)		**4. Energy (electricity)**			
nil		RM300/month or at 235 kWh per month (at hrs production time)	300	Excess cost/cash outflow	–300
5. Water		**5. Water**			
RM 3.90 × 30 days (3250/1000=RM 3.90)	117	nil		Cash savings for water	117
6. Sales revenue		**6. Sales revenue**			
3.5 ton × RM 7,000/ton per day RM 24,000 ×30 = RM 720,000 per month	720,000	4.5 ton × RM 7,000 per day RM 31,500 × 30 = RM 945,000 per month	945,000	Excess sales revenue (945,000-720,000)	225,000
				Grand total	**RM107,684**

NPV = Present value of cash inflows – initial investment:

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+i)^t} - I$$

Note: t = year 1,2 … 5.

The decision criterion

If NPV is greater than $0, accept the project; if NPV is less than $0, reject the project.

Assumptions

The cash inflows growth rate is 5% for each year as shown below.

Year	1	2	3	4	5
CF	1,292,208	1,356,818	1,424,659	1,495,892	1,570,687

The firm cost of capital (discount factor) is 10% for Scenario 1 and 14% for Scenario 2.

Scenario 1. Discount Factor is 10%

Year	**Cash inflows (A)**	**Present value interest factor at 10% (B)**	**Present value [(A)/(B)] (C)**
1	1,292,208	1.100	1,174,735
2	1,356,818	1.210	1,121,338
3	1,424,659	1.331	1,070,368
4	1,495,892	1.464	1,021,784
5	1,570,687	1.611	974,976
	Present value of cash inflows		$5,363,200
	minus initial investment		–70,000
	Net present value (NPV)		$5,293,200

For Scenario 1, since the NPV is positive, buy the machine. The project (machine) contributes $5,293,200 of value in excess of its cost.

For Scenario 2, since the NPV is positive, buy the machine. The project (machine) contributes $4,770,140 of value in excess of its cost.

Based on the two scenarios, we can conclude that Scenario 1 is more cost effective because it contributes more value than Scenario 2.

Scenario 2. Discount Factor is 14%

Year	Cash inflows (A)	Present value interest factor at 14% (B)	Present value [(A)/(B)] (C)
1	1,292,208	1.140	1,133,516
2	1,356,818	1.300	1,043,706
3	1,424,659	1.482	961,309
4	1,495,892	1.689	885,667
5	1,570,687	1.925	815,941
	Present value of cash inflows		$4,840,140
	minus initial investment		–70,000
	Net present value (NPV)		$4,770,140

Other Improvements

In addition to the purchase of the peeling machine, Fika made other changes to its factory with environmental benefits.

Renovation of production area

Improvements were made through renovation of the production floor area. Previously, wastewater was discharged directly to the drain outlet located outside the factory. As part of the renovation process, internal drains were constructed along the production floor area to trap the outflow of wastewater, thereby reducing the water flow onto the production floor area. These drains were then connected to a larger drain with sieves to collect the solids before the wastewater is discharged outside of the factory.

Improvement in working environment

Based on the room temperature of the production area, the workers are working in a cooler environment. Previously, the room temperature for the production area averaged 19^{o} C however, the room temperature brought down to around 15 ^{o} C through the installation of better ventilators, air conditioners, and readjustment of equipment. At the same time, with a better drainage system, the floors are drier, thereby reducing the risk of accidents due to slippery floors.

Preparation and deboning of chicken

Previously, the factory only ordered dressed chickens that were already deboned by the supplier. After the improvements to the production area and the purchase of additional machinery, dressed chickens are now bought directly from the farms, providing a cheap and fresher meat source. The factory performs the task of deboning and sells the bones to a wholesaler for fish meal.

Options for Further Improvements

Treatment of wastewater

This will be a necessary consideration in the future as production increases lead to higher levels of pH, BOD, and oil and grease contents. The present system allows the wastewater to be discharged directly into the main drain outlet located outside the factory.

The factory will eventually have to treat the high acidic contents of the wastewater prior to discharge. In addition to the pollutants in the water, solids that escape collection by the sieves are also released.

Reduction of water consumption

The factory could potentially find ways to reduce water consumption either through recycling or decreasing water use in one or more steps of the production process. From a “walk-through” of the production area, the cooling of the sausages by showering was identified as one area where the water can be collected and reused for the same procedure. The water consumption for this process is 2,560 litres per day or 934,400 liters per year. Recycling of showering water will reduce water intake and simultaneously reduce wastewater generation.

Disposal of cellulose casings

The cellulose casings are an essential item in the production of sausages. However, they are imported, expensive, and are used only once. The factory purchases 990 kg of these casings for about RM 60,000 every month. The casings are biodegradable, and the factory has given considerable attention to the issue of recycling, re-using, or re-selling these casing to the manufacturer and supplier. The factory’s garbage includes an average of 990 kg of cellulose casings per month at present, amounting to 11.9 tons of solid waste per year. Further options should be explored.

Human Resource Management

The company does not have a human resources department, but it has undertaken the training of its personnel by its senior production executives and supervisors. Presently, the factory is a small organization, but has begun to consolidate its training needs and programs by providing training, especially in the areas of health, cleanliness, and good housekeeping.

Since the renovation of its factory and reorganization of the production area, the company has thus far been noted to have undertaken changing processes and inputs, as well as some recycling. While it has adapted some GP practices, there is significant room for further implementation of GP practices within the organization.

GREEN PRODUCTIVITY PROMOTION IN MALAYSIA

Current Policies

The listing below (see Table 13) gives an indication of the present level of environmental awareness and practice in Malaysia. This will help any agency involved in the promotion of GP in the country to chart an appropriate GP program.

GP Techniques Applicable to the Food Industry in Malaysia

Most of the food industries in Malaysia suffer from the universal problem of wastewater. High consumption of water leads to high discharge of wastewater, most of which contains high concentrations of chemical and organic materials. The key to both problems is to control water consumption at the source and reduce BOD, COD, and SS

Table 13. Current Features of Malaysia's Environmental Regime

Indicators	Yes	No	Comments
Polluter Pays	√		
Integrated Pollution Control		√	Carried out on an individual department basis e.g., DOE, PORIM, SIRIM, but not integrated.
Inventory of Emissions Discharges and Wastes	√		Based upon sectors e.g., water, air, solid waste, and not on per industry per se.
Emission and Discharge Limits	√		
Process Approval	√		
Product Regulations	√		
Public Access Information	√		On an ad hoc basis by each department e.g. SIRIM, DOE.
Waste Minimization and Pollution Prevention	√		
Environmental Auditing	√		Confined to individual companies.
Cradle to Grave		√	
Recycle and Reuse	√		Voluntary effort carried out by community-based NGOs.

loadings. The following suggestions have been adapted from Noyes's handbook on pollution prevention.[70]

1. Recover as much product as possible;
2. Reuse and recycle as much water as possible;
3. Segregate waste streams;
4. Develop a leak prevention program for valves, pumps, piping, and equipment;
5. Drain all product from tanks and vats before cleaning;
6. Use dry cleanup methods. Avoid hosing material into drains if possible;
7. Install water meters and read them on a continual basis;
8. Monitor the treatment plant for BOD on a weekly basis;
9. Practice better inventory control;
10. Use raw materials more efficiently;
11. Convert as much waste as possible to animal feed;
12. Use water sparingly in hosing and cleaning operations; and
13. Install valves that shut off automatically when water is not needed.

[70] Noyes, Robert (ed.), *Pollution Prevention Technology Handbook*, Noyes Publications, New Jersey, USA.

Although the Malaysian case study specifically concentrates on a food sub-sector (i.e., sausage making), the above documentation on wastewater management can be universally applied in this sub-sector, especially for benchmarking purposes. Undeniably, certain differences do occur from one nation to another and between one factory and another within the country, but the documentation can be applied as part of GP practice in many food factories. Factors affecting the scale of the GP impact include:

1. The size of factory/production;
2. Existing environmental policies in the company;
3. Economic constraints; and
4. Management team/attitude.

In so far as the food industry in Malaysia is concerned, GP has a central role in the activities of the SMEs. It will become increasingly important that the issue of water consumption and resulting wastewater be addressed since water is a crucial resource in the food industry.

Role of NPC and Related Agencies in Promoting GP

Towards this end, the role of supporting agencies like the NPC, the NGOs, and quasi-governmental bodies can help in promoting awareness of existing environmental practices that may generate better environmental performances by the small-scale enterprises located in urban areas.

For the implementation and promotion of GP in a city, government agencies like the NPC in Malaysia should take the initiative to promote the GP concept through various approaches, such as technical demonstration, public awareness and training programs, information services, and offering financial incentives. At present, the practice of GP amongst SMEs in Malaysia is virtually nonexistent, although the concept is familiar to many. The implementation of environmental techniques by Malaysian SMEs is based very much on ad hoc practices and many of them do not actually subscribe to any particular environmental concept.

The efforts of the NPC in Malaysia for the SMEs so far have been targeted towards developing training, consulting, and research programs for enhancing quality improvement, product and process innovations, and developing competitive strategies. While such efforts are indeed commendable, much more could probably be achieved if the environmental awareness of the SMEs could be further enhanced with the assistance of the NPC, given the present scenario of global market demands and trade liberalization. In tandem with the relevant agencies, the NPC may want to consider carrying out the following activities in addition to its present programs in environment management.

1. Generate and coordinate environmental projects for SMEs in Malaysia;
2. Conduct research and implement HRM skills in GP practices in selected industries (i.e., upgrading through R&D) with the collaboration of related agencies such as universities;
3. Develop a data bank of information and materials on factories that are implementing environmental practices, especially in GP;
4. Promote and disseminate GP practices through regular publications, workshops, and seminars;

5. Establish benchmarking standards on best practices in environmental management with a focus on SMEs; and
6. Form GP Circles for effective promotion and dissemination of GP practices via social networking between agencies, SMEs, and individuals. This is a low or even no cost option.

The efforts by the NPC in this direction will ensure long-term sustainability of good environmental practices within the country, especially when they are integrated with the organization's objectives of increasing productivity and quality.

CONCLUSION

Many organizations in Malaysia do recognize the need to consider the relationship between business and the environment and the benefits to both. In this regard, the efforts of the local NPOs in promoting GP practices and making related information available should be encouraged. Although some efforts have been made in this direction in Malaysia, the lack of technical information, difficulty in getting existing compiled data, and lack of funding have hampered the adoption of GP practices amongst most SMEs. In the future, with the interest shown by the local NPOs (especially in Malaysia) in promoting GP, some of the above problems can hopefully be overcome. There is no reason why GP practices should not be well received amongst the SMEs and the community, especially if properly executed and documented for use by all concerned. What is expected for the future, in terms of environmental management, is the wide acceptance and practice of GP in industries and related organizations.

APPENDIX

Appendix 1. DOE's Standard B Limit

Temperature	$40^{o}C$
pH Value	5.5–9.0
BOD at $20^{o}C$	50 mg/l
COD	100 mg/l
Suspended solids	100 mg/l
Oil and grease	10 mg/l
Cadmium	0.02 mg/l
Mercury or Chromium	0.05 mg/l
Other heavy metals	range from 0.1 to 5 mg/l

Source: DOE Malaysia.

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PHILIPPINES

Arnel D. Abanto
Productivity & Development Center
Development Academy of the
Metro Manila

INTRODUCTION

The many problems created by the excessive burden placed on natural systems by human activities are now manifesting themselves at a fast rate and on a global scale. Since the start of the industrial revolution, the pace of natural resource consumption and waste generation has been accelerating and causing severe damage to the environment.

Throughout Southeast Asia, a growing level of environmental awareness and concern is being translated into an active environmental movement and increased government support for the enforcement of pollution control measures. Present environmental problems in many Southeast Asian countries result from their success in attracting large manufacturing investments to drive their industrialization programs and their sustained high levels of economic growth. Failure to conserve natural resources and minimize increasingly toxic industrial pollutants is now manifesting many undesirable impacts around the region.

The industrial sector in East Asia has grown more than nine times since 1965. The total pollution load in the region contributed by the industrial sector has grown exponentially. Estimates of industrial pollution in Asia indicate that emissions of sulfur dioxide, nitrogen dioxide, and total suspended particulate increased by factors of ten in Thailand, eight in the Philippines, and five in Indonesia between 1975 and 1988 (World Bank Report 1992). However, there is still not enough comprehensive data on either pollution loads or pollution intensities in Asia to fully assess the scope and cost of the industrial pollution.

In the Philippines, the central, regional, and local government authorities are collaborating with non-governmental organizations and the corporate community to support and implement the Philippine Agenda 21. At present, the Philippine Council for Sustainable Development is actively working with local government units to localize the Philippine Agenda 21. Parallel to the Agenda 21 initiative, the Philippine Council for Productivity is also working at the national, regional, and local levels to formulate the Medium-Term National and Regional Action Agenda for Productivity (MTNAAP and RAAP). These two initiatives are being undertaken to address concerns about sustainable development, as well as productivity.

The concept of Green Productivity plays a vital role in helping to balance concerns regarding sustainability and productivity. Under this concept, productivity improvement provides the framework for continually strengthening economic performance, and environmental management techniques provide the foundation for making development sustainable. This paper discusses the basic Green Productivity practices currently being applied in the meat processing industry. The paper also discusses the basic practices, issues, and challenges that affect economic, productivity, and environmental development in the Philippines' industrial sector.

COUNTRY PROFILE

Basic Information[1]

The Republic of the Philippines is a democratic, republican state that is located five degrees north of the equator. Its government has three main branches: The Executive (President), the Legislative (Congress and senate), and the Judiciary (Supreme Court).

It is made up of 7,107 islands and islets with a total land area of 299,765 sq. kilometers. Because of its numerous islands, the country has an irregular coastline that stretches 334,539 kilometers. It is divided into three major island groups –Luzon Island (the northernmost part), Visayas Island (the center), and Mindanao Island (the southernmost). These islands are further subdivided into 16 regions with 73 provinces and 60 cities.

The country has a total population of approximately 70 million. Most of the residents are of Indo-Malay, Chinese, or Spanish descent. Sixty-three percent of the total population belong to the working-age group (15-to-64-year-olds) and thirteen percent live in Metro Manila alone.

Overview of Philippine Economic Development

The performance of the Philippine economy in the last decades has been characterized by "boom and bust" cycles of growth. The economy grew at 6.1 percent per year in the second half of the 1970s. However, annual growth dropped to 3.1 percent in the early 1980s and subsequently registered a large dip to –3.9 percent in the middle of the 1980s. The economy was able to recover during the second half of the decade with an average growth rate of 6.0 percent, but slowed again to a rate of 2.3 percent in the early 1990s. During this period, the economy was hit with numerous crises: political instability, power shortages, and natural calamities (volcanic eruptions and earthquakes).[2]

Recent economic performance

During the Ramos administration (1992–98), the Philippine economy exhibited sustained growth from 1992 to 1996 as shown in Table 1. The gross national product (GNP) grew at a peak of 7.2 percent in 1996 after growing at a mere 0.3 percent in 1991. The average growth of 5.8 percent in the last three years of the period demonstrates an economic recovery that can be attributed to economic reforms implemented in the 1980s and the political stability maintained during the last administration. The economy attracted substantial foreign capital, as well as new domestic investments. At the same time, the strong economic performance of the country generated more jobs, particularly in 1996. In 1997, the economy stumbled briefly to 5.3 percent in growth due to the onset of the Asian financial crisis.

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[1] This section draws heavily on the *Philippines' Business and Industrial Guide*, 1998.
[2] Productivity & Development Center, *Productivity Watch*, 1998.

Sector contributions[3]

From 1992 to 1997, gross domestic product (GDP) grew at an average of 3.8 percent. The growth in domestic production during this period was led by the service sector, which benefited from the liberalization of the financial, transportation, and communication sectors.[4] The service sector includes wholesale and retail trade, hotel and restaurant, real estate, and community/personal services. Table 2 shows that the contribution of the service sector to the GDP has been consistently higher, on average, than that of the agricultural and industrial sectors. In 1997 alone, the services sector contributed 43.4 percent of domestic growth. The growth of the service sector peaked at 6.4 percent in 1996 when it accounted for 43.3 percent of the GDP.

Table 1. GNP and GDP Real Growth Rates, 1991–1997

	1991	1992	1993	1994	1995	1996	1997
GNP	0.34	1.27	1.48	5.26	4.87	7.24	5.30
GDP	-0.58	0.34	2.12	4.40	4.67	5.85	5.17

Source: National Productivity Database, DAP-PDC.
Unit = percent.

Table 2. Sector Growth Rates and Share of GDP, 1992–1997

	1992	1993	1994	1995	1996	1997
Agriculture						
Growth rate	0.4	2.1	2.6	0.9	3.8	2.9
Share (%)	22.8	22.8	22.4	21.5	21.1	20.7
Industry						
Growth rate	-0.5	1.7	5.8	7.0	6.2	6.1
Share (%)	34.4	34.2	34.7	35.4	35.6	35.9
Service						
Growth rate	1.0	2.5	4.2	5.0	6.4	5.5
Share (%)	42.8	43.0	42.9	43.0	43.3	43.4

Source: Philippine Council for Productivity, *1997 Annual Report*.

Industrial growth (consisting of manufacturing, mining and quarrying, construction, and utilities) was also on an upward trend from 1992–1997. Contributing about 35.0 percent of domestic growth, the industrial sector registered an average growth of 4.4 percent from 1992-1997. The manufacturing sector, which contributes about 25 percent of the GDP, also increased by 4.4 percent, on average, from 1993 to 1997.

The agriculture sector averaged growth of over 2 percent from 1992–1997. However, the contribution of the agriculture sector to GDP exhibited a downward trend during this period.

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[3] This data is primarily drawn from the Philippine Council for Productivity's *1997 Annual Report*.
[4] Philippine Council for Productivity, *1997 Annual Report*, Manila, 1998.

Overall, economic data and trends indicate that the service sector is providing the impetus for growth in overall output and employment.

Sources of Economic Growth

Over the last six years, the growth in GDP can be traced to new investments. Estimates of the country's capital stock show an average growth of 5.16 percent, and the contribution of capital to domestic production has been growing at an average of 3.4 percent per year. During the same period, employment grew at an average of 3.23 percent per year, and its contribution to domestic growth increased annually at 1.09 percent on average (Table 3).

Table 3. Percent of Growth Rates in Capital, Employment, and Total Factor Productivity (TFP), 1991–1997

	1991	1992	1993	1994	1995	1996	1997
Capital	4.31	4.56	4.80	5.09	4.96	5.53	6.03
Capital contribution to GDP growth	2.49	2.61	3.26	3.46	3.38	3.74	3.97
Employment	3.16	3.41	2.89	2.66	2.58	5.88	1.95
Labor contribution to GDP growth	1.31	1.44	0.91	0.84	0.81	1.87	0.66
TFP	-4.38	-3.72	-2.06	0.10	0.48	0.24	0.54

Source: National Productivity Database, DAP-PDC.

The growth in capital stock can be attributed to growing investments, particularly direct foreign investments (DFI). Table 4 shows that value of investments approved by the Board of Investment (BOI) and the Philippine Economic Zone Authority (PEZA) boomed from 1993–1996. The high level of investment was a result of the overall improved macroeconomic environment and the political stability of the country. Accordingly, the investments generated substantial new employment that peaked at approximately 6 percent growth –the highest level achieved since 1992 (Table 3). However, unemployment remains a concern with the unemployment rate at approximately 10 percent and 14–20 percent underemployed.

It should also be noted that rising growth rates alone do not indicate "sustainable" economic growth. The sustainability of any economic expansion is ultimately tied to the nature of the new investments, the quality of employment generated, the manner and speed with which resources are consumed, and other similar aspects of the expansion. Increasingly efficient resource utilization, as demonstrated through improvements in productivity, is particularly important for judging the quality of economic growth, and is also central to the concept of Green Productivity. It is the opinion of this author that the pattern of economic growth in the Philippines indicates significant inefficiencies in the economic system. To date, growth has depended heavily on new inputs into the economy (capital/investment) rather than improving utilization of existing resources. This issue will be discussed in more detail in the following sections.

Table 4. BOI-Approved Projects and Investments in PEZA by Sector, 1990–1996
(Covers new and expansion projects with incentives)

	1990	1991	1992	1993	1994	1995	1996
A. BOI-Projects							
Domestic	73,963	63,292	31,088	52,308	387,730	279,334	368,156
Manufacturing	18,828	35,661	13,547	21,348	148,879	131,580	24,521
Agriculture	768	537	988	1,496	2,353	1,255	4,591
Mining	7,193	1,843	411	93	1,936	805	5,895
Energy-related proj.	23,420	20,140	14,341	27,011	118,037	13,164	13,855
Tourism-oriented	12,852	3,004	481	492	8,580	3,428	13,707
Public utilities	3,477	966	685	1,319	85,811	122,522	36,163
Others	7,425	1,141	635	549	22,134	6,580	269,424
Export	25,932	10,887	8,537	17,462	63,625	19,945	14,309
Manufacturing	22,939	9,694	5,885	14,866	58,837	17,941	11,175
Agriculture	386	924	2,536	681	1,206	1,078	292
Mining	2,607	269	100	1,915	3,582	926	2,842
Energy-related proj.	0	0	0	0	0	0	0
Tourism-oriented	0	0	0	0	0	0	0
Public utilities	0	0	0	0	0	0	0
Others	0	0	16	0	0	0	0
Total	**99,895**	**74,179**	**39,625**	**69,770**	**451,355**	**299,279**	**382,465**
B. PEZA Investments	nd	nd	nd	nd	52,243	65,342	104,121

Source: Board of Investment (BOI) and Philippine Economic Zone Authority (PEZA).
Unit: million pesos.

Productivity performance

Despite new investments and growth in employment during the Ramos administration (1992–98), the overall improvement in GDP was undermined by negative growth in Total Factor Productivity (TFP). From 1991 to 1997, the TFP grew at an average of -1.26 percent. However, the general trend of increasing TFP growth suggests an emerging ability to improve the utilization and quality of both capital and labor. In 1997, the TFP of the Philippines grew at a rate of 0.54 percent compared to 0.24 percent in 1996. This growth was due to an increase in labor productivity.

On the sector level, industry and services posted a greater increase in real labor productivity than agriculture, rising from P42,820 per worker in 1992 to P43,184 per worker in 1997 (Table 5). In terms of growth rate, however, agriculture achieved the highest rate in the period since 1994. This has been attributed to the increased productivity in the livestock and poultry sub-sectors from 1994 to 1997, as well as a general shift towards the production of high-yielding crops. Capital productivity also improved, as measured in terms of incremental capital-output ratio (ICOR). ICOR dropped from 13.6 in 1992 to 4.8 in 1997 (Table 5).[5]

Table 5. Real Labor Productivity and Incremental Capital-Output Ratio, 1992-1997

	1992	1993	1994	1995	1996	1997
Total labor productivity						
Level (P)	30,340	30,111	30,616	31,269	31,234	32,221
Growth (%)	(2.97)	(0.76)	1.68	2.13	(0.11)	3.16
Agriculture						
Level (P)	15,250	14,997	15,486	15,506	15,410	16,326
Growth (%)	(3.69)	(1.66)	1.26	2.11	(0.62)	5.94
Industry and services						
Level (P)	42,820	42,823	43,284	43,360	43,088	43,184
Growth (%)	(2.35)	0.01	1.08	0.18	(0.63)	0.22
Incremental Capital Output Ratio (ICOR)	13.61	10.51	4.34	4.51	3.33	4.76

Source: Philippine Council for Productivity, *1997 Annual report*.

Looking at productivity performance alone, one can be misled into thinking that productivity is indeed driving the economy towards sustainable growth. However, economic development has come at a steep cost. In the succeeding sections, a review of the country's environmental condition will show the impact of poor domestic and industrial pollution control. This is intended to highlight the importance of Green Productivity in achieving sustainable economic growth.

Current Economic Strategies and Directions[6]

The current economic policies and programs of the Philippines are founded on the premise that the new century will bring a closer and more highly integrated global economic community. Hence, programs have been designed based on two parallel and mutually supportive themes: "free enterprise" and "economic democracy."

To allow the productive forces of free enterprise to operate, the government will ensure that sectors liberalized during the previous Administration remain liberalized and deregulated. In addition, the Estrada administration will remove the remaining government regulations and artificial restrictions that hamper the operation of productive market forces in other sectors.

[5] Philippine Council for Productivity, *1997 Annual Report*, Manila, 1998. Falling ICOR values demonstrate that more output is being produced per additional unit of capital.

[6] This section draws heavily from the "*Ten-Point Action Program of an Estrada Presidency*," Unpublished Material, 1998.

Under the principles of economic democracy, government economic programs will place special emphasis on aiding those sectors that were not given equal economic opportunity to develop in the past. The government will dismantle monopolistic privileges in certain sectors and privatize some public functions to eliminate state competition with the private sector.

In line with these two major strategies, the current Administration has adopted the following economic agenda:

1. Pursue reforms in fiscal and monetary policy;
2. Establish a prudent budgetary policy and greater fiscal discipline by eliminating unnecessary government spending, while maintaining budget support for development priorities;
3. Accelerate the implementation of infrastructure development with increased private sector participation;
4. Pursue agricultural modernization to boost productivity and achieve food security;
5. Provide credit to small and medium-sized enterprises (SMEs) to develop a competitive position in the service industries, particularly health, information technology, and tourism; and
6. Participate actively and support commitments to the global economic community.

ENVIRONMENTAL PROFILE

The Philippines is well-positioned to move with the other rapidly industrializing economies of the world in the new millennium. This inevitable progress also brings with it the danger of increasing pollution and environmental degradation. While the Philippines is facing the challenge of preventing further environmental degradation, the country also has to deal with other problems such as its rapidly growing population and public security.[7]

To address these social challenges and still achieve growth that is sustainable and meaningful, the Philippines must carefully weigh its options and utilize its resources in an optimal manner. The proper management and utilization of the country's remaining resources is an important aspect of its development strategy. Sound management requires maintaining a sound resource base, developing a long-term vision for future generations, and implementation of effective strategies towards this vision. This section of the study will examine the current environmental status of the Philippines, existing policy tools, compliance performance, and opportunities for the promotion of Green Productivity.

Environmental Quality in the Philippines

While the performance of the Philippine economy has been characterized by "ups and downs," the environmental performance of the country cannot easily be assessed with the limited data available. However, on the basis of natural resource consumption,

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[7] This section draws heavily from the Environmental Management Bureau, DENR, *Philippine Environmental Quality Report, 1990–1995*, Manila, 1996.

the rate of increase in domestic and foreign investments is likely indicative of the trends in natural resource consumption.

It should be noted that during the 1980s, the government aggressively promoted large-scale industrialization to reduce imports and correct the country's balance of payments deficit resulting from a high trade deficit. The protection created through high tariff and nontariff barriers has affected the overall competitiveness of local industry and resulted in widespread inefficient use of energy and materials, as well as utilization of "dirty" equipment and technologies. This section reviews the overall environmental quality of the Philippines and the primary sources of pollution.

Emissions status[8]

The country ended the decade of the nineties still saddled with major air quality problems, particularly in its prime metropolis: Metro Manila. Based on the latest data available, the air pollution in Metro Manila reached alarming levels with the principal sources being motor vehicles (63 percent), power plants (29 percent), and industrial activity (8 percent). Table 6 provides a summary of emissions from all sources in Metro Manila in 1990. While no recent data are available, it is unlikely that the situation has improved substantially over the last ten years.

According to the 1990 Environmental Management Bureau's (EMB) Emissions Inventory, stationary sources were the largest emitters of SO_x with electric power generating plants contributing the lion's share (87 percent). Other significant emission sources were the pulp and paper, food manufacturing, primary metals, lumber and wood products, and chemical manufacturing industries.

Sources such as construction, gasoline dispersion, aircraft operation, etc., individually would not seem to contribute significantly to the air pollution problem. However, the EMB inventory showed that they generated significant amounts of particulate matter as a group, accounting for 82% of the total PM and 73% of the total PM_{10} emissions in Metro Manila.

The above characterization of the air quality in Metro Manila indicates that much room for improvement remains. While Green Productivity offers opportunities to prevent, reduce, and/or control air pollution, the use of policy measures appears to be a more practical approach considering that motor vehicles are the main source of pollution. Data are not available for other parts of the Philippines.

Water quality and wastewater impact[9]

Periodic water supply shortages plagued some areas of the country from 1992–1998, indicating the threats facing the country's freshwater resources. While total supply still exceeds demand, water quality has been deteriorating at a considerable rate since the early 1990s, foreshadowing grave problems ahead. By the year 2000, some regions, notably Central Luzon (Region 3) and Western Visayas Regions (Regions 6 and 7) have been projected to experience acute water shortage problems. To fend off this looming crisis, the government passed the Water Crisis Act and held a Water Summit in 1994.

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[8] Statistics drawn from: Environmental Management Bureau, DENR, *Philippine Environmental Quality Report, 1990–1995*, Manila, 1996.

[9] Ibid.

Table 6. Summary of Emissions from All Sources in Metro Manila, 1990

Pollutants	Source category *(tons per year)*			
	Mobile	**Stationary**	**Area**	**Total**
TOG	100,954	1,816	5,162	107,932
%	93.53	1.68	4.78	100.00
CO	572,626	4,046	525	577,197
%	99.21	0.70	0.09	100.00
NO_x	66,216	13,418	276	79,910
%	82.86	16.79	0.35	100.00
SO_x	10,350	78,094	12	88,456
%	11.70	88.29	0.01	100.00
PM	13,220	9,323	102,286	124,829
%	10.59	7.47	81.94	100.00
PM_{10}	11,540	7,494	51,042	70,076
%	16.47	10.69	72.84	100.00

Source: Environmental Management Bureau.

Human settlements, industry, and agriculture have heavily polluted both inland and coastal waters. In 1992 alone, some 6.2 million metric tons of BOD were discharged nationwide. Domestic sewage still contributes approximately 52 percent of the total pollution load, while agriculture and industry contribute the remaining 48 percent. Table 7 shows a breakdown, by industry sector, of the estimated BOD generated and discharged in the Philippines. This continuing pollution could seriously compromise the country's water resources for domestic, agricultural, and industrial uses. As a result of pollution, 50 of 421 rivers in the Philippines are considered biologically dead, including all five major river systems in Metro Manila.

The rapidly declining quality of remaining fresh water sources demands an effective campaign to slow deterioration and facilitate rehabilitation efforts. This situation also suggests the need for effective promotion of Green Productivity concepts (particularly within industry) to encourage the adoption of relevant techniques and management systems to reduce wastewater discharge.

Land use status and solid waste problems[10]

Land, particularly arable land, is an extremely important natural resource for the Philippines. Over the last several decades, however, the country's landscape has undergone substantial changes and land degradation is becoming one of the most serious problems confronting the agricultural sector.

The causes of degradation include soil erosion, heavy use of agricultural chemicals (fertilizers and pesticides), and contamination from heavy metals. Land conversion also threatens to result in the irreversible loss of prime agricultural lands. The encroachment of settlements and industrial activities into agricultural areas is highly visible in regions such as Central Luzon (Region 3) and the Southern Tagalog Provinces (Region 4).

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[10] Ibid.

Table 7. Biological Oxygen Demand (BOD) Estimates by Industry Sub-sector, 1992

Industry sub-sector	BOD generated *(tons per day)*	BOD discharged *(tons per day)*
Food processing	212.9	100.9
Piggeries	162.2	104.1
Beverages	58.4	22.3
Dyes and textile	48.6	24.9
Petrochemical/Chemical	25.1	16.8
Leather tanning	14.3	10.4
Pharmaceutical	12.1	2.0
Metal finishing	9.0	6.6
Commercial laundries	4.9	3.5
Hospitals/Clinics	4.7	4.7
Electronics	4.6	3.7
Pulp and paper	4.1	2.3
Automotive	1.3	0.8
Construction	0.2	0.2
Paints and solvents	0.2	0.2
Batteries	0.1	0.1
Total	**562.7**	**303.5**

Source: Industrial Efficiency Pollution Control Project, 1992.

From 1960 to 1990, data showed that there was a steady increase in alienable and disposable (A&D) lands, almost 90 percent of which have been converted to agricultural production. Total area increased by 7.45 percent from 11,883,353 hectares (39.6 percent of the country's total land area) in 1960 to 14,117,729 hectares in 1990. The data on the country's A&D and agricultural lands for the period 1960–1994 are given in Table 8.

Improper disposal of solid waste is also having an impact on the quality of land in the Philippines. In 1998, Metro Manila alone generated an estimated 6,000 tons of household and industrial solid waste per day. Solid waste volume is projected to increase to 13,300 tons per day by the year 2014.[11] The poor disposal techniques used at the community level further increase the damage caused to land quality by solid waste. Considering the scope of Green Productivity techniques, the current situation presents numerous opportunities for waste minimization, resource recovery, recycling, and reuse initiatives as part of a broad-based Green Productivity program.

Environmental Agencies

The primary agency involved with the development of environmental laws and policies in the Philippines is the Department of Environment and Natural Resources (DENR). Ensuring that sustainable development principles are implemented in the country is the responsibility of the Philippine Council for Sustainable Development (PCSD).

[11] JICA-MMDA, *Study on Solid Waste Management for Metro Manila–Progress Report (1)*, Manila: 1997.

Table 8. Agricultural Lands as Part of Alienable & Disposable Lands, 1960–1994

Year	Alienable & disposable lands		Agricultural lands		Lands devoted for rice and corn	
	Area *(ha)*	**% of total**	**Area** *(ha)*	**% of total**	**Area** *(ha)*	**% of total**
1960	11,883,353	39.60	7,596,000	63.92	5,152,000	67.82
1970	12,572,433	41.90	8,946,600	71.16	5,533,000	61.84
1980	13,269,340	44.23	12,155,400	91.60	6,669,500	54.87
1990	14,117,729	47.06	13,096,300	92.76	7,138,300	54.50
1993	14,117,244	47.05	12,549,400	88.89	6,431,700	51.25
1994	14,172,244	47.06	13,087,300	92.70	6,657,300	50.87

Source: Philippine Statistical Yearbook, 1988, 1993, 1994, and 1995.
Unit: Hectares.

Department of Environment and Natural Resources

The Department of Environment and Natural Resources is the primary government agency responsible for the conservation, management, development, and proper use of the country's environmental and natural resources. In pursuit of its mandate, the DENR issued policies and related administrative orders, implementation rules, and regulations for the protection and enhancement of environmental quality. The department also established a number of environmental management programs and projects, some of which directly impact on business and agricultural activities. In recent years, there has been a shift away from a pure command-and-control approach that relies on penalties to a preventive, self-regulated strategy that focuses on promoting the importance of environmental compliance to business success.

A review of recent budgets (Table 9) shows that DENR's total budget has been decreasing since 1990. The proportion allocated for the monitoring and control of polluting activities is indirectly shown through the budget of the Environmental Management Bureau (EMB) and the DENR Regional Environmental Management Sectors. These agencies supervise the implementation of regulations and standards at the local level. While the agencies have seen their allocation increase to allow for improved monitoring and inspection, they still only receive a small portion of the total DENR budget. Allocations to EMB ranged from a low .004 percent of the total DENR budget in 1991 and 1992 to 2.1 percent in 1995. Regional EMS allocations started at .006 percent in 1991 and later rose to 3.8 percent in 1995.

The Philippine Council for Sustainable Development (PCSD)

The PCSD was created on September 1, 1992 by Executive Order No. 15. The PCSD is mandated to ensure that sustainable development principles are implemented in both local and international policy.

The PCSD is chaired by the Director-General of the National Economic Development Authority (NEDA), and vice-chaired by the Secretary of the Department of Environment and Natural Resources. Some 14 government departments and seven

Table 9. Budget for Environmental Management, 1990–1995

Year	DENR	EMB	Regional EMS
1990	4,549,610,000	36,804,000	33,669,000
1991	3,737,663,000	20,250,000	31,258,000
1992	4,631,481,000	21,633,000	35,988,000
1993	3,665,127,000	21,078,000	79,873,000*
1994	4,370,104,000	46,349,000	89,419,000*
1995	3,231,900,000	68,736,000	121,414,000

Source: Philippine Appropriations Act, 1990–1995.
Note: * Including congressional insertion.

non-governmental/people's organizations (NGO) are members of the Council. A composite secretariat comprised of NEDA, DENR, and NGO groups serves the PCSD. The Philippine Institute for Alternative Futures (PIAF) currently serves as the NGO representative in the secretariat.

The PCSD operates through four committees and their respective sub-committees. The committees correspond to the major chapter concerns of the Global Agenda 21. Figure 1 depicts the structure of the Council. Every Committee/Sub-Committee has a government agency chair and vice-chair as well as an NGO co-vice-chair.

Among the past and present initiatives of the PCSD are the following:

- Formulation of the Philippine Agenda (PA) 21;
- Quarterly Meetings with the Philippine President;
- Incorporation of the Principles of Agenda 21 into the development plans and budgets at the national, regional, and local government levels;
- Supporting the "Movement for Clean Air"[12];
- Formulation of the Philippine Strategy for Biological Diversity Conservation (PSBDC);
- Providing lead roles to NGO's in the implementation of NGO-Initiated Projects in the Philippines;
- Ratification of the Basel Convention;
- Hosting of the International Experts Group Meeting on Operationalizing the Economics of Sustainable Development on July 28–30, 1994;
- Preparation of Philippine positions for various international forums;
- Review and integration of sustainable development activities into the budget of the Philippine government; and
- Conference on sustainable agriculture.

Environmental Policies and Regulatory Framework

The system of environmental laws in the Philippines covers all stages of project development from planning and operation to decommissioning. The regulations, permits, sanctions, and incentives of major environmental laws are described in the succeeding sections.

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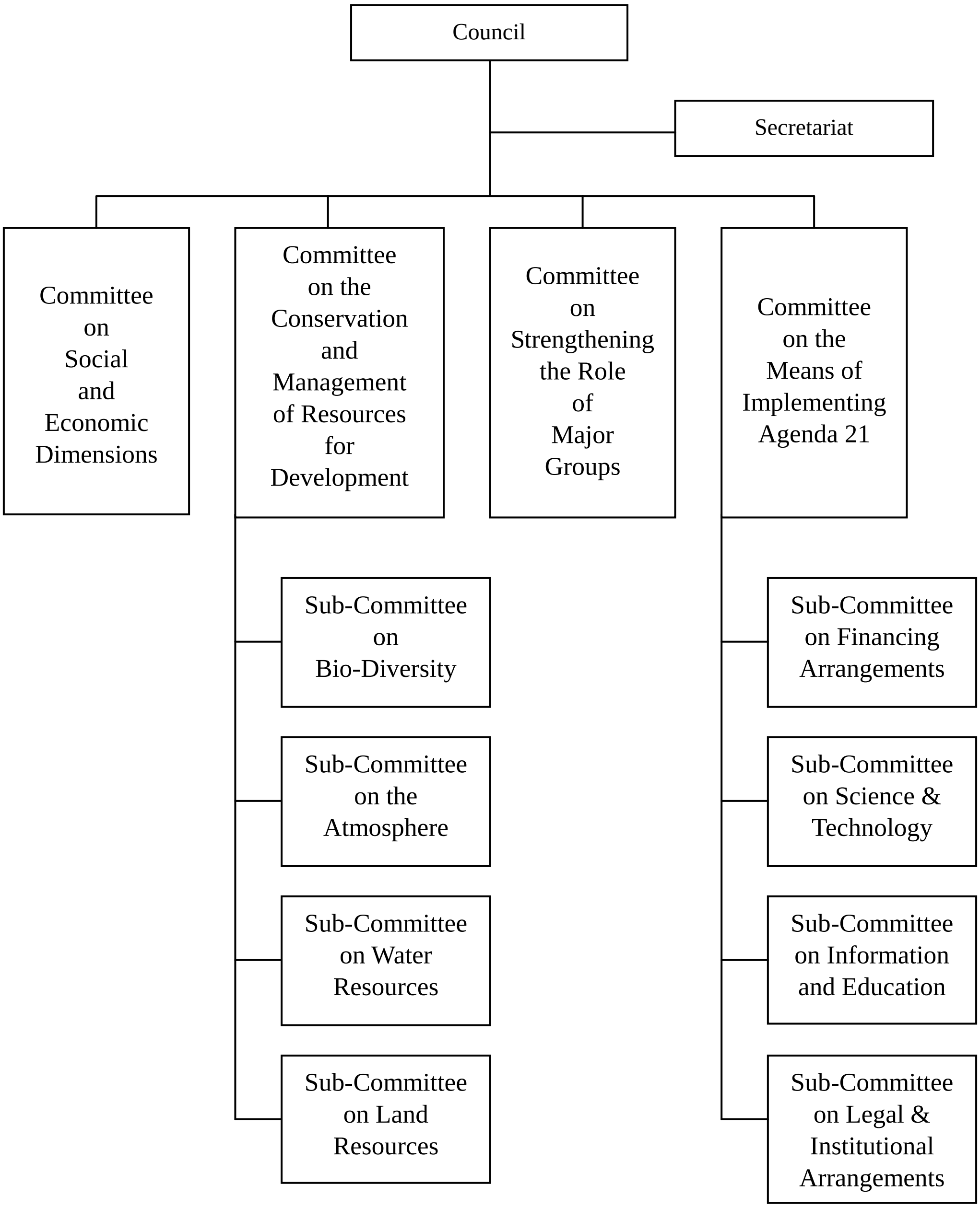
[12] This refers to an effort to ensure the passage of the Clean Air Act. The Act has been approved.

Figure 1. Organizational Structure of the PCSD



Philippine Environmental Policy and Environmental Code (PD 1151 and 1152)

The integrated environmental protection and natural resource management policy of the Philippines was established on June 6, 1977 through the issuance of Presidential Decrees (PD) 1151 and 1152 (also called the Philippine Environmental Policy and Environmental Code). PD 1151 declared three environmental policies for the state:

"…(a) to create, develop, maintain, and improve conditions under which man and nature can thrive in productive and enjoyable harmony with each other, (b) to fulfill the social, economic, and other requirements of present and future generations of Filipinos, and (c) to insure the attainment of an environmental quality that is conducive to a life of dignity and well-being."

The above policy statements addressed the need for equal emphasis on environmental protection and economic development in order to provide for the needs of present and future generations of Filipinos. PD 1151 clearly captures the spirit of Green Productivity with its emphasis on the need to balance economic and environmental concerns.

In addition, PD 1151 also mandated the creation of the environmental impact statement system.

"…all agencies and instrumentalities of the national government-owned or controlled corporations, as well as private corporations, firms, and entities, shall prepare, file, and include in every action, project, or undertaking which significantly affects the quality of the environment a detailed (environmental) statement"

Under PD 1152, the overriding concern was the establishment of policies and standards to protect environmental quality. It mandated the implementation of a "comprehensive program of environmental protection and management which includes air and water quality, and waste management." PD 1152 also provided the regulatory framework for land-use, as well as natural resource management and conservation. The air and water quality management outlined by PD 1152 included standards, supporting regulations, and enforcement (monitoring, surveillance, and licensing/permitting of pollution control facilities).

Pollution Control Law (PD 984)

Prior to PD 1151 and PD 1152, PD 984 was introduced in 1976 specifically to regulate industrial activities impacting air and water quality. PD 984 still serves as the foundation for managing industrial activity in the Philippines. The Decree empowered the DENR to impose ex-parte cease and desist orders (CDO) *"on grounds of immediate threat to life, public health, safety or welfare, or to animal or plant life or when wastes or discharges exceed the allowable standards."* A CDO is an order given by DENR to stop the operation of pollution generating activities, machinery, or equipment.

Philippine Environmental Impact Statement System (PD 1586)

Presidential Decree 1586 can be considered the most effective regulatory mechanism among current legislation for controlling site selection for new projects. To ensure that industry planning is carried out with due regard to its potential impact on the environment, PD 1586 mandates government agencies, government-owned and controlled corporations, and private companies to conduct an environmental impact assessment (EIA) on any project or activity that potentially will affect environmental quality.

Projects located in an environmentally critical area, or considered environmentally critical (as defined by Presidential Proclamation 2146), are required to perform an EIA. Areas considered environmentally critical include: national parks, wildlife preserves, potential tourist spots, habitats of endangered or threatened species, historic archaeological areas, areas occupied by cultural communities, areas that frequently suffer natural calamities, prime agricultural land, high slopes, water bodies, mangrove, and coral reefs. A project is critical if it falls under any of the following categories: heavy industries (non-ferrous metal industries, iron and steel mills, petroleum and petrochemical industries, smelting plants); resource extractive (major mining and quarrying, forestry, and fishery projects); or infrastructure (major dams, major power plants, major reclamation, major roads and bridges). Currently, projects considered environmentally critical must prepare an environmental impact statement (EIS) as part of the EIA process while those located in critical areas are only required to submit a project description. The difference between the two procedures is that an EIS requires a more thorough assessment of the environmental impact of the project and incorporates a more comprehensive public participation process.

Toxic Substances and Hazardous and Nuclear Wastes Control Act (RA 6969)

Republic Act (RA) 6969 was introduced in 1990 to respond to increasing public health and environmental risks associated with toxic chemicals and hazardous and nuclear wastes. RA 6969 mandates the control and management of the import, manufacturing, processing, distribution, use, transport, storage, treatment, and disposal of toxic substances and hazardous and nuclear wastes.

Violations of RA 6969 carry stiffer sanctions than PD 1586 and PD 984. Administrative violations carry imprisonment from six months to six years and a fine between P600–P500,000. Violations include failure or refusal to submit reports, obstruction of entry for DENR inspection, failure to comply with pre-manufacture/ importation requirements, failure or refusal to allow testing of chemical substances when required, and failure to comply to a subpoena.

Regulatory Strategies

To implement the aforementioned laws and decrees, the Department of Environment and Natural Resources has adopted a series of measures combining command-and-control regulations with programs to promote the prevention and minimization of pollution.

Air and water pollution control

To implement PD 984, DENR crafted Administrative Orders (DAO) 34 and 35 series of 1990 and DAO 14 series of 1992 to control effluent and emission levels of industrial wastes discharged into the environment. DAO 34 classifies water quality for all fresh water, coastal, and marine areas according to the most beneficial use. DAO 35 establishes effluent regulations controlling the discharge of BOD, metals, pH, solids, organic compounds, and temperature of the effluent. The effluent standards for industries generating wastes are given in Table 10. For air emission control, DAO 14 provides air quality standards and regulations emphasizing the need to limit particulate, NO_x, SO_2, and H_2S emissions.

Table 10. Effluent Standards for New Industries or Generators of Strong Wastes

Industry classification based on BOD of raw wastewater	Maximum allowable limits in mg/l based on receiving body of water	
	Inland waters *(Class C & D)*	**Coastal waters** *(Class SC & SD)*
A. Industries producing within 3,000 to 10,000 mg BOD per liter	130 or 98% removal	200 or 97% removal
B. Industries producing within 10,000 to 30,000 mg BOD per liter	200 or 99% removal	600 or 97% removal
C. Industries producing more than 30,000 mg BOD per liter	300 or 99% removal	900 or 97% removal

Source: DENR-Environmental Management Bureau.

Air and water quality standards are enforced through monitoring, permitting, fines, and closure of pollution sources. The DENR Regional offices issue two kinds of permits under PD 984. The first is the authority to construct (AC) which is issued before the construction of a pollution source. Next, DENR issues the annual permit to operate (PO) which authorizes the holder to operate the pollution sources. Violations of PD 984 and DAO 14, 34, and 35 include an administrative fine of not more than PhP 5,000 per violation, closure for non-payment of fine, CDO, and two to six years of imprisonment.

PD 984 also offers incentives to companies that voluntarily participate in the Pollution Management Appraisal (PMA) program of the Industrial Environmental Management Project (IEMP). As contained in DAO 17 series of 1993, industries that participate in the PMA are given a one-year moratorium on compliance with effluent and emissions standards upon demonstrating their commitment to minimize their wastes.

Hazardous and toxic waste management

Republic Act 6969, implemented by DAO 29 series of 1992, regulates the range of activities associated with hazardous and toxic materials (use, transportation, storage, export, distribution, manufacture, and processing). Users or handlers of chemicals must first check with DENR whether the substances are included in the Philippine Inventory of Chemicals and Chemical Substances (PICCS). A Chemical Control Order (CCO) prohibiting, limiting, or subjecting use to certain controls or conditions may be issued for chemicals that pose an unreasonable risk to public health or the environment.

Environmental Impact Management System

An on-going innovation under the EIS system is the introduction of programmatic compliance. Under this program, industries sited in declared industrial development areas may be issued a single Environmental Compliance Certificate (ECC). This approach has the advantage of reducing the cost of document preparation and review. Furthermore, it justifies the future application of carrying capacity assessments to determine the number and types of industries that should be allowed to locate in a given area.

Environmental Management Programs

The start of the 1990s saw a small shift in regulatory strategies, but no significant changes in the structure of the Philippines' environmental laws. Traditional command-and-control methods continued to be the primary means of enforcement however, now the government has started to consider more innovative measures such as market-based instruments and participatory approaches. It also has adopted a more proactive approach to encouraging industry to improve its performance by providing technical assistance on environmental management. The government outreach programs focused primarily on waste minimization for industry and local government units (LGU). In the following sections, the structures and budgets of programs to prevent pollution are discussed to provide an overview of Green Productivity-related initiatives in the Philippines.

Industrial Environmental Management Project (IEMP), 1993–1996

The IEMP was a four-year project supported by the United States Agency for International Development (US-AID) to demonstrate the cost benefits of waste minimization in 150 volunteer firms. The project involved the implementation of training and on-site pollution management appraisal (PMA). In exchange for their participation and willingness to become industry models, participants were given a one-year moratorium on environmental monitoring. Table 11 summarizes the results of this project.

Pasig River Rehabilitation Program (PRRP), 1991–present

The PRRP was implemented by the River Rehabilitation Secretariat of the DENR with grant support from the Danish International Development Agency (DANIDA). A major component of the program focuses on waste minimization activities for the food, textile, and pulp and paper industries. The PRRP has thus far resulted in the establishment of several community-based waste management schemes and has reduced the BOD load of the Pasig River from 327 to 230 metric tons per day. The project aims to further reduce BOD loading to 35 metric tons by the year 2005.

Philippine–German Project on Industrial Pollution Control in Cebu (IPCC), 1991-1996

The IPCC was a five-year project implemented in Metro Cebu to introduce mechanisms for the proper management of toxic and hazardous waste, particularly from metal finishing operations. The program stressed waste minimization approaches.

Asian Environmental Improvement Project (AEIP), 1993–1996

The AEIP was a project funded by US-AID that provided management and technical assistance in three areas: (1) policy development and institution-building for implementation of effective environmental programs and policies; (2) technology transfer and training on waste minimization and prevention; and (3) technology commercialization and investment promotion. The project also conducted waste reduction assessments for the iron and steel industries.

Private Sector Initiative for Managing the Environment (PRIME), 1998–2002

PRIME is a project supported by the United Nations Development Program (UNDP) that aims to support government regulatory mechanisms by strengthening

Table 11. Results of IEMP Project, 1993–1996

Industry sub-sectors	No. of firms	Investments on WM *(Pesos)*	Est. annual benefits *(Pesos)*
Poultry and swine raising	14	22,493,300	22,870,400
DCN	10	2,476,800	29,028,800
Coconut oil	10	5,031,000	24,553,700
Tuna canning	11	24,865,500	54,939,800
Seaweeds	6	853,600	19,325,000
Other seafood	2	76,400	235,300
Fruit canning	4	5,171,100	1,850,700
Starch manufacturing	4	3,172,600	218,826,800
Soft drink bottlers	2	5,037,200	5,959,300
Slaughtering	5	509,100	1,618,700
Distilled spirits	3	2,166,300	8,048,600
Pulp & paper	7	25,593,900	11,331,700
Wood products	3	15,565,300	38,467,600
Metal finishing	8	6,028,000	10,221,100
Tanneries & leather	2	673,800	274,100
Industrial chemicals	6	495,600	3,296,400
Sugar milling	13	48,461,000	86,413,500
Cement	2	381,948,500	276,190,000
Others	6	405,900	1,358,600
Totals	**118**	**551,024,900**	**814,810,100**

Source: IEMP.

"emerging private sector initiatives" to minimize environmental impacts. PRIME has four main elements: (1) the development of a Business Agenda 21 to serve as a blueprint for private sector involvement and action; (2) promotion of industrial ecology concepts among industrial estates; (3) promotion of industry self-regulation through EMS implementation in SMEs; and (4) environmental entrepreneurship. The Bureau of Product Standards of the Department of Trade and Industry (DTI-BPS) is implementing this four-year project in cooperation with the Philippine Association of Environmental Assessment Professionals (PAEAP).

Industrial Initiatives for a Sustainable Environment (IISE), 1998–2002

The IISE, formerly the Municipal Coastal Environment Initiative (MCEI), is funded by US-AID. DENR is responsible for program supervision and Chemonics International is implementing the project. The IISE aims to promote the widespread adoption of environmental management systems (EMS) and cleaner production techniques and practices among Philippine industries. The target industries are those located along or affecting coastal areas within the Visayas and Mindanao regions. Ultimately, the program aims to reduce industrial pollution in these coastal areas.

Promotion of ISO 14000 Series

In the Philippines, the EMS standards that have been adopted are based on the ISO 14000 series. At present, the ISO 14000 environmental management standards that have been adopted as the Philippine National Standards (PNS) are: (1) ISO 14000 as *PNS 1701, EMS-Specification with Guidance for Use*; and (2) ISO 14004 as *PNS 1704, EMS General Guidelines on Principles, Systems and Supporting Techniques*. These two standards are intended to guide businesses towards self-assessment and registration/certification.

The promotion of these standards was implemented primarily by the DENR and by the Bureau of Product Standards of the Department of Trade and Industry (DTI-BPS) in conjunction with other private organizations. However, only 20 companies were certified as of 1998.

Status of Environmental Compliance[13]

Environmental Impact Assessment and Management

The implementation of EIA requirement continues to be the main means for the government to ensure that environmental dimensions are incorporated into the planning of development projects. From 1990 to 1995, the Environmental Management Bureau of the DENR received a total of 2,137 applications for various projects nationwide, 303 or 14 percent of which were environmentally-critical projects. From 1990–1995, 1,056 Environmental Compliance Certificates (ECC) were issued (49 percent of the applications received).

To improve the EIA system, environmentally-critical projects were required to establish an Environmental Guarantee Fund (EGF) starting in the 1990s. Developers offer the EGF as an assurance that any damages arising from the project implementation will be paid for, and cash is available for, immediate implementation of rehabilitation measures. The EGF is governed through a Memorandum of Agreement between the developer and the DENR.

Implementation of the Pollution Control Law

The level of enforcement of PD 984 (the Pollution Control Law) can be estimated from the number of pollution cases resolved by the Pollution Adjudication Board (PAB). The Board is a quasi-judicial body that has been given authority to rule on pollution cases. From 1991 to 1995, the number of Cease and Desist Orders (CDO) issued by the PAB to erring firms declined from 142 in 1991 to 41 in 1995. In 1990, the DENR was able only to monitor 5,276 of the manufacturing facilities in the country. Based on the limited data for the period from 1990–1995, it appears that the number of firms monitored has been generally increasing.

Based on the limited data available on numbers of firms with permits to operate, compliance with regulations has generally been decreasing. Among Potentially Air Pollutive Firms (PAPF), the percentage of firms with permits to operate dropped from 57 percent in 1990 to 39 percent in 1995. However, the percentage of firms with air pollution control devices increased from 86 percent in 1990 to 98 percent in 1995. While

[13] Statistics drawn from: Environmental Management Bureau, DENR, *Philippine Environmental Quality Report, 1990–1995,* Manila, 1996.

the rise in the number of firms with air pollution controls is encouraging, it should be remembered that installation of a system does not guarantee compliance with standards. The same trend can be observed among Potentially Water Pollutive Firms (PWPF). The percentage of firms with permits to operate dropped from 40 percent in 1990 to 32 percent in 1995. However, the percentage of firms with water pollution control devices rose from 87 percent in 1990 to 92 percent in 1995.

Environmental Agenda of the Estrada Administration

The environmental agenda of the Estrada administration is focused on two areas: 1) combating the negative environmental trends; and 2) maintaining the integrity of the country's ecological zones.

Under the new environmental agenda, the government will pursue strict implementation of environmental laws, and polluting industries will be subjected to fines and/or closures. No large project will be approved without a valid Environmental Impact Assessment and a Social Impact Assessment. To hasten the implementation of this policy, private sector groups will be deputized to enforce environmental laws. Proper natural resource accounting will also be pursued to cover the actual cost of environmental damages to society. Resource conservation is also a major focus and the government will seek to curtail the over-exploitation of natural resources. Conservation efforts will involve improving urban planning and the formulation of a national land use plan.

Environmental Performance of Small and Medium Enterprises

More than 90 percent of the businesses in Asian countries are small and medium enterprises (SMEs). In several countries around the region, SMEs employ over half of the workforce, contribute nearly half of the GDP, and produce 35 percent of exports according to a 1994 study by the PECC and Australian APEC Studies Centre. SMEs in the region generally employ less than 100 people and have capital of less than US$1.0M.

In addition to their economic contribution, SMEs are also responsible for a significant proportion of certain types of pollution. For example, recent studies conducted by national and donor agencies have demonstrated that different industry sectors discharge disproportionate amounts of pollution to surface water. It appears that a significant portion of toxic wastes in several Asian countries come from the SMEs operating in the textile processing, pulp and paper, metal surface finishing, leather processing, food processing, and plastics industries.

SMEs typically have difficulty controlling their environmental impact due to outdated process technology and lack of adequate pollution control equipment. Although they are often not the major polluters by total volume in their sectors, SMEs often pollute more per unit of output than large firms in the same sector. Typically, pollutants generated by SMEs are extremely heterogeneous and potentially hazardous. In many instances, SMEs find it difficult to analyze their complex pollution problems and are unable to identify appropriate, cost-effective countermeasures. Due to lack of adequate technical expertise and experience in handling pollution issues, many private sector support institutions such as industry associations/chambers of commerce are not well-prepared to assist SMEs.

Tackling the problem of SME environmental performance will require well-planned, coordinated efforts from both private sector industry groups and enforcement organizations. Government agencies are in the process of drafting new legislative measures to reduce and control the level of environmental pollution, however, legislation alone will not succeed. Raising awareness, ensuring access to adequate expertise and training, and building commitment among SME managers are the keys to long-lasting progress.

Definition and Characteristics of SMEs

In the Philippines, SMEs are classified based on the number of employees and total capitalization. According to the latest guideline issued by the Bureau of Small and Medium Business Development of the Department of Trade and Industry (DTI-BSMBD), all firms with less than 200 employees and total capitalization of less than PhP 60 million are considered small and medium enterprises (SMEs).

SMEs form the backbone of Philippine industry and services. Including cottage industries, 98 percent of businesses in the Philippines are SMEs and they account for 50 percent of total employment and 25 percent of the total value-added of the manufacturing sector. The majority of manufacturing companies in the Philippines are engaged in food processing and 45 percent of all food processors are classified as small and medium-sized companies. Table 12 shows that out of 89,180 SMEs in the manufacturing sector, almost half are involved in food processing.

The importance of SMEs is their contribution to the overall economic growth of the country. Collectively, however, they are also significant sources of localized pollution such as organic wastes in water effluent and hazardous wastes. Typically, SMEs are difficult for regulatory agencies to monitor and do not practice safe disposal techniques. The problem is compounded by the fact that most SMEs operate at marginal profitability and consider the costs of controlling pollution prohibitively high in relation to sales revenue. This situation also poses a problem for regulatory enforcement agencies since strict implementation may threaten the viability of a key economic sector.

Table 12. Distribution of SMEs in Manufacturing in the Philippines, 1993

Industry	Number of SMEs	Percentage distribution
Pottery, China and earthenware	456	0.51
Footwear	1,708	1.92
Textiles	1,894	2.12
Machinery except electrical	2,090	2.34
Wood & cork prods.	2,376	2.66
Non-metallic mineral	2,812	3.15
Furniture	5,719	6.41
Fabricated metals	8,714	9.77
Wearing apparel	14,135	15.85
Food	40,465	45.37
Others	8,811	9.88
Total	**89,180**	**100.00**

Source: National Statistics Office.

Environmental problems faced by SMEs

Small and medium enterprises are considered to be more efficient in generating income from often-limited financial and other resources than large companies. Yet, this is not matched by a corresponding efficiency in complying with environmental laws and regulations. A review of environmental compliance of industries revealed that a greater proportion of large firms were in compliance than SMEs. Environmental compliance is normally evidenced by the issuance of relevant permits or certificates by a responsible government agency.

Based on the criteria of environmental permits, many SMEs failed to comply with some, if not all, of the requirements of the Department of Environment Natural Resources and the Laguna Lake Development Authority (LLDA). In many cases, companies do not properly understand environmental regulations and fail to apply for the necessary permits. A second common occurrence is an under-estimation of the scale or extent of the environmental impact of the company's activities. Many SME managers mistakenly assume that they do not fall within legislated standards or requirements.

Broadly speaking, the challenges facing SMEs can be categorized into four areas:

- Lack of awareness or understanding of the applicable environmental legislation;
- Insufficient technical expertise on how to comply with requirements;
- Limited financial resources to acquire the technical services or hardware required to achieve compliance; and
- Owner-managers who either view compliance as a waste of time and money or unnecessary since many other SMEs are not complying also.

Given these problems, Green Productivity can provide a framework for effectively addressing compliance issues and simultaneously improving productivity performance. Practical and appropriate techniques and technologies can help reduce the cost of compliance by increasing output and profit potential while reducing wastes and optimizing the use of resources and facilities to produce marketable products/services. In particular, implementing a Green Productivity program may generate substantial savings to sustain improvement efforts and investments in improving environmental performance.

Current Programs and Projects for SMEs Relevant to Green Productivity

Wastewater Treatment Technology Transfer and Cleaner Production Demonstration Projects (WWTTT&CPDP), 1997–2000

The program is funded by AusAID and implemented through the Department of Science and Technology (DOST)-Industrial Technology Development Institute (ITDI). Intended for SMEs, the program aims to: 1) reduce waste generation; 2) improve the quality of wastewater discharged by factories; and 3) raise awareness about cleaner technology opportunities and waste minimization. The program includes implementation of one full-scale industrial demonstration project. Waste audits are conducted in participating factories and environmental improvement plans are prepared with support from program specialists. Seminars, workshops, and "train-the-trainer" activities are organized to facilitate technology transfer.

Environmental Management Plan Project (EMP), 1992–present

The EMP project is funded by the Swedish International Development Agency (SIDA) and implemented through the Development Bank of the Philippines (DBP). The project started in 1992 with a training program to enhance the technical capabilities of the

Environmental Management Bureau. The second phase provided technical assistance to selected industry sectors, including pulp and paper, cement, textile, semiconductors, and ship repair. Companies were given assistance in preparing self-monitoring plans (SMP) and environmental management plans that focus on waste minimization. The third phase focused on cocoa, canned fruits and vegetables, veneer and plywood, fish canning, and desiccated coconut industries.

Center for Clean Technology and Environmental Management (CTEM)

The establishment of the CTEM was funded by United States-Asia Environmental Partnership (US-AEP) and implemented by the Philippine Business for the Environment (PBE). The information center provides access to cleaner technology case studies. While it is not limited to SMEs, many of the reference materials are appropriate for SME needs.

Environmental Technology Assessment Center (ETAC)

The preparatory studies for the design and implementation of an Environmental Technology Assessment System were conducted with funding and technical assistance from UNDP and implemented by the United Nations Industrial Development Organization (UNIDO). The output of the study was a set of design recommendations for a center and network to support SMEs with environmental advisory and technical services with a focus on promoting cleaner production. The study recommended that the Industrial Technology Development Institute (ITDI) of the Department of Science and Technology (DOST) host the center. Government, academic, non-governmental resource organizations, and consultants will support center activities.

Green Productivity Advocacy and Development Program for SMEs (GPAD-SMEs), 1999–2000

The Green Productivity Advocacy and Development Program for SMEs (GPAD) was developed by the Productivity and Development Center of the Development Academy of the Philippines (PDC-DAP) and is supported by the Canadian International Development Agency-Private Enterprise Accelerated Resource Linkages Project (CIDA-PEARL). The concept of Green Productivity integrates environmental protection with productivity improvement. The GPAD-SMEs includes development of a GP advocacy program and GP champions, establishment of GP demonstration SMEs, networking, and infrastructure development.

Barriers and Incentives to GP Promotion among SMEs

The key barriers identified in the process of the implementation of the programs described in this paper are:

1. Limited information on productivity and environmental performance results in a low awareness about the impact and seriousness of the problems. Also, the lack of information about the costs and benefits of Green Productivity options discourages interest in GP activities;
2. The existence of several policy barriers such as strict regulatory requirements that companies are unable to meet. The typical result is that companies either hide their activities from enforcement agencies or shift their investments to more loosely regulated industry sectors;

3. Companies having limited technical expertise do not understand how to achieve compliance or implement productivity and environmental management techniques;
4. The existing GP-related programs and projects are limited in scope and coverage. There is also an insufficient number of qualified, affordable service providers and information sources on best practices; and
5. The overall economic and competitive situation discourages companies from investing in low value-added activities.

Balanced against the aforementioned barriers are a number of drivers encouraging SMEs to adopt Green Productivity practices including:

1. Numerous organizations are promoting GP-related programs and projects in the Philippines. These organizations cover a wide range of private, government, non-government, and foreign-funded groups;
2. The country's basic environmental policy incorporated the key concepts underpinning Green Productivity;
3. There is a widespread campaign involving a number of organizations to promote adoption of EMS by SMEs;
4. The Philippines is beginning to apply economic incentives (market-based instruments) certain regional environmental programs which, in turn, are creating financial incentives for companies to consider Green Productivity-related programs; and
5. Financing packages to help SMEs invest in environmental improvements are now provided by some government institutions such as the Development Bank of the Philippines (DBP).

ENVIRONMENTAL PERFORMANCE OF THE MEAT PROCESSING INDUSTRY

Background of the Food Processing Industry

Supported by a supply of low cost, high quality raw materials from the fertile soil and rich waters of the Philippines, the food sector has grown in importance, diversity, and sophistication. Early development of processed foods was aimed at import substitution and the large domestic market, but recently the priority has shifted to serving the export market.

The processed food sector is important to both the domestic and export economies of the Philippines. There are over 40,000 businesses related to food processing in the Philippines, but only 2,689 of these employ five or more people. In 1993, these 2,689 establishments employed an estimated 144,530 people. Six large, integrated food conglomerates dominate the domestic market and now are aggressively expanding into exports. Multinationals such as Dole Corporation and Del Monte also contribute significantly to the exports of the Philippines.

Food exports from the Philippines were initially concentrated on "traditional food products" (canned pineapple, centrifugal sugar, desiccated coconut, copra meal/cake, and inedible molasses) and crude coconut oil (classified as a "traditional resource-based product”). The industry’s growth in recent years has come from those products classified as non-traditional “processed” and “fresh foods.” Table 13 shows the export performance of the food processing industry.

Table 13. Philippines Food Exports by Sub-sector, 1992–1997

Food sub-sector	1992	1993	1994	1995	1996	1997
Coconut products	643	532	639	989	730	835
Sugar products	110	129	77	74	134	99
Fruits and vegetables	371	439	429	458	486	459
Marine products	290	343	379	378	296	291
Processed food* and beverages	220	271	303	292	334	346
Total	**1,634**	**1,714**	**1,827**	**2,191**	**1,980**	**2,030**

Source: National Statistics Office.
Unit: Million US$.
Note: *Includes processed meat.

The Meat Processing Industry

The meat processing industry is an intermediate sub-sector of the larger and more complex livestock industry. Agricultural products undergo an intermediate stage of processing before being sold to the consumer market. The intermediate stage includes slaughterhouse activities for beef, pork, and poultry.

The Philippines has 248 accredited meat establishments operating nationwide. The accredited meat establishments consist of 153 abattoirs, 47 poultry dressing plants, and 48 meat processing plants. Of the total number of meat processing plants in the Philippines, only four percent can be said to be large and 16 percent medium size with the remainder being small-scale operations. At present, there are 14 large meat processing plants and 474 SMEs.

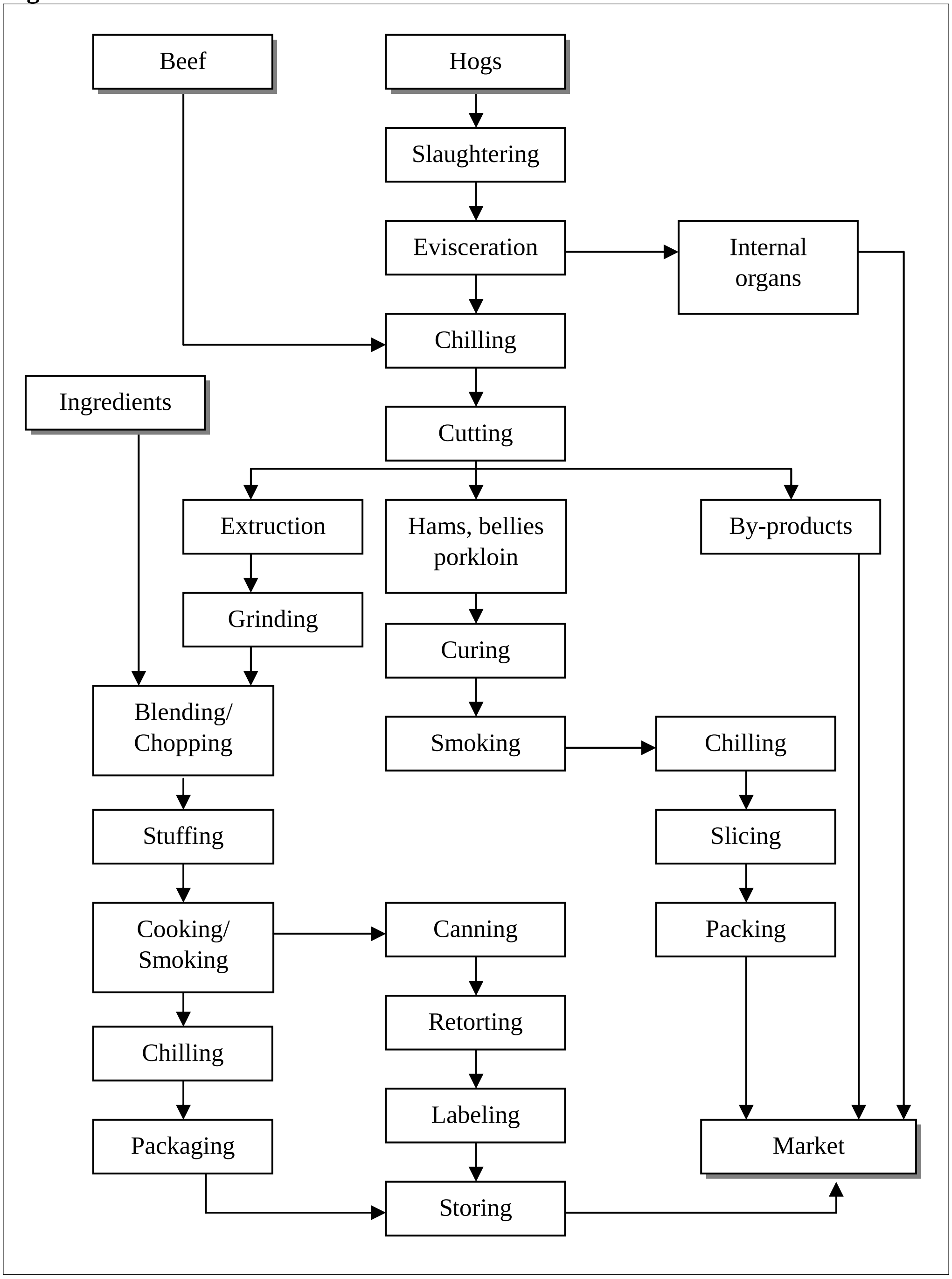
Manufacturing process

Meat processing involves several steps, depending on the type of end product. The processing adds value to the animal carcasses by prolonging the storage life of the meat and allowing consumers a more varied diet. The major operations in meat processing include: meat preparation, emulsification (chopping and blending), stuffing and linking, and smoking or cooking. Figure 2 shows the general process flow in meat processing.

Prior to meat preparation, the animal carcass is inspected to confirm that it meets the quality and hygiene requirements set by the processing plant. Typical requirements include: lean-to-fat ratio, no foul odors, tallow fat, no signs of greening, no lymph nodes, no blood clots, no visible dirt or hair, and no signs of spoilage. The internal temperature of the meat and the National Meat Inspection Commission (NMIC) seal/mark are also checked. For large processing plants, samples from different cuts are also taken to measure the microbial load of the carcass. Meat that fails to meet the requirements is returned to the vendor.

Once the meat passes inspection, it is weighed and washed to remove any dirt, loose hair, or other foreign matter. The meat is disinfected with a 200 ppm chlorine solution prior to refrigeration. The chlorine solution kills any bacteria on the surface of

Figure 2. General Process Flow of Meat Products



the meat and helps maintain overall quality. The meat is chilled at a temperature of 0–4^{o}C for 12 to 24 hours to maintain a level of firmness suitable for fabrication.

The cutting of meat is done in a fully air-conditioned room at 10–13^{o}C in order to keep the meat at the required temperature for the fabrication process. Different cuts require different processing methods, but fabrication is generally guided by a few principles to minimize losses: (1) tender meat should be separated from tough meat; (2) thick cuts are separated from thin cuts; (3) muscles should be cut across the meat fibers to allow easier chewing; and (4) inexpensive parts are separated from expensive parts.

Emulsification is a process by which the meat is "chopped and blended" to create the desired end product. Lean meat, ice, salt, seasoning, curing components, nitrite, and sodium erythorbate are pounded together for a set period of time. More ice and salt are added and the mixture is blended and minced. The length of this process is very important since either too little or too much pounding can cause a breakdown of the emulsions. Temperature is also monitored carefully since it contributes to the formation of stable emulsions.

The emulsified meats are then stuffed into either natural or cellulose casings, and are linked according to the desired product sizes. The stuffing and linking operations are usually performed in the same area.

Smoking or cooking is a process of subjecting the meat to smoke and/or heat by burning hardwood or sawdust. In hot dog preparation, cooking is done by convection or steam heat at 140–150^{o} C. For hams and bacon, curing is done at a temperature of 0–4^{o} C to minimize the growth of microorganisms.

Environmental Characteristics of Meat Processing Industry

Environmental aspects

The greatest environmental problem associated with meat processing is wastewater, as measured by conventional indicators such as BOD, Chemical Oxygen Demand (COD), suspended solids (SS), oil, grease, and dissolved solids. However, there is insufficient data on pollution loads and intensities in the Philippines to conduct a comprehensive assessment of the extent of pollution generated by the sector. Researchers typically find companies protective of their information, particularly on the subject of wastewater.

A limited amount of sector-level data is available for assessing other categories of pollution. According to the 1990 EMB emission inventory, food processing industries released high amounts of NO_x and SO_x. This study attempted to assess the contribution of the meat processing sub-sector to total air emissions, but was unable to complete the task due to gaps in the available data.

While there have been no nationwide surveys of industrial pollution loading by sector, there have been some studies of groups of companies in specific geographic areas. Records from the River Rehabilitation Secretariat of DENR (DENR-RRS) indicate that the average volume of wastewater from meat processing plants ranges from 16 to 32 liters per kg of meat product with an average of 25 liters per kg. This level is considered high when compared to other food processing industries (see Table 14). The wastewater flow rate in slaughterhouses is considerably higher than meat processors, ranging from 230 to 1,300 liters per head of animal or 23 to 130 liters per kg of meat (assuming that 1 head = 100 kg). Slaughterhouses also have a higher wastewater flow rate than poultry-dressing operations, which registered a rate of 18 to 33 liters per bird (approximately 1.25 kg per bird).

In terms of BOD loading, records from DENR-RRS revealed that the industry's BOD load ranged from 42 to 98 gm per kg of processed meat with an average of 70. This

Table 14. Typical Wastewater Flow Rates and Pollutant Loads of Selected Food Processing Industries, 1995

Food sub-sector	Units*	Minimum	Maximum	Average
Wastewater flow rates				
Dairy	liters/liter	4.0	22.00	10.0
Snack foods	liters/kg	2.5	42.00	15.0
Confectionery	liters/kg	3.4	8.80	5.8
Meat processing	liters/kg	16.0	32.00	25.0
Poultry dressing	liters/bird	18.0	33.00	23.0
Slaughterhouse	liters/head	230.0	1,300.00	390.
Vegetable oil	liters/kg	0.6	5.20	2.5
Pollutant load				
Dairy	gm/liter	50.0	100.0	70.0
Snack foods	gm/kg	1.7	34.0	12.0
Confectionery	gm/kg	18.0	63.0	34.0
Meat processing	gm/kg	42.0	98.0	70.0
Poultry dressing	gm/bird	15.0	55.0	30.0
Slaughterhouse	gm/head	900.0	2,700.0	1,500.0
Vegetable oil	gm/kg	2.3	15.0	8.5

Source: River Rehabilitation Secretariat, DENR.
Note: * Volume of wastewater/BOD per unit of final product.

is equivalent to about 2,600 to 6,000 mg BOD per liter of wastewater. This level is higher than the pollutant load in the confectionery and snack food industries.

The main sources of air emissions in meat processing are the cooking and smoking processes, while wastewater is generated mainly from the washing of meat and equipment. Some solid wastes (such as scrap meat, bones, blood clots, etc.) are also generated from meat preparation, but these are generally sold for animal feed processing.

The environmental regulations applicable to meat processing are listed in the DENR Administrative Order (DAO) Number 35. Table 15 shows the parameters applicable for meat processing. This standard is intended for existing companies. Waters receiving discharges are divided into inland waters (Class D) and coastal waters (Class SC).

Material and energy inputs

The primary material input to the meat processing industry is the meat itself. Meat processors use pork lean, pork fat, and lean beef as the base for their products. The base is then supplemented with non-prime parts of beef, pork, and chicken which are utilized as additives. Hot dog sausages, for example, are made from lean and fat meat with chicken trimmings at times used as substitutes for either the lean or the fat content of the product. Corned beef products are primarily made of beef, but pork fat or skin are used as additives to improve the body and flavor of the final product.

Table 15. Environmental Standards Applicable to Meat Processing

Parameters	Maximum limits, mg/L *(except pH)*	
	Inland waters	Coastal waters
BOD	120	150
COD	250	250
TSS	200	200
TDS	2,000	nd
Oil/grease	nd	15
pH	6.0–9.0	6.0–9.0

Source: DENR – Administrative Order No. 35, 1990.

Aside from these raw materials, the meat processing industry also uses several ingredients such as salt, sugar, spices, prague powder, ice water, MSG, and others, depending on the meat product.

Water and energy also are utilized during the course of meat processing. Most of the water is consumed as rinsing, heating, and cooling water. Also, water is converted to steam for heating and cooking. Electricity is required to operate the chillers, coolers, motor-driven equipment (such as cutting, grinding, stuffing, and linking machines), smokehouse, lighting fixtures, and air conditioners. Chillers, smokehouse, and air-conditioning units consume most of the energy used in meat processing.

HI-PRO FOOD MANUFACTURING CORPORATION: A CASE STUDY[14]

Company Profile

Hi-Pro Food Manufacturing Corporation (HPFMC) started in 1992 in one of the buildings of the Food Processing Complex in Taguig, Metro Manila. Considered a small-scale enterprise, the company manufactures processed meat products including hot dogs, hams, bacon, corned beef, cured-smoked sausage, local tocino, and tapa.

During its initial year of operation in 1992, total production was 790 tons. Five years later in 1997, production had grown to 1,850 tons. Hi-Pro takes pride in being one of the qualified toll processors for leading meat processors in the country. Currently, Hi-Pro employs 70 regular workers. Sixty percent of production goes to toll processing, while 40 percent carries Hi-Pro's own brand of "Tasty Meaty."

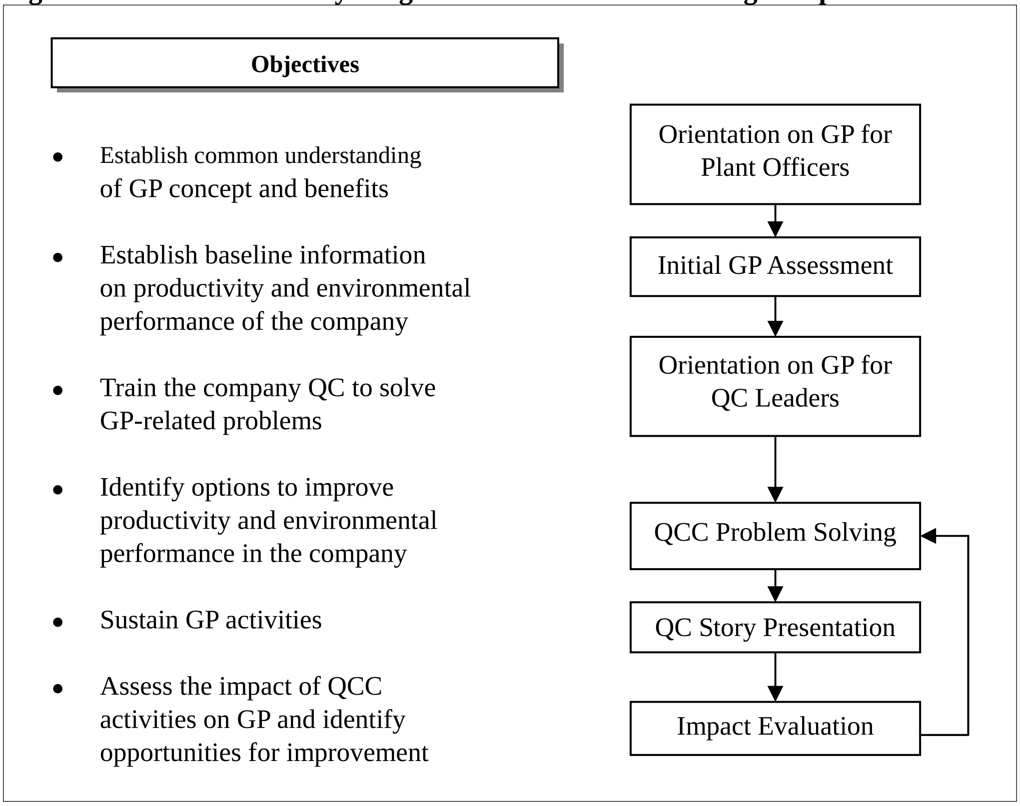
The company hopes to continue its growth and achieve a higher level of productivity through sustained implementation of productivity and quality improvement programs. The plant has existing productivity and quality improvement programs based on 5S and Quality Circles (QC). The 5S program was implemented as part of the Good Manufacturing Practice initiative (GMP). Although QC was started in 1996, it has not yet been fully implemented and only four out of six Quality Circles are considered active.

[14] Names and other identifying details have been changed.

Green Productivity Program Concept

Given the company management's strong interest in improving productivity, Green Productivity was introduced as a strategy to strengthen the existing productivity improvement program. The General Manager hoped that the plant would be able to increase its value-added and reduce its pollutant load through developing a GP Program. With this end in view, the plant accepted the GP Program methodology outlined in Figure 3.

Figure 3. Green Productivity Program Flow Chart at HPF Mfg. Corp.



The first step identified was a brief orientation on GP to help company officers understand the potential benefits of GP and to clarify their role in program implementation. Following orientation, a Green Productivity Audit was undertaken to analyze the performance of the plant and develop baseline data. The GP Audit included measuring productivity and conducting an initial environmental review. Labor and material productivity levels were determined using physical measures. The environmental review assessed the volume of wastewater and the pollutant load per unit of output. Based on the results of the GP Audit, the company's quality circles were encouraged to prioritize problems and develop solutions based on GP themes.

Results of the Initial GP Assessment

The results of the survey to gather baseline information on the plant were as follows:

Productivity level

Productivity levels were assessed based on physical measurements. The labor productivity of the plant was 84.7 kg of product per employee per day. This level is considered low since the plant had previously achieved a level of 100kg of product per employee per day in 1997. Detailed data on productivity trends were not available at the time of this survey. Material productivity was also measured in terms of processing yield by type of product. Results show that the actual processing yield for products such as hot dogs, hams, and corned beef was below the laboratory standard set by the company. Table 16 shows the actual yield versus the standard processing yield of the plant.

Table 16. Comparative Information on Actual vs. Standard Processing Yield, 1998

Product type	Processing yield *(%)*		
	Actual	**Prod. std.**	**Lab. std.***
Hot dogs	86.50	88.00	85.00
Hams:			
- Restructured	106.00	108.00	105.00
- Smoked (whole)	89.00	93.00	90.00
- Smoked (sliced)	81.60	83.00	80.00
Bacon	80.00	79.00	76.40
Corned beef	94.00	98.00	95.00
Tocino	116.00	115.00	110.00
Meat loaves	nd	92.00	89.00
Salami	nd	77.00	75.00

Source: Production Records, HPF Mfg. Corp., 1998.
Note: *Laboratory Standard.

Environmental aspects

Based on the initial measurements conducted by the Quality Circles during the GP Audit, the average volume of wastewater generated by the plant was 124.5 m^3 per day. The level was 31 percent higher than the lowest wastewater flow-rate shown in Table 14. Sixty-eight percent of the wastewater came from washing raw materials, 37 percent came from equipment and floor washing, and about 5 percent from washing and cooling end products.

The BOD of the wastewater was estimated at 3,600 mg/L. The plant discharged its wastewater through a sewage canal. Solid wastes were gathered every morning by a garbage collector, but data on the characteristics of the waste were not available at the time of the study. The GP Audit identified the major environmental aspects and impacts as summarized in Table 17 and illustrated in Figure 4. It should be noted the company does not have a wastewater treatment facility.

Results of Quality Circle (QC) problem solving

Since the company produces food products, the need to maintain sanitary and hygienic conditions takes priority over waste minimization. The strengthening of the GMP and the 5S Program was accepted to protect customers, as well as reduce spoilage and rejects.

Table 17. Summary of Environmental Aspects and Impacts

Process/ Activities	Environmental	
	Aspects	Impacts
1. Deboning and meat fabrication	Disposal of scrap meat, bones, blood clots, and other solid by-products including packaging	Carcass by-products were sold to local feed millers. Plastic and other packaging materials may impact soil.
2. Washing	Discharge of wash water Consumption of water	Water pollution Depletion of water supply
3. Chilling/Freezing	Consumption of energy	Air pollution from power plants
4. Chopping	Discharge of wash water	Water pollution
5. Emulsification	Discharge of wash water	Water pollution
6. Stuffing and linking	Discharge of wash water	Water pollution
7. Cooking	Discharge of smoke	Air pollution
8. Cooling	Discharge of ice water	Water pollution
9. Packaging	Disposal of scrap packaging materials	Soil pollution

Maintaining sanitary conditions may lead to an increase in the wastewater volume and BOD load.

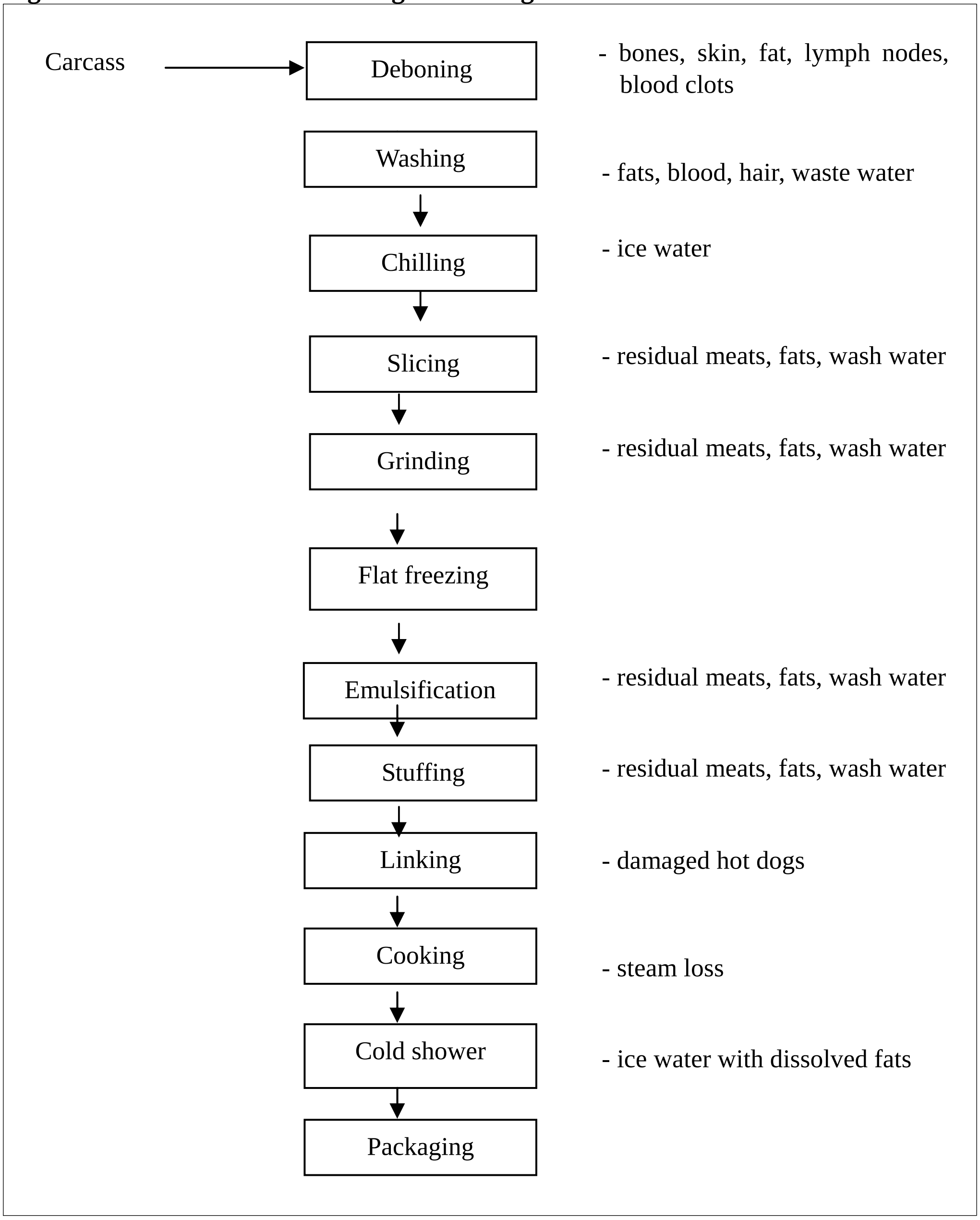
However, to improve the productivity and environmental performance of the company, the Quality Circles were encouraged to focus their thinking on Green Productivity and minimizing wastes at the source. Using the initial results of the GP Audit, the teams were given three themes to use as a basis for brainstorming options: 1) reduction of wastewater; 2) reduction of wastewater pollutant load; 3) increased material productivity. The following options were identified:

A. Meat Preparation Area

QC theme no. 1: Reduction of wastewater
GP options identified:

- The washing of meat was done using ½-inch high-pressure faucets that led to excessive amounts of wasted water. An option considered by the QC was to replace the faucets with spray nozzles to increase pressure and simultaneously reduce water flow;
- The flow of water from faucets was regulated using screw-type control valves. Faucets were often left open while the meat was being transferred for chilling. The installation of foot-regulated control valves was proposed to automatically shut-off the spray nozzles after washing; and

Figure 4. Waste Stream in Hot Dog Processing



- The amount of wastewater varies depending on the skill of the worker in washing meat, equipment, fixtures, and floors. The QC identified the need to establish guidelines and standards for washing to reduce water consumption.

QC theme no. 2: Reduction of wastewater pollutant load

GP options identified:

- The team noted that the company's requirements for carcass quality were not followed strictly by suppliers. Usually, suppliers would simply offer to reduce the price once the meat had been delivered. However, poor quality carcasses were leading to excessive amounts of scrap materials which affected the amount of suspended solids in the wastewater. Although scraps were sold to local feed millers, cost recovery was almost negative. The QC determined that meat suppliers should be trained on plant requirements for carcass quality followed by strict implementation of the company's meat inspection standards. Specific options included delivery requirements by types of cut per delivery van, ensuring acceptable lean-fat ratio, etc.;
- The gathering and collection of bones, scrap meat, and blood clots is usually done when the accumulated volume gets high or when the supervisor gives the instruction. However, these waste materials can significantly increase the amount of suspended solids generated in wastewater during washing. The options considered included provision of disposal containers near working areas and collecting materials prior to washing; and
- The installation of strainers at drainage outlets was considered to collect solid particles for recycling into animal feed.

B. Processed Meat Area

QC theme no. 1: Reduction of wastewater

GP options identified:

- The Circle considered the establishment of guidelines and standards for washing equipment, fixtures, and floors to improve washing efficiency in the processed meat area; and
- Repair of leaking faucets and pipes.

QC theme no. 2: Reduction of pollutant load

GP options identified:

- The removal of residual material on the surface of grinding, cutting, and stuffing machines was usually done by hand and by spraying the machinery with high-pressure hot water. Cleaning was done after each batch. Options considered included the use of rubber spatulas to recover materials sticking to the surface of the machinery. A continuous production system was also suggested to reduce the number of washing intervals; and
- To support the implementation of a continuous production system, the QC also suggested the attachment of emulsion mills to the stuffing machine. This would also eliminate the need for flat freezing prior to emulsification.

QC theme no. 3: Increase material productivity

GP options identified:

- The low material yield for some products was traced to high volumes of rejects, particularly during stuffing and linking operations. Rejects were either mixed with raw materials for reprocessing or sold at a lower price. The QC identified the need for an effective training program to enable the workers to reduce the bursting of casing materials due to carelessness; and

- Adoption of a more efficient production schedule and replacement of certain machines was recommended to improve tonnage output per day.

Results of GP implementation

Given the financial situation of the company at the time, only low cost options were given priority by the management. While the intention was to present the Checksheet, Fishbone Diagram, and Pareto Chart in this report, the company did not allow the author to publish said information. However, the summary of the results and impact of the GP options implemented are presented below:

A. GP Options Identified	**B. Results and Impact**
1. Replacement of faucets with spray nozzles 2. Replacement of screw-type valves with foot-regulated control valves	- Options 1 and 2 were implemented at the Meat Preparation area. - A total of 5 spray nozzles and 5 valves were installed at the cost of P6,145. - About 15–20 m^3 of water were saved everyday.
3. Orientation of meat suppliers on quality standards	- Implemented for all suppliers. - No cost for implementation. - 46.7 percent reduction in scraps.
4. Installation of containers in work area to collect solid wastes	- Implemented using old stainless steel containers. Accumulation of solid particles in the drainage canals was significantly reduced.
5. Repair of leaking faucets	- A total cost of P750 was incurred. - Water consumption was reduced by an average of 0.25 m^3/day.
6. Training for machine operators	- A total cost of P7,250 was incurred. - Average material yield (productivity) increased from 86.5 percent to 87.8 percent.[15]

C. Actual Cost-Benefit Data *(in pesos)*

a. *Investment costs*	
1. Replacement of faucets	6,145.00
2. Repair of leaks	750.00
3. Food and materials for orientation/seminars	8,150.00
Subtotal	**15,045.00**

[15] The actual material yield data represent the hot dog product only. Higher yield was also achieved for other meat products.

b. *Savings/income from operations*	
1. Average cost of water saved per month	1,445.00
2. Yield recovery[16]	29,370.00
Subtotal	**30,815.00**
c. *Cost of monthly incentives for QCs*	7,500.00
d. *Net monthly benefits*	23,315.00
e. *Payback period (a/d):*	0.65 month

D. Other Benefits Derived

The strengthening of the QC program resulted in a reduction in wastewater volume of about 12–16 percent (from 124.5–108 m^3/day) and a decrease in the BOD load of approximately 20–30 percent (from 3,600–2,700 mg/l). Following the principles of 5S, the Quality Circles were able to identify the various sources of wastes and set standards for good housekeeping. Through their regular 5S audit and sustained QC activities, the company was able to increase labor productivity by about 1.5–2 percent. Following these benefits, the company established targets to further reduce the pollution load and to create an environmental management system leading to ISO 14000 certification. An Environmental Management Committee was formed to work closely with Quality Circles to achieve these new targets. The company realized not only substantial savings, but also was able to build an image of being an environment-friendly organization.

GREEN PRODUCTIVITY PROMOTION

Promotion of Green Productivity (GP) started in the Philippines in early 1995. Initial activities centered on GP workshops led by experts identified through the Asian Productivity Organization (APO). The convocation of the First APO World Conference on Green Productivity in Manila in December 1996 laid the foundation for a broader outreach and training program. In particular, the Manila Declaration on GP, the key output of the conference, became the blueprint for the succeeding programs on GP by the PDC-DAP.

To further strengthen the promotion of GP in the Philippines, two GP Promotional Missions were organized in 1998. These two missions succeeded in raising awareness and generating increased interest in GP and resulted in more organizations seeking collaboration opportunities with the PDC-DAP. To guide activities for the three year period from 1999–2001, the PDC-DAP developed the Green Productivity Development Program (GPDP). The objectives, components, and projects for 1999 are outlined in the succeeding sections.

[16] Based on the average additional yield of 26.7 kg sausage per day at P50/kg × 22 days/month.

PDC-DAP Green Productivity Development Program (GPDP)

Objectives

In line with the PDC-DAP mission, the GPDP was designed to pursue a mission of *making green productivity a way of life for every Filipino who envisions sustainable development*. Specifically, the GPDP sought to provide better opportunities to various stakeholders to:

a. Understand and accept the responsibility to improve productivity with due regard to environmental protection;
b. Help effect actual improvements in productivity and environmental performance at the enterprise level; and
c. Harness institutional networks necessary to drive continued progress towards sustainable development.

Program components

GP advocacy

Under this component, the GPDP addresses the need to generate awareness of the concept, importance, and benefits of GP. The plan calls for organizing seminars, forums, and symposia on Green Productivity, as well as the publication of instructional materials on GP concepts, methodologies, approaches, and techniques.

GP demonstration SME project development

This component seeks to demonstrate the practical applications of GP tools and techniques. The Program will document and disseminate useful experiences. In addition, GP Demonstration SME Projects will be implemented in the food, chemical, packaging, plastic, and metals industries. Technical services will be provided to companies seeking to implement GP.

Development of GP champions

This component addresses the need to develop a critical mass of technical experts and senior executives who can champion advocacy initiatives in both private and public sectors. This is being carried out by conducting training and accreditation of GP professionals, as well as organizing study missions on GP.

GP institutional linkage development and exchange of best practices

This component addresses the need for concerted efforts to enhance identification, documentation, dissemination, and adoption of GP practices. This component involves selective documentation and dissemination of GP practices and experiences, enlisting GP experts/practitioners/partners, and conducting GP roundtable meetings and conferences.

Establishment of GP Fund

Given the various activities of the GPDP, this component provides the mechanism by which resources will be established and managed to support sustained operation of the program. This includes identification and selection of sponsors and/or donors.

Activities for 1999

Schedule	Projects/Activities	Sponsor/Partner
April-March 2000	Green Productivity Advocacy and Development for SMEs	CIDA-PEARL
April	Development of Manual on Waste Minimization	DENR-RRS, APO
	TES-Training of GP Trainers & Consultants for SMEs	DENR-RRS, APO
May	GP Workshop on EMS Audit for Electroplating & MF Ind.	ASEP, APO
July	GP Follow-up Workshop on EMS for Electroplating & MF Ind	ASEP, APO
Sept. & Nov.	3rd GP Promotion Mission for Visayas & Mindanao	APO
Oct.	GP Workshop on EMS for Textile Industry	ASEP, APO
Nov.	Multicountry Advanced Workshop on GP for Productivity Facilitators	APO

CONCLUSIONS AND RECOMMENDATIONS

As in most developing economies, the economic performance of the Philippines has been primarily driven by investments in capital and related growth in employment. The preferred scenario would be to achieve growth through productivity improvement, however, the negative average growth in TFP of the country has weakened the quality of economic growth during the last five years. While efforts were taken to increase total-factor productivity, the deteriorating environmental quality indicates severe inefficiencies in the economic system as a whole. It can also be concluded that the effects of poor environmental management have weakened the country's ability to generate higher economic growth. Hence, the need to integrate productivity and environmental performance improvement efforts has become apparent.

This paper examined the issues related to economic, productivity, and environmental performance at the national, industry, and firm levels. Clearly, the most practical strategy to sustain socio-economic growth in the country is to increase productivity and improve environmental quality. At the firm level, these goals can be addressed through:

- Integration of programs for productivity/quality enhancement and environmental protection;
- Implementation of simple, practical, low-cost measures such as good housekeeping and small-group activities;

- Adoption of cleaner technologies and waste minimization approaches including product design improvement, raw material substitution, and process improvement; and
- Application of appropriate tools, techniques and management approaches (e.g., TQM, TPM, industrial engineering techniques).

There are several programs and projects that were undertaken to mitigate the impact of economic activities on the environment. The following recommendations are offered specifically to promote widespread adoption of Green Productivity techniques.

Policy Measures

The current emphasis on pollution control may hamper initiatives to increase economic advancement among small and medium enterprises in rural areas. Hence, policy measures should focus on encouraging value-added activity that is backed by incentives to adopt Green Productivity practices. Specific recommendations are as follows:

1. When faced with complex and strict standards, many companies (especially SMEs) will adopt a strategy of avoiding notice of inspectors rather than seeking to achieve compliance. Review current environmental standards and penalties to identify instances where the structure of regulations and enforcement practices are leading to pursue indefinite noncompliance rather than compliance;
2. Strengthen policies and programs to support adoption of market-based instruments;
3. Establish a regional or national recognition system for top performers as a form of incentive;
4. Enhance incentives for implementation of productivity programs; and
5. Establish a system for ensuring that the various policies, rules, and regulations are communicated to, and understood by, industry.

Although not addressed in this paper, the pricing system for natural resources needs revision including restructuring of the subsidies for water and energy use.

Information and Data on Green Productivity

The lack of relevant and useful data on productivity and environment inhibits formulation of effective GP policies and programs. It is therefore recommended that research be undertaken to establish an information system to provide industry productivity and environmental performance data for comparison and benchmarking purposes. The database and other related information should be made easily accessible to all stakeholders in the Philippines. Likewise, more market-oriented research should be undertaken to continuously update information on the needs for GP services. Also, it is recommended that the capacity for measuring and monitoring productivity and environmental performance be strengthened at the national, industry, and firm levels.

Capability Building

This recommendation focuses on the need to raise industry awareness, particularly among SMEs, regarding the importance and benefits of Green Productivity. The awareness campaign should broaden the general understanding and raise acceptance of the responsibility to practice Green Productivity. This could be achieved through development of an effective advocacy program on GP for SMEs.

Conducting of GP training for local service providers and observational study missions for industry practitioners will also help raise the number of GP champions in the country.

Recommendations Specific to the PDC-DAP as the NPO

The PDC-DAP's Green Productivity Development Program covers a wide range of strategies to promote Green Productivity. However, specific targets should be established to:

- Increase the number of GP champions in key SME sectors;
- Increase the number of GP demonstration SMEs;
- Strengthen the GP advocacy program to influence key decision makers to provide policy and resource support to GP activities;
- Strengthen institutional networking and encourage best practice exchange;
- Promote policies supportive of GP programs; and
- Promote technology adaptation and/or adoption of clean technologies by Philippine industry.

Recommendations to APO

Given the APO's regional network, it is in a strong position to encourage member economies to actively promote Green Productivity. Thus, the following recommendations are offered to APO:

- Pursue establishment of GP Excellence Centers within the NPOs;
- Intensify GP Demonstration Projects for SMEs;
- Increase assistance provided for GP promotions and dissemination;
- Support follow-up studies to establish a GP information system in each member country;
- Conduct more multicountry training courses and encourage best practices exchange among countries and within countries;
- Promote eco-design, Life Cycle Assessment (LCA), and recycling technologies, as well as waste minimization;
- Intensify promotions for widespread adaptation and integration of productivity and environmental management tools and techniques; and
- Pursue development of new strategies to help NPOs effect actual improvements in productivity and environmental performance.

This study has drawn significant lessons on the various issues, practices, and strategies related to achieving harmony between productivity improvement efforts and environmental protection. While command and control structures are necessary, they will be more effective when supported with sound productivity improvement, pollution prevention, and resource recovery programs.

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SINGAPORE

Peck Thian Guan
Director
Environmental Technology Centre
Singapore Productivity and Standards Board
T. Raghavan
Environmental Technology Centre
Singapore Productivity and Standards Board

COUNTRY PROFILE

Geography and Population

The Republic of Singapore is an island nation of approximately 647.8 square kilometres. It is situated at the southern end of Peninsula Malaysia, approximately 140 km north of the equator. Its location at the crossroads of several Southeast Asian trade routes has contributed greatly to the development of Singapore as a regional centre for commerce, finance, transport, communications, and other services.

The main island of Singapore is about 42 kilometres wide from east to west and 23 kilometres across from north to south. It has a coastline of 150.5 kilometres. Of the total land area, approximately 49.7 percent has been developed for residential, commercial, and industrial usage and another 1.6 percent for agriculture. The remainder consists of forest reserves, marsh, and other undeveloped areas (Table 1).

Table 1. Land Use

	Area *(sq km)*
Total land area (main island and offshore islands)	647.8
Built-up areas (including new industrial sites)	322.2
Farm holding areas (licensed farms)	10.8
Forest	28.6
Marsh and tidal waste	15.5
Other (inland waters, open spaces, public gardens, cemeteries, non-built up areas in military establishments, and unused land)	270.7

Source: Singapore Facts and Pictures, 1997. Published by Ministry of Information and the Arts.

Several offshore islands have been amalgamated into a large petroleum and petrochemical complex through landfill and reclamation. The amalgamated islands include: Pulau Ayer Chawan (169.2 hectares), Pulau Ayer Merbau (137.8 hectares), Pulau Merlimau (101.6 hectares), Pulau Seraya (193.4 hectares) and Pulau Sakra (170.0 hectares).[1]

As of June 1997, the resident population (Singaporean citizens and permanent residents) was 3,103,500, representing an increase of 1.9 percent from the previous year.[2] The population density was 5,768 persons per square kilometre in 1997. Singapore's labour force was comprised of 1,876,000 persons aged 15 years and over as of June of 1997. The majority of the workforce is employed in manufacturing (22%), commerce (21%), and community, social and personal services (20%).[3]

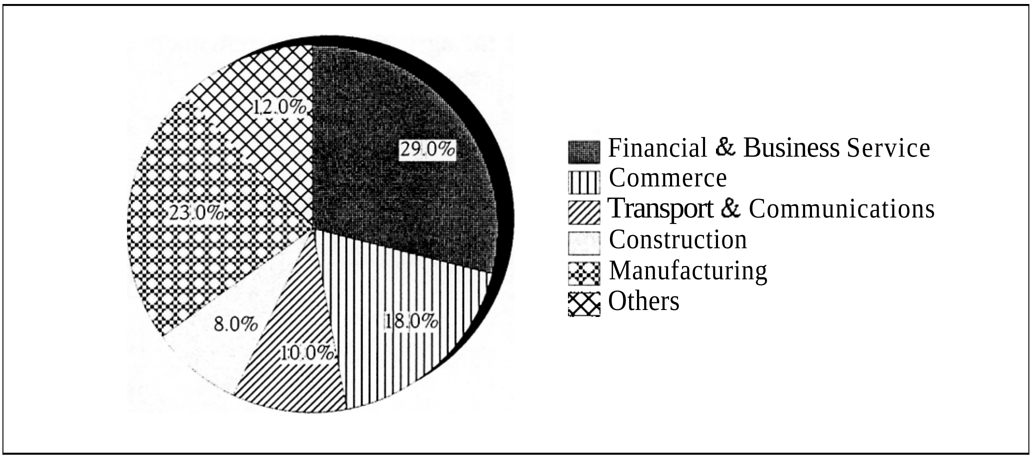
Industry Structure

Over the past two decades, Singapore achieved rapid economic growth. The Gross Domestic Product (GDP) reached S$143.0 billion in 1997, an increase of 8.5 percent over the previous year of S$130.8 billion.[4] The Singaporean economy can be divided into six main sectors: manufacturing, financial and business, commerce (trade and hotel industry), transport, communications, and construction. Other economic sectors, such as agriculture, only make small contributions to Singapore's GDP.

Singapore's economy maintains a healthy balance between manufacturing, commerce, and services. The manufacturing sector is highly dynamic and has contributed greatly to Singapore's economic growth and employment expansion. The manufacturing sector contributes nearly 23 percent of the national GDP (Figure 1).[5]

Manufacturing also employs more people than any other sector, accounting for 23 percent of total employment (Figure 2).[6] As of 1994, there were 4,013 manufacturers operating in Singapore.[7]

Figure 1. **Singapore GDP**



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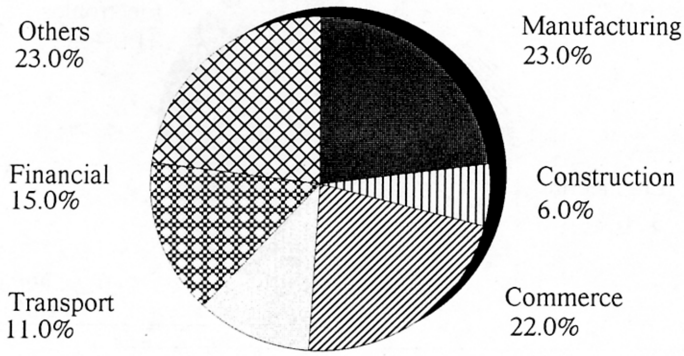
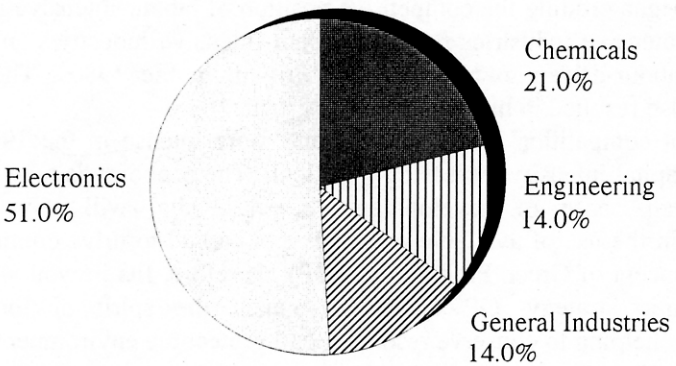
[1] **Petrochemical Corporation of Singapore website at *http://www.pcs.com.sg/sub13.htm*.**
[2] **Singapore Department of Statistics website at *http://www.singstat.gov.sg/FACT/KEYIND/keyind.html* (Sept. 1998).**
[3] **Ibid.**
[4] **Ibid.**
[5] **Ibid.**
[6] **Ibid.**
[7] **Singapore Productivity and Standards Board website at *http://psblink/STA/Spore/estm.htm*.**

Figure 2. Employment by Industry



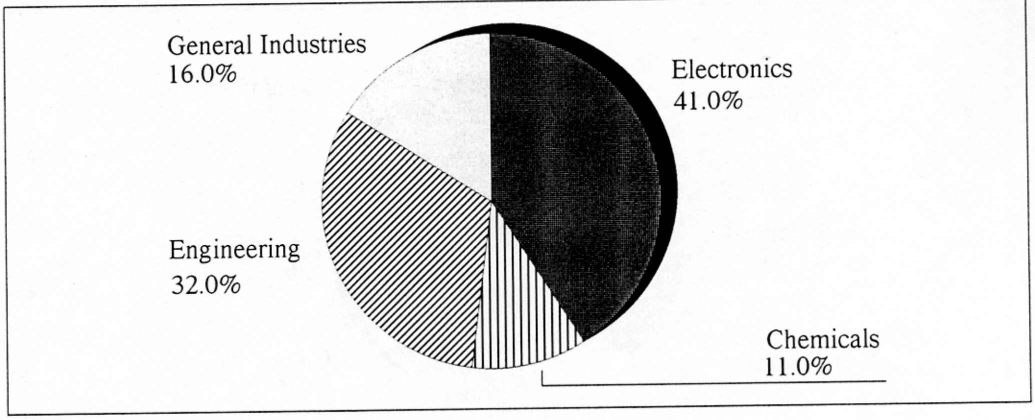
Within manufacturing, the electronics, chemicals, and engineering (precision, marine, aerospace, and process) industries account for nearly 85 percent of the sector's GDP and employment (Figures 3 and 4).[8]

Figure 3. Major Industrial Sectors in Manufacturing



[8] Ibid.

Figure 4. Employment by Manufacturing Sector



Government Programs for Industrial Development

Singapore launched its blueprint for leading the economy into the 21st century. Under the blueprint, Singapore's twin engines of growth –the manufacturing and services sectors– will power Singapore's transition into a knowledge-based economy.

Green Productivity for a knowledge-based economy

Singapore's economic growth in the past was due largely to labour and capital accumulation. When industrialisation started in the 1960s, there was an abundant pool of workers. Hence, labour-intensive industries were encouraged to invest in Singapore to reduce high unemployment rates. In the late 1970s, a tighter labour market and rising wages slowly began eroding the competitive position of labour-intensive industries. As a result, capital-intensive industries replaced labour-intensive industries and the economy moved from labour-driven to capital-driven growth in the 1980s. The rapid capital accumulation also resulted in high productivity growth.

As global competition for capital became more intense in the 1990s, Singapore found raising capital intensity increasingly difficult. The economy is now moving into an innovation-driven phase of development –a phase that will rely on qualitative improvements in the use of available resources and capital to drive continued economic growth. The concept of Green Productivity (GP), therefore, fits in well with Singapore's current economic strategy. GP techniques match the spirit of innovation-driven development by helping to conserve resources and protect the environment, with minimal additional demands on manpower or capital investment.

ENVIRONMENTAL PROFILE

Singapore realised very early that environmental protection and economic development are mutually supportive and that rapid industrialisation is sustainable only if the environment is given sufficient protection. When Singapore attained its independence in 1965, polluted rivers, dirty streets, rapid population growth, and poor waste disposal facilities were of concern to the government. Hence, environmental protection policies and strategies were developed and backed with legislation by newly established governmental institutions.

Key Environmental Agencies in Singapore

Three government ministries are directly involved in land-based environmental management: the Ministry of the Environment (ENV), the Ministry of National Development (MND), and the Ministry of Trade and Industry (MTI). The Port of Singapore Authority (PSA) manages marine pollution.

Ministry of the Environment

The Ministry of the Environment was established in 1972 to ensure that economic growth and rapid industrialisation were not achieved at the expense of the environment. The Ministry of the Environment established the infrastructure and measures for waste management and the prevention and control of pollution. Within the ENV, the Pollution Control Department (PCD) is responsible for incorporating environment factors into land-use planning and development. In addition, the PCD is responsible for routine air and water pollution control as well as hazardous substances and toxic waste management.

The Ministry today heads a complex administrative network that: 1) plans, develops, and operates comprehensive sewerage, drainage, and solid waste facilities; 2) sets standards related to air, water, and soil pollution; 3) monitors air and water pollution through island wide monitoring stations; and 4) administers and enforces environmental regulations.

Ministry of National Development

The Ministry of National Development (MND) uses land planning under the Statutory Master Plan to form the basis for sound environmental management. An essential feature of the Master Plan is the use of zoning and the control of the intensity of land use in each zone. Facilities are located in areas zoned for industrial use that are subdivided into special, general, and light industry zones. Heavy industries are located furthest from residential and commercial areas. Special industries that have the potential to cause serious pollution, such as oil refining, electric power generation, and petrochemical manufacturing are located on off-shore islands and in Tuas at the southwestern tip of the main island. Only light industries such as packing of dried foodstuffs, packing and bottling of medicinal herbs and medicated oil, and assembly of electronic and electrical components are allowed near residential areas.

Ministry of Trade and Industry

The relevant bodies under MTI are the Singapore Economic Development Board (EDB), Jurong Town Corporation (JTC), Trade and Development Board (TDB), Singapore Productivity and Standards Board (PSB), and National Science and Technology Board (NSTB). MTI is also responsible for ratifying international treaties with environmental implications, and ensuring that trade and environmental policies are mutually supportive.

(a) Economic Development Board

The Economic Development Board is the lead government agency responsible for the formulation and implementation of economic and industrial development strategies for the manufacturing, services, and exportable services sectors.

Environment-related activities:

EDB identifies investment opportunities for foreign environmental technology companies with expertise in waste management. It also administers incentive schemes to encourage industries to adopt clean technology.

(b) National Science and Technology Board

Established in 1991 as a statutory board under the Ministry of Trade and Industry, the National Science and Technology Board was commissioned to spearhead the drive towards strengthening Singapore’s technological competencies through research and development.

Environment-related activities:

NSTB promotes and supports R&D efforts on environmental technologies, including both clean technology and end-of-pipe treatments. NSTB funds the Environmental Technology Institute (ETI) which undertakes research in waste management.

(c) Singapore Productivity and Standards Board

On April 1, 1996, the Singapore Productivity and Standards Board was established under the Ministry of Trade and Industry. The PSB’s mission is to enhance Singapore's competitiveness and stimulate economic growth to help improve the quality of life for the people of Singapore. To support this mission, PSB has six key thrusts: Productivity Promotion, Manpower Development, Technology Application, Industry Development, Standards and Quality Development, and Incentives Management.

Environment-related activities:

To encourage industries to improve productivity while preserving the environment, PSB launched its Green Productivity Program in 1996. The PSB is now the key organization promoting GP in Singapore. The PSB also sets local standards related to the ISO 14000 series.

Environmental Legislation in Singapore

The growth of industrial activity and solid waste prompted the government to enact the Environmental Public Health Act in 1968. The Clean Air Act followed in the early 1970s and required industry to comply with prescribed emission standards and calls for adequate air pollution and fuel burning control equipment. The Factories Act of 1973, the Poisons Act, and the Radiation Protection Act were subsequently designed to guarantee safe and healthy working conditions in factories. More laws followed in the 1970s to protect water resources from pollution including: the Prevention of Pollution of the Sea Act (1971), the Water Pollution and Drainage Act (1975), Trade Effluent Regulations (1976), and Surface Water Drainage Regulations (1976).

In recent years, several new laws have been enacted to address emerging environmental concerns. Recently passed acts include: the Factories Act (Noise) Regulations (1996), Environmental Public Health (Boundary Noise Limits for Factory Premises) Regulations (1997), and the Hazardous Waste Act (1997).

To unify Singapore's numerous laws and regulations under a single umbrella, the Environmental Pollution Control Act was passed in February of 1999. In addition to deleting outdated provisions and modifying other clauses, the Act also established new powers for environmental agencies, including:

- Capping the amount of pollutants can be emitted by industries; and
- Controlling land contamination and site remediation.

Environmental Policies and Strategies

Singapore has relied heavily on proper land use planning, judicious siting of industries, control of development and building plans, and provision of an environmental infrastructure to maintain environmental quality and prevent pollution. The government has also used regulations, enforcement, and financial incentives to help encourage industry to adopt cleaner technologies. Singapore's environmental goals for the next decade have been laid out in the Singapore Green Plan.

Singapore Green Plan

To prepare Singapore for the next decade, the Singapore Green Plan[9], a master plan for environmental protection and improvement, was prepared in May of 1992. The Singapore Green Plan was presented at the Earth Summit in Rio de Janeiro, Brazil in June of 1992.

The plan is a cooperative effort formulated with input from various ministries, private and public organizations, and members of the public. The Green Plan maps the policies and strategies to: 1) transform Singapore into a model green city with a high standard of public health; 2) establish an environmental quality conducive to gracious living; and 3) create a population that cares for both the local and the global environment by the year 2000. The Ministry of the Environment is responsible for overall coordination of the Green Plan, but actual program implementation has been divided amongst various ministries and organizations based on their specialized skills.

Six strategic directions have been identified under the Singapore Green Plan:

1. *Environmental education* – to educate the people of Singapore to be environmentally conscious;
2. *Resource conservation* – to engage public support in minimizing waste generation, as well as reusing and recycling wastes;
3. *Cleaner technology* – to promote cleaner technologies and processes to create a cleaner and healthier environment and to offer the only long-term solution to environmental pollution;
4. *Environmental technology* – to become a regional hub in environmental technology (ET) by setting up research and development facilities;
5. *Nature conservation* – to set aside 5 percent of Singapore's land for nature conservation; and
6. *Noise management* – installation of technologies to achieve greater noise reduction at the source.

[9] Ministry of the Environment, *The Singapore Green Plan – Action Programs* (1993), Singapore, 1993.

Various government and non-government agencies were tasked with executing each of these activities. Working committees were formed to monitor the activities of each agency.

As the target year of 2000 is fast approaching, the Green Plan is being reviewed to set future directions and targets.[10] The Ministry of the Environment is already gathering feedback from the public, industry, and various other stakeholders to incorporate into the revised Green Plan. Committees are being formed to review activities taken so far and revise the plan as required.

Planning control

As already noted, planning control has been a key strategy in preventing pollution in Singapore. Environmental impacts from new developments are minimised through judicious selection of site, technology and process, and the incorporation of pollution control measures into project design. To date, pollution control measures have primarily emphasized end-of-pipe treatments, however, waste prevention has received growing recognition in recent years.

Industries are classified according to their pollution potential as light, heavy, or special. ENV ensures that industries have adequate treatment facilities to manage their waste before they are given permits to operate. Industries that are water intensive and high polluting, such as leather tanning and hog farming, are being phased out.

Development of environmental infrastructure

Singapore has invested heavily in its environmental infrastructure including its sewerage system, surface water drainage system, solid waste handling and disposal system, and ambient air quality monitoring system. To illustrate how Singapore's environmental infrastructure is used to support industry, some common wastewater treatment and solid waste management practices are described below:

(a) As it is expensive and difficult to manage secondary biological treatment facilities, most industrial facilities located on the mainland are linked to the sewer system. Sewage treatment plants managed by the government are adequately sized to handle the industrial wastewater load. Most facilities only need a simple primary treatment system to meet the sewer discharge standards. This approach minimises many noncompliance incidents related to wastewater discharge.

(b) Non-toxic general wastes are segregated as burnable and non-burnable at the source. Three incinerators with a combined capacity of 1.75 million tons per year handle the burnable wastes. Non–burnable wastes are disposed of in the offshore sanitary landfill. Both the incinerators and the landfill are managed by the Ministry of the Environment.

Financial incentives

The government provides a range of tax incentives to encourage investment in clean technology/production. Programs are explained in more detail in subsequent sections.

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[10] Editor's note: this paper was originally drafted in late 1999.

NGO Awards for Good Performance

While not directly a result of government policy, it is worth noting the role of the Singapore Environmental Council (SEC) in providing incentives for good performance. The Singapore Environmental Council is a non-governmental, nonprofit organization. SEC administers the annual "Singapore Environmental Achievement Award" – the first award that recognises the achievements made by local enterprises in greening their processes and products. Award criteria include: the level of innovation of the initiative and its potential applicability to other companies; the level of commitment and involvement of senior management and staff in environmental protection; the extent to which the initiatives achieve tangible environmental improvements; and evidence that the initiative is both environmentally and commercially viable.

Legal Compliance

As part of its standard regulatory enforcement regime, the Ministry of the Environment tracks the number of incidents of noncompliance each year. The data collected by the Ministry provide overall figures for all industrial sectors; breakdowns according to sectors and sub-sectors are not available.

Air

In 1997, ENV received 470 complaints of air pollution, 227 of which were verified incidents. The main causes of these incidents were poor maintenance, improper operation of equipment, and/or overloading of pollution control equipment. The violators were required to take remedial action to ensure compliance with the allowable limits. The breakdown of air pollution complaints and incidents in 1996 and 1997 is provided in Table 2.

Table 2. Complaints and Incidents of Air Pollution

Types of air pollution	No. of complaints		No. of incidents	
	1996	1997	1996	1997
Odour	111	148	54	71
Fumes/Dust	138	146	81	82
Smoke/Soot	50	43	16	19
Noise	97	98	43	42
Others	26	35	11	13
Total	**422**	**470**	**205**	**227**

Source: The Ministry of the Environment, *Annual Report (1997),* p12.

Water

In 1997, ENV received 138 complaints of water pollution, 57 of which were substantiated. Most of the water pollution incidents were due to illegal discharge or spillage of industrial wastewater into drains. The Ministry required the offenders to clean up the pollution and took legal action against them for violating regulations. A breakdown of water pollution complaints and incidents in 1996 and 1997 is provided in Table 3.

Table 3. Complaints and Incidents of Water Pollution

Types of water pollution	No. of complaints		No. of incidents	
	1996	**1997**	**1996**	**1997**
Chemical/Oil	37	49	18	21
Industrial wastewater	6	4	4	2
Farm wastes	2	1	1	0
Domestic wastewater	38	55	17	17
Others	46	29	17	17
Total	**129**	**138**	**57**	**57**

Source: The Ministry of the Environment, *Annual Report (1997)*, p25.

Small and Medium Enterprises (SMEs) in Singapore[11]

An SME is defined as a company having at least 30 percent local shareholding and less than 15 million Singapore dollars (SGD) in fixed productive assets (in terms of net book value). For service companies, there is a further condition that they employ fewer than 200 employees.

SMEs play an important role in Singapore's economy by generating wealth and creating employment for many people in the workforce. They also provide vital support and sub-contracting work for the larger multinational companies and large local enterprises. The SME sector has evolved significantly over the years. Currently, there are more than 90,000 SMEs which account for nearly 92 percent of the total number of registered businesses. SMEs now play an important role in the manufacturing, service, and commerce sectors. The SME manufacturing sector alone has consistently accounted for approximately 8 percent of the total value-added for Singapore and about 20 percent of the manufacturing sector's value added.[12] The SME manufacturing sector's value-added rose from SGD $4.3 billion in 1990 to SGD $5.4 billion in 1993, demonstrating an annual growth rate of 8 percent.

The productivity of the SME sector, measured by value-added per worker, has also been climbing steadily. Between 1987 and 1993, value-added per worker improved by 58 percent, rising from SGD $27,000 to SGD $43,000.

Environmental Performance of SMEs

The Ministry of the Environment (ENV) is responsible for monitoring industrial pollution in Singapore. It only measures macroscopic environmental performance data that are an aggregate of all the industries in Singapore. Environmental performance data specific to SMEs are not compiled. Environmental performance of SMEs is expected to be poorer than the multinational and local large enterprises as they lack the necessary technical skills to upgrade and monitor their operations.

Government Incentives for SMEs

The government offers a range of incentives outlined below:

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[11] ASEAN Small and Medium-Sized Enterprises, website at *http://www.aeup.brel.com/sme/sme13.html* (Aug. 13 1999).

[12] Singapore Productivity and Standards Board website at *http://psblink/STA/Spore/estm.htm*.

Incentives to adopt Green Productivity

The Singapore government provides a range of incentives to encourage industries to comply with environmental legal requirements. Many of the incentives are focused on helping local SMEs upgrade their capabilities. The following section provides an overview of the incentives offered by the Singapore government to encourage industries to improve their environmental performance. Initiatives include measures to promote both end-of-pipe controls and cleaner production strategies.

a) Tax incentives in the form of investment allowances (IA) are given to companies that adopt clean technology/cleaner production. This includes water/energy conservation. Up to 150 percent of the capital investment made for improvements is tax-exempt. Allowances are administered by the Singapore Economic Development Board (EDB).
b) The government offers a one-year accelerated depreciation scheme for companies that meet a higher/better emission or discharge standard than the existing legal limit or display superior energy conservation efforts. In Singapore, expenditure on equipment is usually depreciated over three years. By accelerating the rate of depreciation on pollution control or energy saving equipment, companies are encouraged to replace their existing pollution control or energy intensive equipment sooner. The Inland Revenue Authority of Singapore (IRAS), a Singapore government agency, administers these tax incentives to factories or companies in conjunction with the Ministry of the Environment (ENV).
c) National Cost of Quality (NCOQ) Program[13] – The Singapore Productivity and Standards Board (PSB) initiated the National Cost of Quality Program to assist Singapore industries in becoming more quality and cost competitive. NCOQ encourages companies to establish a system to minimise waste of resources such as human resources, material, time, etc. As the aims and methodology of NCOQ are similar to that of GP, GP has now been recognised as a sub-set of NCOQ and the program also serves as a platform for GP promotion. SMEs participating in the NCOQ Program may also apply for LETAS grants to cover up to 90 percent (as opposed to the standard of up to 70 percent) of a consultant's fees for technical support services. Hence, there is greater encouragement for SMEs to implement GP. See the following sections for details on the LETAS program.
d) Incentives for setting up recycling parks – Low cost land is provided to entrepreneurs setting up recycling facilities. The goal is to minimise the volume of solid waste entering landfills and incinerators.
e) ISO 14001 certification – The first Environmental Management System (EMS) certification scheme, known as the PSB ISO 14000 (Environmental Management System) Certification Scheme, was officially launched on May 28, 1996. The scheme is open to both local and overseas companies, and certification is based on the ISO 14001:1996/SS ISO 14001:1996 standard. To date, more than 80 companies have been certified.

[13] PSB website at *http://www.psb.gov.sg.*

In addition to the above incentives, the government offers two programs specifically for SMEs:

a) LETAS – The Singapore Productivity and Standards Board (PSB) administers the Local Enterprise Technical Assistance Scheme (LETAS). SMEs receive subsidies to engage technical consultants to apply GP measures such as waste minimization, improved end-of-pipe treatments, ISO 14001, etc.
b) LEFS – The PSB also administers the Local Enterprise Finance Scheme (LEFS) which provides soft loans for factory and machinery financing as well as short-term loans to help finance implementation of GP and other productivity improvement measures.

ENVIRONMENTAL PERFORMANCE OF THE PRECISION ENGINEERING (MACHINING) INDUSTRY

Profile of the Precision Engineering Industry[14]

Precision Engineering (PE) is the third largest industry in Singapore, after electronics and chemicals, in terms of annual fixed asset investment (FAI) commitments. The industry's total output in 1997 was approximately SGD$10.4 billion and accounted for 11 percent of the manufacturing sector's share of the Gross Domestic Product. There are an estimated 1,000 international and local companies employing 62,800 people in the PE industry. The industry can be classified into the following three sub-sectors:

- Industrial equipment, automation systems, associated sub-modules, and manufacturing software;
- Equipment and related industries for semiconductor manufacturing; and
- Precision components and toolings for industries such as electronics, telecommunications, healthcare products, and automotive.

Precision Components and Toolings

The precision components and toolings (PCT) sector is the largest contributor to the PE industry's output and encompasses an extensive product range. In 1997, the sector employed approximately 50,800 people and had an output of SGD$8.2 billion.[15] This PCT sector supplies the electronics, telecommunications, and healthcare product sectors and is dominated by SMEs.

Manufacturing Process

The typical manufacturing process in the precision machining industry starts with the machining of a base material (e.g., stainless steel, hard cutting steel, aluminium, or brass rods) using CNC or CAM machines to shape the desired contours. The machined parts undergo secondary processing such as deburring, grinding, surface treatment, or heat treatment to further fine-tune the contours. These operations require the use of cutting fluids, so the machined parts must be degreased and dried before packing. Some

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[14] Singapore precision Engineering Industry website at *http://www.singapore-precision.com.sg/news1.cfm*, Sept. 1, 1999.

of the parts (e.g., mild steel) are further treated to impart corrosion resistance before undergoing additional secondary processing such as electroplating. Most of the precision machining companies in Singapore out-source electroplating operations, so environmental aspects related to plating are not discussed here. The typical process flow is shown in Figure 5.

Significant Environmental Aspects

In discussing the environmental aspects of the industry, two major groups of aspects are addressed: resource-use and pollution generation. Resource-use aspects relate to input of raw materials into the operation; while pollution aspects relate to the wastes from the manufacturing process.

In the machining of the base material, the major resource-use aspects are the metal/alloy base material, electricity, cutting fluids, hydraulic oil, degreasing solvents, and water. The major pollution aspects are scrap metals, cutting fluid mist, spent cutting fluids, cutting fluid spillage, cutting fluid spill kit wastes, wastewater, and spent solvents.

The major resource-use aspects in the secondary processes are cutting oil, coolant, and electricity. The major pollution aspects are spent oil, spent coolant, spent solvent, and grinding sludge.

Semi-finished components are degreased, dried, and packed. The major resource-use aspects are city water, de-ionised (DI) water, degreasing chemicals such as Trichloroethane (TCE), diesel, kerosene, electricity, and packaging materials. Major pollution aspects are wastewater, spent TCE, spent diesel, spent kerosene, emissions from TCE, diesel, and kerosene.

Environmental regulations relevant to the aspects listed above are provided in Table 4.

Table 4. Applicable Environmental Regulations

	Aspects	Environmental legislation
1	Spent cutting oil, spent coolant, oily wastes, spent solvents, grinding sludge	Environmental Public Health Act (Toxic Industrial Waste) Regulations require that these wastes be segregated from general wastes and treated by a licensed disposal contractor.
2	Metal scraps	Since these wastes are oily, they must be treated by a licensed disposal contractor as required by Environmental Public Health Act (Toxic Industrial Waste) Regulations. The contractors will recycle the metals.
3	Wastewater	Wastewater is to be treated to meet the Trade Effluent Regulation and disposed into the sewer.
4	Gaseous emissions	There are no major gaseous emissions from these factories. However, the indoor air quality must comply with the Department of Industrial Health’s guidelines. Companies must control oil mist and solvent emissions.
5	General wastes	The Code of Practice for General Wastes requires industries to segregate general wastes from toxic industrial wastes. It also requires general wastes to be further segregated as Class A (mainly inorganic meant for landfill) and Class B (organic for incineration).

Compliance

The available environmental compliance data in Singapore are an aggregate for all industrial sectors. Hence compliance details of the precision machining industries are not available. As there are many SMEs in this sector, compliance level is generally expected to be low.

Barriers to GP in the Precision Machining Sector

While incentives exist, many barriers are also present which impede the successful adoption of GP by industry.

Socio-cultural (Mindset)

Companies view waste generation as inevitable and do not perceive wastes as lost resources. As a result, waste minimization is not considered a “business improvement” activity by many managers. Companies do not understand the hierarchy of waste management and, unfortunately, waste treatment and/or disposal is often the chosen option. To reduce waste at the source, companies may have to change their current operating procedures. Many companies, especially SMEs, are unwilling to do so as they fear any deviation from current practices may affect output or product quality.

Information

Many GP-related publications are available in Singapore libraries. For example, the Clean Technology and Environmental Management (CTEM) Centre supported by United States-Asia Environmental Partnership Program (US-AEP) has a large collection of publications on techniques or approaches used in GP. Unfortunately, very few companies are aware that information is available on GP-related techniques. Those who do attempt to use the information often find it difficult to apply to their own operations due to a lack of technical expertise.

At the national level, policy makers and planners lack detailed data on wastes generated in Singapore and on the current state of waste minimization as practiced by industry. As a result, the government has difficulty in identifying the industrial sectors generating the largest amounts of wastes and promoting appropriate minimization technologies.

Economic

Many companies, especially SMEs, face a shortage of capital for investment in equipment changes and covering associated operating costs. Investment in GP is generally given a low priority. Government grants are available to SMEs to cover GP implementation, however, very few companies are aware of the grants programs. With the current economic downturn affecting Southeast Asia, companies are unsure of the economic climate and some are even facing bankruptcy. As a result, there is little interest in adopting GP measures since they are viewed as a long-term investment.

In addition, the low cost of waste disposal provides little incentive for companies to aggressively pursue waste minimization. The cost of waste disposal in Singapore is still relatively low compared to many developed countries. However, increasing waste disposal costs to encourage waste minimization may lead companies to begin dumping waste illegally.

Legal

The present legal requirements stipulate discharge levels, but not waste treatment methods for industry. The flexibility of the system allows industry the freedom to adopt GP options to achieve the discharge limits, as opposed to being required to install a specific treatment technology. However, there are no laws at present to specifically encourage waste minimization or to require suppliers to take their used products back for recycling.

Technical

Companies are not fully aware of the existence of applicable GP technologies. At the same time, even the consultants and vendors who are aware of GP technologies are only interested in selling end-of-pipe solutions to industry as they involve low risk for high gains.

Human resources

There is very little awareness of GP principles and techniques within industry. GP is not taught in local schools and universities. Companies that seek to pursue waste minimization therefore lack trained personnel capable of designing and executing GP strategies. The absence of trained consultants to advise companies on GP also serves as a barrier to GP promotion.

GP Practices in the Precision Machining Industries

Table 5 shows the qualitative assessment of the state of implementation of GP in the precision machining sector.

CASE STUDY OF GP IMPLEMENTATION IN A PRECISION MACHINING COMPANY

Overview

Three companies in precision component manufacturing were chosen for a comparative study to develop environmental performance indicators and study GP option generation.

Company A is a US-based manufacturer of aluminum precision machined parts. Company A's data were used as a reference to compare against the other two companies, both of which are Singapore-based.

Company B, located in Singapore, serves a diverse set of industries including electronics, home appliances, and process industries. Its portfolio includes more than 400 products ranging from printer shafts to precision screws made with free cutting steel, stainless steel, brass, and aluminum. The company is certified in ISO 9002 and ISO 14001. This company was chosen for one of the Asian Productivity Organization's GP demonstration projects.

Company C is also a Singapore-based company. Like Company B, it sells its products to a diverse range of industrial sectors including electronics, home appliances, and process industries. Company C's products range from printer shafts to precision screws made with free cutting steel, stainless steel, brass, and aluminum. This company is certified in ISO 9002. Company C was chosen as the subject for this case study.

Table 5. Qualitative Assessment of GP Implementation in Singapore

Aspects	Level of implementation of GP options among precision machining companies in Singapore		
	High	**Medium**	**Low**
Resource-use aspects			
Metal/alloy base material	Ordering rods of exact diameter to reduce machining time and wastage		
Electricity usage	Turning machines off when not in use		
Cutting fluids, hydraulic oil		Recycling of used oil	
Degreasing solvents		Reuse of degreasing solvents (e.g., kerosene, TCE)	
Major pollution aspects			
Scrap metals	Sold to recyclers		
Cutting fluid mist		Air pollution control system	
Spent cutting fluids	Recovered, purified, and reused		
Spillage of cutting fluid			Inventory control, worker training, and secondary containment to capture spillage
Oily rags*		Disposed through licensed waste collector	
Wastewater		Discharged to sewer	Recycling and counter current washing
Spent solvents*		Disposed through licensed waste collector	Recycling
Grinding sludge*		Disposed through licensed waste collector	

Note: * Licensed waste collectors recover materials of value (if any) and treat the residual waste to meet the legal requirement before disposal.

Environmental Performance Indicators (EPI)

Operational and management data of the three companies were gathered and data are provided in Tables 6-9. Each of the companies manufactures a diverse set of products of varying shapes and sizes. At any point in time, at least 50 different types of products are being manufactured by either company B or C. The product mix changes continuously depending on customer needs. As a result, the EPIs generated at any one point can only be used as a very general point of reference and can not serve as benchmarks for analysis of the company's environmental performance.

GP Study

The GP options that were identified for the three companies are listed in Table 9. Existing practices are highlighted. The options listed for company B as "Proposed" were generated through the Green Productivity Demonstration Project. GP options listed as "Proposed" for company C are the options identified through this project.

The focus of this case study (Company C) is located in Jurong, which is on the western part of Singapore where most factories are located. The company is a local SME and was established in 1981. It employs approximately 100 staff and the physical size of the plant is 4,710 square meters. It has 24 CNC Auto Lathe and 50 CAM Auto Lathe machines.

The company manufactures precision-turned parts, shafts, precision screws, and other related products for use in printers, computers, disk drives, electrical appliances, telecommunications equipment, automotive components, and medical instruments. The parts are made from free cutting steel, stainless steel, brass, or aluminum. The company is certified to ISO 9002.

This company was chosen as the candidate for this case study because:

- The environmental aspects of this company (e.g., metal scraps, cutting fluids usage and wastage, and cutting fluid mist) are common to most of the other companies in the sector; and
- EPI data were readily available from similar companies (A and B).

Manufacturing Process

The flow scheme for the printer shaft manufacturing process is illustrated in Figure 5. The raw materials (stainless steel/free cutting steel rods) are machined in the CNC/CAM machines to make products of the desired contours. Major resource-use aspects at this stage are the metal rods, electricity, cutting oil, and hydraulic oil. Major pollution aspects are scrap metals, oil mist, spent cutting oil, spent hydraulic oil, oil spillage, and oily wastes.

The machined products undergo secondary processing such as Centerless Grinding (C.G.) and denting. Major resource-use aspects at this stage are coolant and electricity. Major pollution aspects are metal scraps, spent coolant, and grinding sludge.

The free cutting steel components are coated with materials such as nickel for corrosion resistance. However, the coating or electroplating operation as well as the preceding degreasing operation are both out-sourced. If a very high surface smoothness is required by the customers, the semi-finished components are superfinished. The components are then degreased, dried, and packed. The major resource-use aspects are superfinishing oil, degreasing chemicals such as Trichloroethane (TCE), and packaging materials. Major pollution aspects are spent TCE and TCE emissions.

Figures 6 and 7 show process flow diagrams for companies A and C.

Figure 5. Flow Diagram for Printer Shaft Manufacture

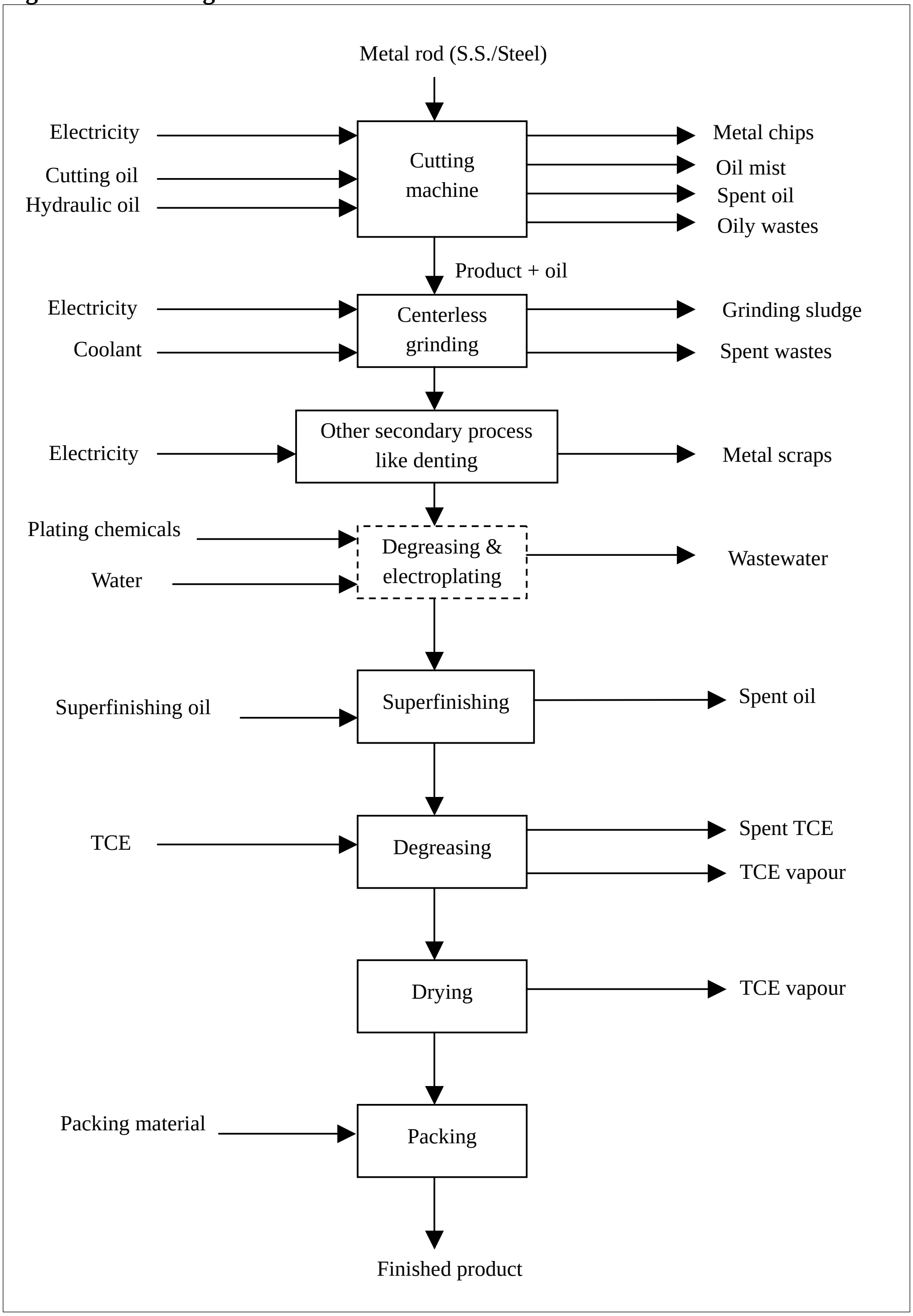


Figure 6. Process Flow Diagram for Company A (U.S. manufacturer)

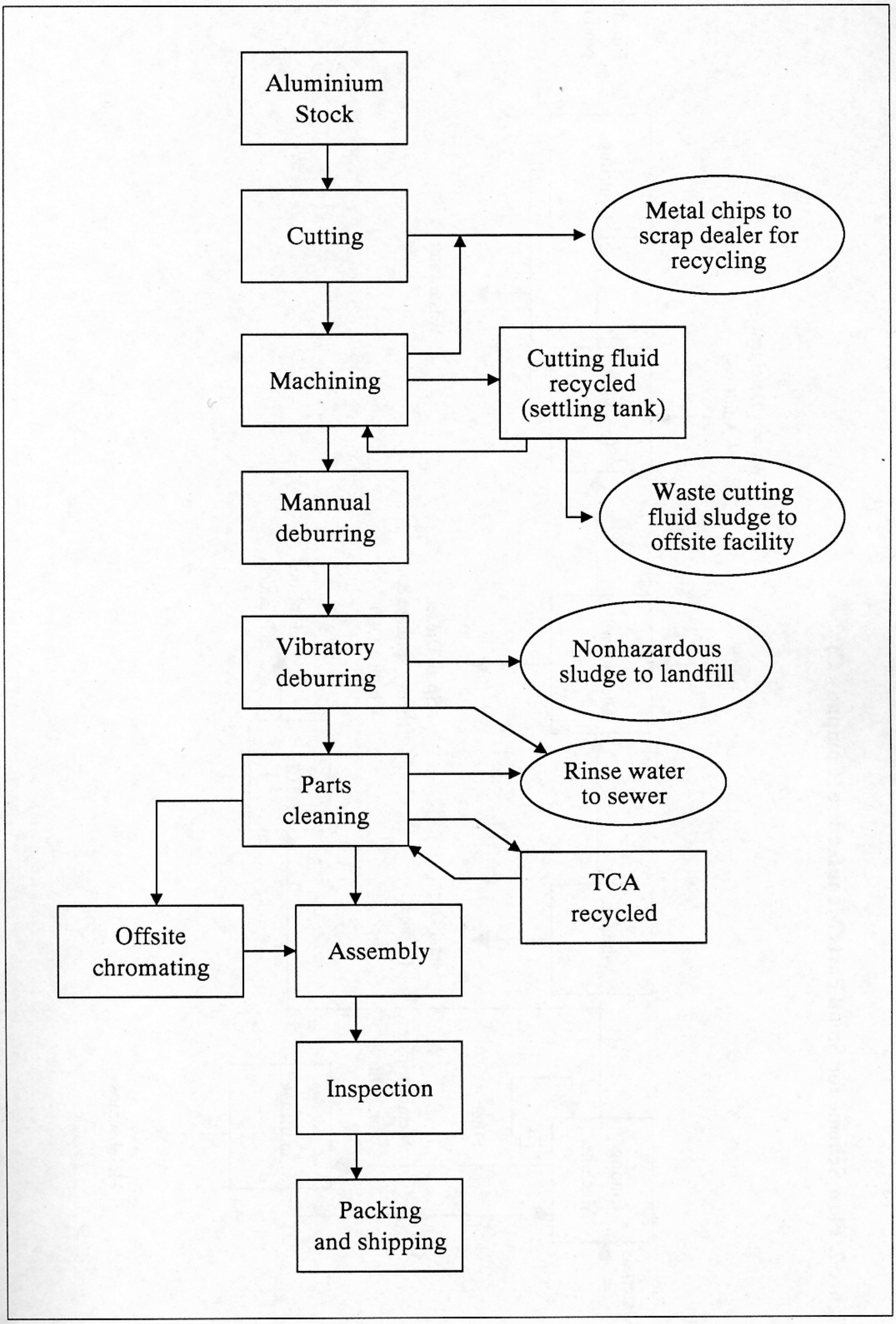
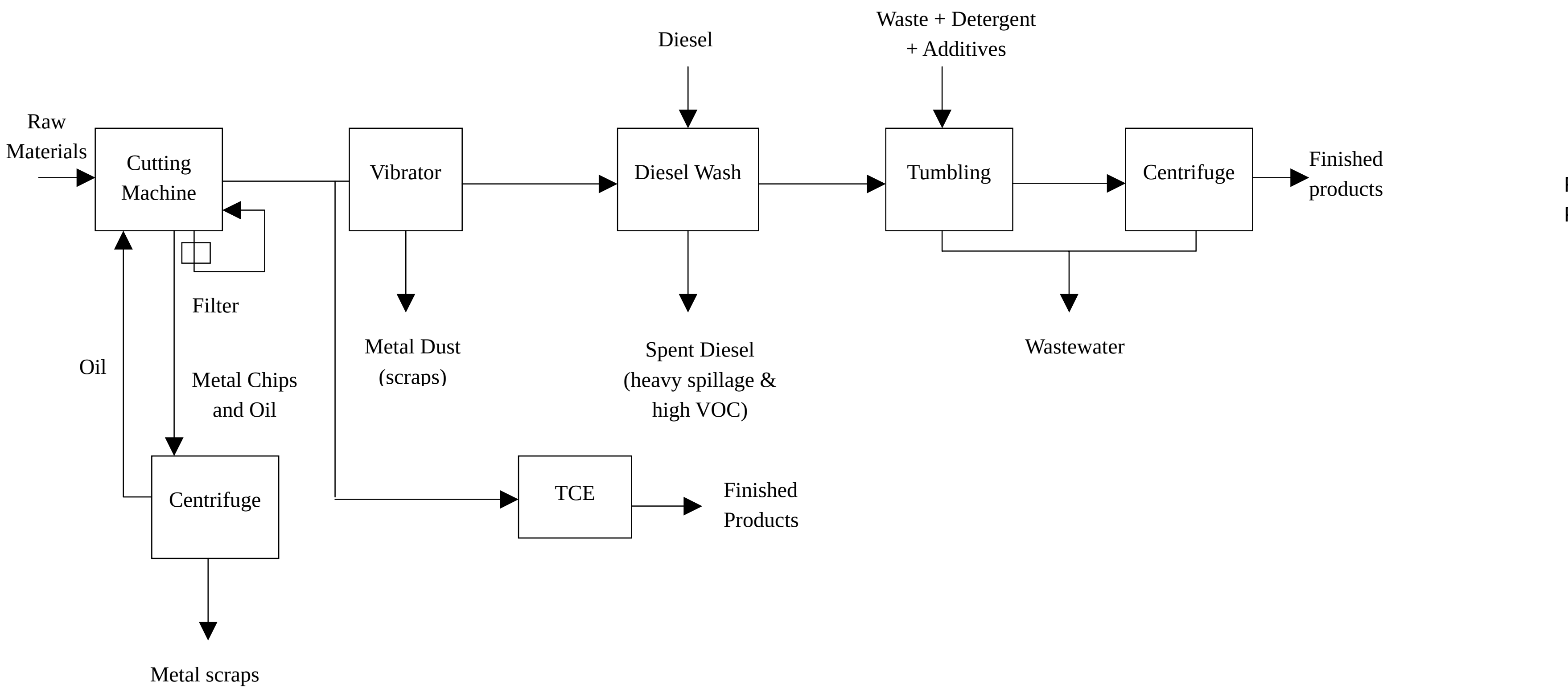


Figure 7. Flow Scheme for Small Parts Manufacture (Company C)



The methodology used for this GP case study is outlined below:

1. GP team formation;
2. Generation of flow scheme;
3. Identification of resource use and pollution aspects;
4. Quantification of aspects to the extent possible;
5. Generation of GP options; and
6. Selection of the most appropriate options for technical feasibility studies and cost-benefit analysis.

The company is currently considering implementation of the GP options listed in Table 9 as well as establishment of a full-fledged GP system.

Sample: decision to recover cutting oil

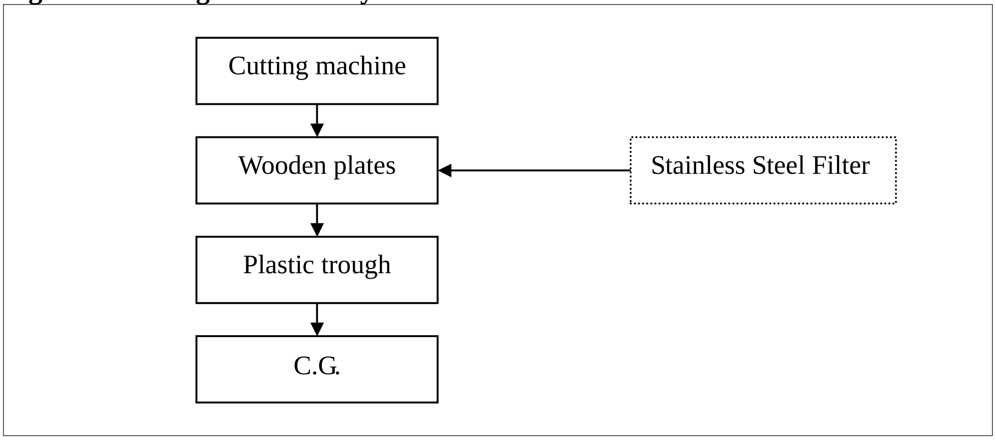
GP Team Formation

Company C's GP team consisted of three core members: the production manager, engineer, and a production executive. Team members were chosen for their technical knowledge, understanding of company systems, and contribution to decision making in the organization. Other staff were involved if and when required.

Generation of flow scheme

A flow diagram (Figure 5) was generated covering the various unit operations involved in the manufacture of printer shafts. The various material inputs and outputs were identified at each stage of the process. GP options were identified for each key aspect (Tables 8 and 9).

Figure 8. Cutting Oil Recovery



Note: Box with dotted line (-------) = GP option.

One of the areas identified for improvement was minimizing cutting oil dragout loss along with the parts after machining. Based on our experience with a similar company, it was observed that a substantial amount of oil was being wasted as dragout along with products. No effort was being made by the company to recover this oil. Hence the area was chosen for a detailed study.

A flow scheme of the steps between the cutting operation up to the Centerless Grinding (C.G.) area was drawn to allow the team to better understand the operation.

Immediately after cutting, the printer shafts and cutting oil were collected on wooden plates, which absorbed a portion of this oil. The shafts were then placed in a plastic trough before being processed in the C.G. Loss due to dragout loss, along with the printer shafts, was estimated to be about 300 litres of oil per month.

Generation of GP options

The GP team generated the following options to recover oil from the printer shafts:

1. Provide a circular scraper to remove the oil from the shaft immediately after machining; and
2. Use an oil filter immediately after machining to allow the oil to drain out, instead of being absorbed by the wooden boards.

Selection of GP options

Option one, though effective in recovering oil, could lead to quality problems such as scratches on the printer shaft. The second option was chosen for a feasibility study since it was simple to implement, relatively inexpensive, and would likely not result in any quality problems.

Assessment of technical feasibility

Based on a feasibility study carried out on two machines, it was observed that approximately 80 litres of cutting oil could be recovered every month by applying option two to all 24 machines.

Cost–benefit analysis:
Cost: S$30 $\times$ 24 = S$720

Savings:

Amount of oil recovered	80 litres per month
Savings from oil recovery	S$3,360 per year

Intangible benefits:
No hazardous waste generation in the form of oily wood waste.
Lower burden on the environment due to decreased oil consumption.

Standardization:
This option is being standardized for all 24 machines used for printer shaft manufacturing.

Other GP Options

Other options listed under Table 9 are being implemented.

The printer shaft degreasing system and the process flow for cutting oil for company B are shown in Figures 9 and 10.

Figure 9. Printer Shaft Degreasing System of Company B

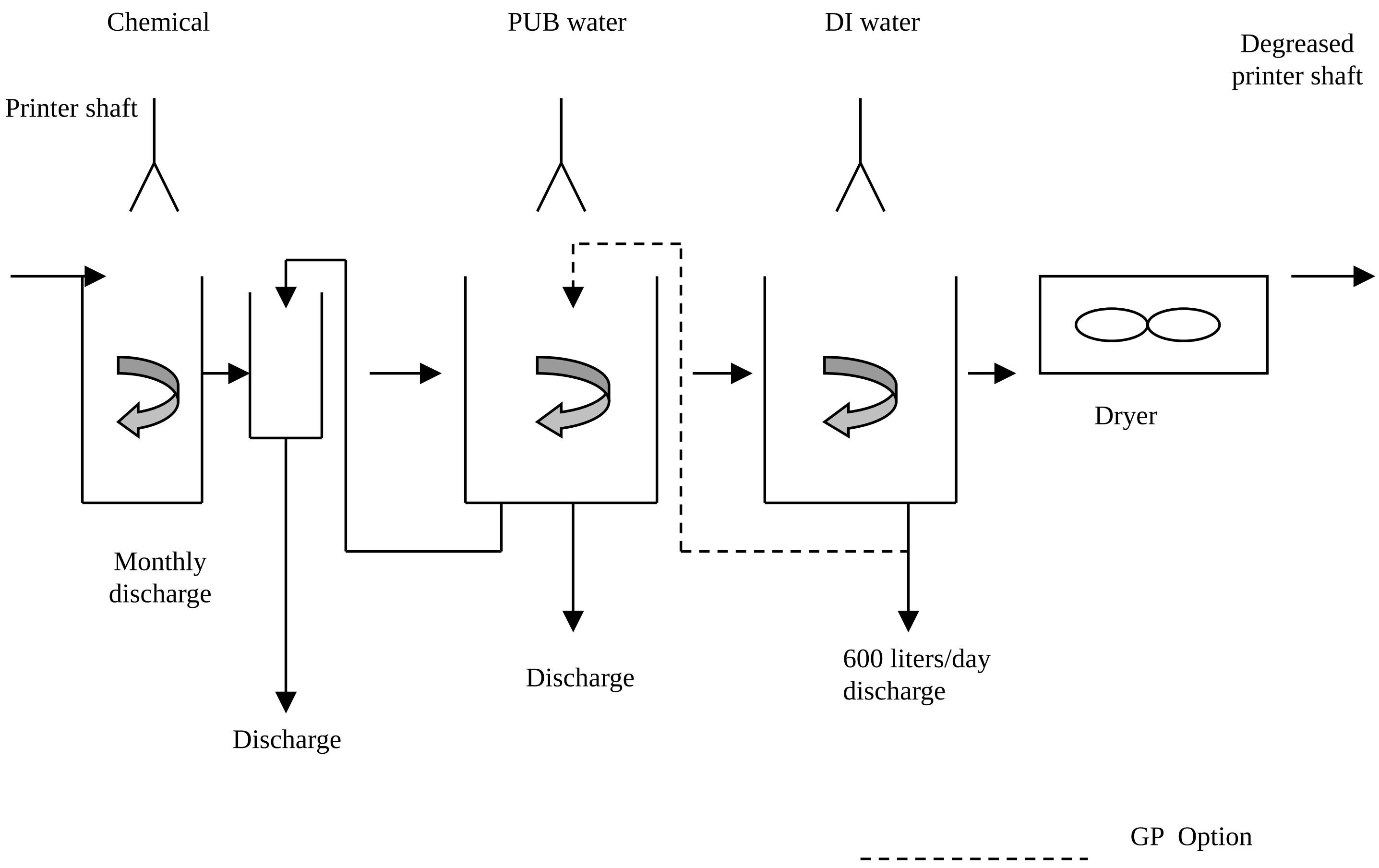


Figure 10. Flow Diagram for Cutting Oil for Company B

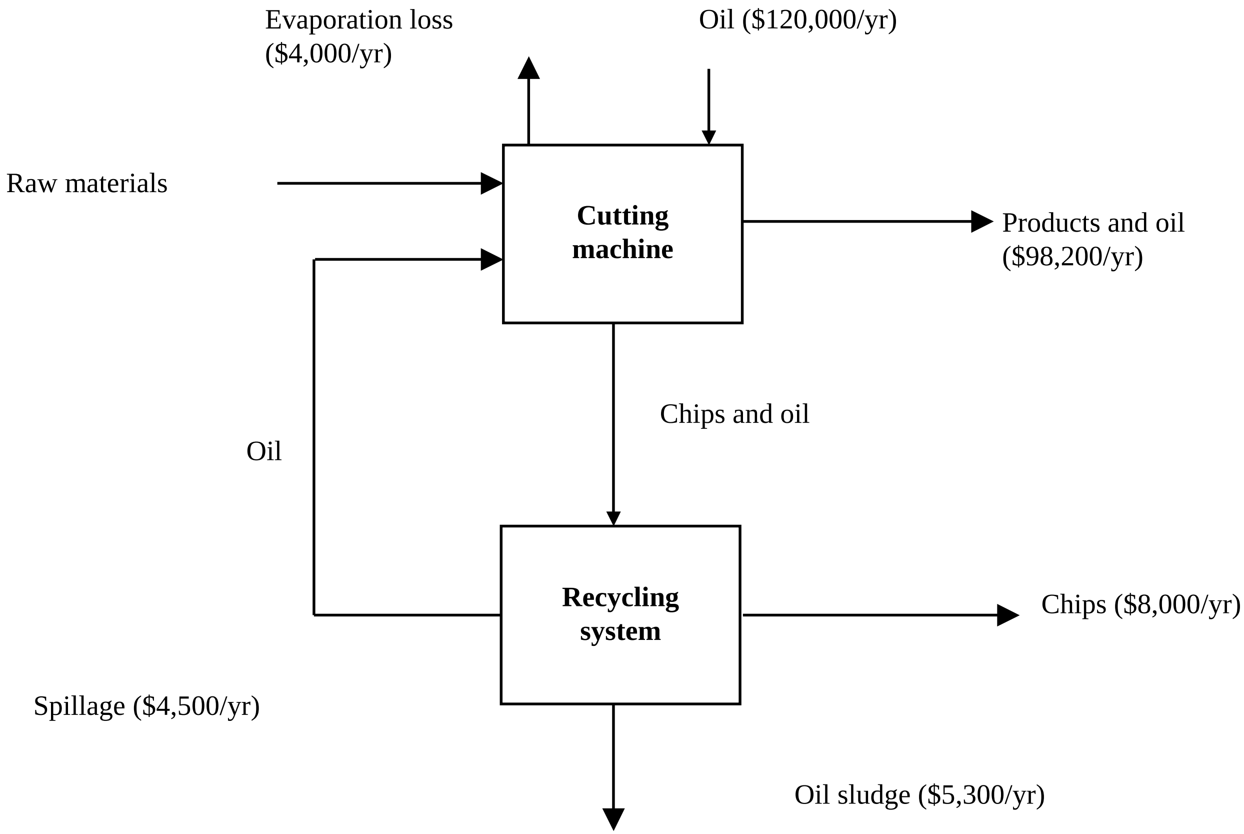


Table 6. Environmental Profiles

Item	Company A*	Company B	Company C
1. Plant Background	Manufactures aluminium machined parts. Operates 2,210 hr/yr and produces 500,000 units per year.	Manufactures free cutting steel, stainless steel, brass, and aluminium machined parts. Products include printer shafts, screws, crash caps, nuts, etc. Annual sales SGD$18 million (1997) and SGD$30 million (1998).	Manufactures free cutting steel, stainless steel, brass, aluminium, and plastic machined parts. Products include pins, shafts, stud/nuts, housing and others. Annual sales of SGD$7.8 million on average.
2. Manufacturing Process	CNC machining (Fig. 4.3).	CNC machine turning, CAM Auto Lathe, centerless grinding, superfinishing, grinding, secondary process.	CNC machine turning, CAM autolathe, centerless grinding, superfinishing, grinding, secondary process (Fig.5 and Fig 7).
3.0 Operation Data			
3.1 No. of machines	Not available.	<u>Cutting machines</u>: CNC machine: 52 CAM machine: 13 ESCO machine: 12 <u>Grinding machines</u>: Centerless & cylindrical grinding: 15 <u>Others</u>: Superfinishing, burnishing: 9	<u>Cutting machines</u>: CNC machine: 24 CAM machine: 50 <u>Grinding machines:</u> Centerless & cylindrical grinding: 7 <u>Others</u>: Superfinishing, tumbling: 4

Table 6. Environmental Profiles (*continued*)

Item	Company A	Company B	Company C
3.2 Raw material consumption (kg/month)	Aluminum	Steel & stainless steel: 92,876 Brass: 8,740 Aluminum: 6,727 Total: 108,073	Steel & stainless steel: 39,167 Brass: 2,167 Aluminum: 167 Total: 41,501
3.3 Cutting oil consumption (m^3/month)	Not available	2.6	1.37
3.4 Solvent consumption (m^3/month)	5.8 (TCE)	Not applicable (1.3 of kerosene used)	0.43 TCE 0.27 Diesel
3.5 Water consumption (m^3/month)	Not available	1171.9	369
3.6 Process wastewater generation (m^3/month)	169.54	90	Not available
3.7 Metal rods, scraps and chips disposal (kg/month)	Not available	6,329.2	Not available
3.8 Electricity (kWh/month)	Not available	200,312.5	131,401
3.9 Spent diesel	Not applicable	Not applicable	200 liters every 3 months
3.10 Spent oil (m^3/month)	2.7	0.12	Not available

* Information on Company A derived from: H. W. Edwards, M. F. Kostrzewa, P. S. Miller, and G. P. Lobby, *Waste Minimization Assessment for a Manufacturer of Machined Parts*, EPA: Environmental Research Brief, 1992.

Table 6. Environmental Profiles (*continued*)

Item	Company A	Company B	Company C
3.11 Frequency of spent coolant disposal	Not available	Not available	Once every 4 months
3.12 Quantity of coolant disposed (liters/month)			200
3.13 Oily rags (m^3/month)	Not available	3.5	Not segregated from waste
3.14 Housekeeping	Not available	Good. Well-defined layout helps. However, oily stains and curtains indicate room for improvement.	Spillage of diesel in diesel washing area. Oil spillage in machinery and chemical storage area.
3.15 Number of employees	Not available	140	100
4.0 Existing waste management practices	1. Wastewater from tumbler and washer discharged into sewer. 2. Abrasive media sludge from tumbler is shipped offsite to municipal landfill. 3. Waste cutting oil sludge from settling tank is periodically drained and shipped offsite to a non-hazardous waste disposal facility.	4. Wastewater from tumbling and degreasing sections are treated in a WWTP and discharged into the public sewer after pH control. 5. Hazardous wastes and general waste are segregated on-site. Hazardous waste (spent coolant, oily rags, WWTP sludge) disposed through a licensed toxic waste disposal contractor.	6. Generates 550-960 liters of wastewater per day which is recycled for floor mopping and toilet flushing. 7. Spent collant and TCE removed from wastewater and disposed of through a contractor.

* Information on Company A derived from: H. W. Edwards, M. F. Kostrzewa, P. S. Miller, and G. P. Lobby, *Waste Minimization Assessment for a Manufacturer of Machined Parts*, EPA: Environmental Research Brief, 1992.

Table 7. Environmental Performance Indicators

Item	Company A	Company B	Company C
5.0 Environmental Performance Indicators			
5.1 Cutting oil consumption per total raw materials (liters/kg)	Not available	0.02	0.03
5.2 Electricity consumption per total raw materials (kWh/kg)	Not available	1.85	3.17
5.3 Water consumption per total raw materials (m^3/kg)	Not available	0.011	0.009
5.4 Ratio of cutting oil top up and cutting oil within system (liter/liter)	Not available	0.49	0.27
5.5 Wastewater generated per ton of raw materials (m^3/ton)	Not available	0.83	Not available
5.6 Spent coolant per ton of raw materials (m^3/ton)	Not available	Not available	0.005

Table 7. Environmental Performance Indicators

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5.6 Spent coolant per ton of raw materials (m^3/ton)	Not available	Not available	0.005

Table 8. Existing GP Practices in Companies Profiled

Aspect	Company A	Company B	Company C
Cutting oil	Cutting oil is periodically drained to a settling tank fitted with a belt oil skimmer. Supernatant oil is reused in the machining equipment. Settled oil sludge is discharged to municipal landfill.	Cutting oil is recycled within the turning machine. Oil from scraps and chips is collected in a settling tank for purification. (Fig.4.6 and Fig. 4.7). Supernatant oil is reused. Oil sludge is disposed of by licensed contractor.	Cutting oil is recycled within the turning machine. Oil from scraps and chips is separated in a centrifuge and oil is recovered (Fig. 4.4).
Metal chips/rods/scraps	Metal chips are shipped off site to a metal dealer for recycling.	Metal rods, scraps, and chips are collected and given to a contractor for off site recycling.	Metal rods, scraps, and chips are collected and given to a contractor for off site recycling.
Solvent and kerosene	Spent solvent (TCE) is distilled on-site using a solvent recovery unit (Fig. 6).	Solvent TCE was replaced with an aqueous cleaning agent. Spent kerosene is allowed to settle and supernatant oil is reused. Settled sludge is disposed of by a licensed contractor.	TCE is recovered using distillation process. However, use is not regular.
Wastewater	--	Concentrated wastewater is segregated from rinse wastewater and treated separately in the WWTP.	Wastewater is recycled for floor mopping and toilet flushing.

Table 8. Existing GP Practices in Companies Profiled *(continued)*

Aspect	Company A	Company B	Company C
Coolant	--	Coolant from the centerless grinding area is purified with a magnetic separator and paper filtration before being reused. Coolant disposal is minimized by maintaining the concentration of coolant chemical and water with the help of a refractometer. However, tramp oil is not recovered.	Coolant from the centerless grinding machine is purified with a magnetic separator system followed by a Hydroclone to remove solid impurities. However, the Hydroclone has not proven effective. Coolant disposal is minimized by maintaining the concentration of coolant chemical and water with the help of a refractometer. However, tramp oil and abrasive materials are not recovered.
Cutting oil	--	Cutting oil from printer shafts is collected using perforated trays.	Not practiced
Superfinish oil	--	Data on recovery of superfinish oil not available.	Superfinish oil is purified using cartridge filters and reused.
Abrasive media	--	Abrasive media are segregated for reuse.	Abrasive media for metal parts polishing are segregated after use and reused.

GREEN PRODUCTIVITY PROMOTION IN SINGAPORE

The PSB's Green Productivity Program

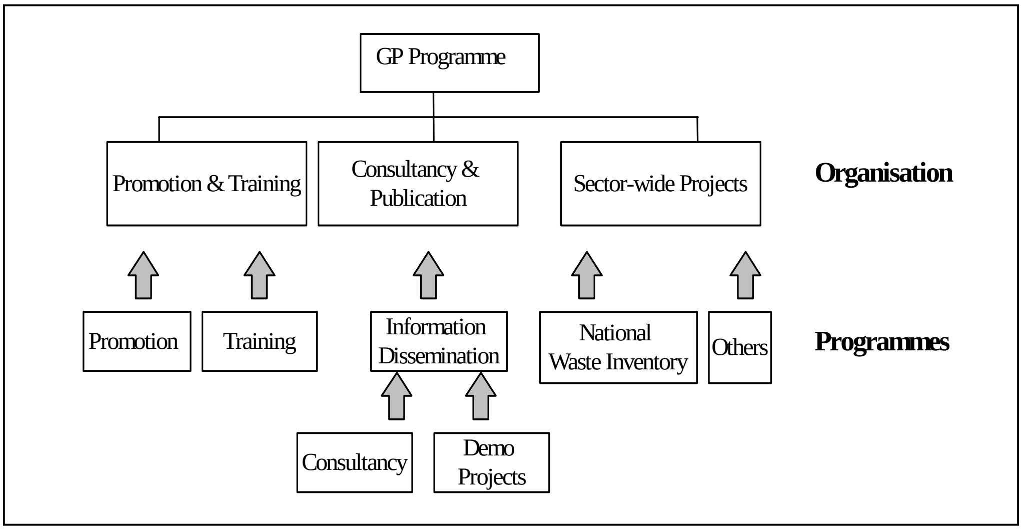
Singapore's economic growth in the past was due largely to labour accumulation (1960s to1970s) and later to capital accumulation driven by new investment (1980s to early 1990s). As global competition intensifies, the next phase of growth will be driven primarily by qualitative improvements in the use of resources. During times when the economy is expanding quickly, inefficiency in resource utilisation is tolerated. However, as the economy slows, cost saving and bottom-line issues can become the factors determining whether or not a company or industry sector survives. Therefore, GP will become increasingly important to Singapore's future economic growth.

Since April 1998, the Singapore Productivity and Standards Board (PSB) has been actively promoting the concept of GP to Singapore industries. PSB's GP program is a concerted effort, leveraging resources within and outside of the PSB to promote GP techniques.

GP Program Components

The PSB's GP program can be divided into three main components:

- Training and promotion;
- Sector-wide demonstration projects; and
- Consulting and publications.



The above strategy is meant to overcome barriers to GP promotion highlighted before. The following are some examples of the PSB's activities to promote the results of this survey.

- Educational institutional lecturers are being trained in GP. They will inculcate GP into their students. This will help address the mindset problem highlighted earlier, and will increase the number of GP experts available to industry. To date, one polytechnic lecturer from Singapore Polytechnic has been trained. The lecturer was involved in the GP demonstration project (GPDP) as well as this survey. He will share the findings of this survey with his students and in future seminars. Another lecturer from Ngee Ann Polytechnic is also scheduled to receive training.
- The findings of this survey will be disseminated to other precision machining companies through a seminar and workshop that will be conducted as part of the GPDP.
- Productivity and environmental (end-of-pipe and EMS) consultants are being trained in GP. The consultants will form the core of a group of trainers capable of disseminating GP to the private sector through their regular consulting activities.

Potential future programs:

1. The Singapore Green Plan, which provides the policy direction for environmental issues in Singapore, is being reviewed by the Ministry of Environment. Waste minimization and resource conservation have been identified as major thrusts for the next decade. The PSB's GP activities are being incorporated into this Green Plan.
2. Formation of a GP club to share experiences among individual companies is being considered. This can follow the existing Quality Circles (QC) models being used by the PSB.
3. The PSB is experimenting with GP as a tool for achieving ISO 14000 and also as a means of sustaining continual improvement in an ISO 14001 certified company. In company B, an ISO 14001 certified company, GP is being applied as a means to support the existing EMS. In company C, GP is being implemented and will form a basis for future ISO 14001 EMS certification.

The authors thank Mr. Lai Swee Fong, Lecturer from Singapore Polytechnic for his contributions to this survey.

REPUBLIC OF CHINA

Ching-Tsung Cheng
Director
Eco-Technology Development Center
CTCI Foundation
Taipei

COUNTRY PROFILE

Overview[1]

The Republic of China (ROC) was founded on January 1, 1912, as a sovereign state and a constitutional democracy. In 1949, as the nationalist forces lost ground to the communists during the civil war, the ROC government moved its seat to the island of Taiwan and established the capital in Taipei. As of February 2000, the total population of the Republic of China stood at more than 22.12 million with a natural growth rate of 0.00756. Taiwan is the second-most densely populated area in the world with an average of 610 persons per square kilometer. Taipei, located in northern Taiwan, is the ROC's most populous city (2.64 million), followed by Kaohsiung (1.47 million) in southern Taiwan. The total land area of the ROC is 36,000 km^2.

The Constitution of the ROC, based on Dr. Sun Yat-sen's Three Principles of the People, was promulgated on January 1, 1947. Recent amendments include the direct election of the president and elimination of the Taiwan Provincial Government. There are three layers of government in the ROC: (1) the central level consisting of the presidency, the five Yuan (Executive, Legislative, Judicial, Examination, and Control) and the National Assembly; (2) the special municipal (Taipei and Kaohsiung) governments and their assemblies/ councils; and (3) the 18 county and five other city governments. Currently, there are 85 registered political parties, but only four play a significant role in electoral activities.

Economy of the ROC[2]

The economy of the ROC has developed rapidly over the last forty years. From 1952 through 1995, the annual growth rate averaged 8.6 percent and per capita GNP soared from US$196 to US$12,439. The gross national product (GNP) topped US$262.3 billion in 1998 and the gross domestic product (GDP) amounted to US$261.4 billion. During this forty year period, the agricultural sector's contribution to the economy has steadily shrunk, accounting for only 2.87 percent of the GDP in 1998. Industry's contribution also dropped from 47.1 percent of the GDP in 1986 to 34.1 percent in 1998. The service sector, on the other hand, has risen in importance and represented 63.12 percent of the GDP for 1998. The nation's industrial base is currently concentrated in heavy, chemical, and technology-intensive industries. The development of the

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1 The statistical data in this paragraph is from the Republic of China Government Information Office.
2 Data from various reports published by the Council for Economic Planning and Development.

information industry has been particularly strong over the last decade and the sector now ranks 3rd in the world. Due to the sluggish Asian market in 1998, all sectors suffered a slowdown in growth. The economic growth rate of the ROC dropped to 4.65 percent in 1998, but climbed again to 5.1 percent in 1999. The Council for Economic Planning and Development expects the economic growth rate for the period 1999–2012 to be approximately 5.0–5.7 percent, and has forecasted that per capita GNP will reach US$ 26,000 by the end of 2010.

The History of Industrial Development in the ROC[3]

Since the retrocession of the island of Taiwan to the ROC in 1945, economic development can be described in terms of six phases:

1. *1940s: Economic reconstruction.* Efforts focused on rebuilding the infrastructure for the agricultural, industrial, and transportation sectors. At the same time, a land reform program and several large-scale projects were implemented to increase the productivity of the textile, fertilizer, and power industries.
2. *1950s: Development of consumer commodity industries.* Private enterprises were encouraged to produce a range of consumer products for the domestic market using imported machines, semi-finished products, and raw materials.
3. *1960s: Rapid growth of light industries.* Manufacturing began to become vertically integrated to include upstream components and parts. The Statute for the Encouragement of Investment was enacted and a number of export-processing zones were established.
4. *1970s: Development of capital- and technology-intensive industries.* The ROC's abundant foreign exchange reserves and skilled workforce were leveraged to develop both capital- and technology-intensive industries.
5. *1980s: Development of high-tech industries.* The establishment of the Hsinchu Science-Based Industrial Park helped lay the foundations for the ROC's high-tech industry. By 1990, high-tech products –mainly electronics, information and machinery products– accounted for 40.2 percent of total exports.
6. *1990s: Industrial restructuring.* In the face of concerns about the international competitive position of ROC industries, the government promulgated the Six-Year National Development Plan and the Statute for Upgrading Industries to enhance traditional industries.

Over the course of the ROC's economic development, both the structure of the economy and industry have undergone several significant changes including:

- The industrial sector's contribution to the GDP rose from 19.7 percent in 1952 to a peak of 47.1 percent in 1986, and then fell to 34 percent in 1998[4];
- The percentage of the total work force employed in the industrial sector rose from 24.8 percent in 1952 to a peak of 42.8 percent in 1987, and then declined to 37.9 percent in 1998;

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3 Industrial Development Bureau of the Ministry of Economic Affairs, *Development of Industries in Taiwan Republic of China*, Taipei, 1997.

4 This includes the manufacturing, utilities, construction and mining industries.

- The value of private sector manufacturing rose from 43.4 percent of total manufacturing production in 1952 to 92.3 percent in 1998; and
- The value of production from technology-intensive and basic industries rose from 25 percent of total manufacturing production value in 1952 to 76.5 percent in 1998.

Table 1 provides a breakdown of current industrial production value and targets for the year 2000.

Table 1. Targets for Ten Emerging Industries for the Year 2000

Industry	**Annual production value** *(US$100 million)*		**Average annual growth rate** *(%)*
	1996	**2000**	
Telecommunications	30	48	12.6
Information	151	254	13.8
Consumer electronics	29	40	8.0
Semiconductors	31	55	14.8
Precision machinery and automation	60	100	13.5
Aerospace	22	48	21.3
Advanced materials	27	44	13.6
Specialty chemicals and pharmaceuticals	68	101	10.3
Health care	6	12	18.6
Pollution control	20	30	11.0

Source: Industrial Development Bureau, MOEA, *Development of Industries in Taiwan*, Republic of China, 1996.

Government Role in Economic Planning

The ROC's development planning has been guided by the principle of seeking growth with stability. As part of fostering broad economic development, the government has paid close attention to the overall industrial structure and the level of coordination between industrial sectors. As a result, the last 40 years of development have resulted in a fair and orderly environment for free competition that emphasizes people's livelihood, encourages private-sector development, and respects the functioning of the market. As incomes have risen during the last 15 years, the nation's economic development has gradually begun shifting towards a more balanced emphasis on both the economy and environmental protection.

Since the early 1950s, the ROC has guided economic development through the use of four-year plans. Between 1953 and 1989, the ROC implemented nine plans. To further reinforce the nation's infrastructure, improve the quality of life in the ROC, and consolidate the country's industrial development capabilities, the government promulgated a Six-Year National Development Plan in 1991. In January of 1994, the government began experimenting with privatization of government projects. Several projects selected from the Six-Year Plan were combined with new priority items into make a list of Twelve Priority Construction Projects. Projects included mixed industrial/commercial zones, new town development, parking facilities, public housing, and a high-speed railway. Several months earlier, the government also unveiled a major plan to establish the ROC as an operations center for businesses in the Asia-Pacific region.[5] Specifically, through liberalization of the rules on trade and investment, relaxation of restrictions on the flow of capital, streamlining bureaucratic procedures, and protection of the environment, the ROC aims to develop into a center for six types of activities: manufacturing, marine shipping, air transportation, finance, telecommunications, and media.

Long-Term Economic Strategies of the Republic of China

The ROC's government has adopted the following strategies to address current domestic and global economic trends:

1. Active participation in international trade organizations to give the ROC more of an international voice;
2. Continuing implementation of the plan to establish the ROC as an Asia-Pacific operations center;
3. Maintaining a favorable environment for industrial development to assure continued new investment;
4. Promoting economic exchanges and trade across the Taiwan Strait that benefit both mainland China and the ROC; and
5. Planning "intelligent" industrial parks and building Taiwan into a technology island.

Given the rapidly advancing trend of globalization of the economy, the ROC government needs to aggressively pursue its strategy of building the Republic of China into an Asia-Pacific operations center. The approach not only supports the Republic of China's short-term development, but can also serve as the means to boost the ROC firmly into the ranks of developed countries. Industrial production targets for the year 2000 are listed in Tables 2 and 3.

Investment and Environmental Protection

Most companies realize that increasing domestic and overseas investment will be the key to maintaining their growth in the future. Over the last few years, the government has been striving to improve the domestic investment environment and implement measures to encourage industrial upgrading. Most companies are aware that they must upgrade their manufacturing technology and restructure their organizations to improve the competitiveness of their products in international markets. As business investments in the Republic of China become more technology-intensive and sophisticated, many labor-intensive industries have also begun to move production lines overseas in search of lower costs and greater competitive advantages.

To date, overseas investments have been concentrated primarily in the United States and Asia. In terms of total investment value and number of projects, the United States is the lead recipient of Taiwanese investment and Hong Kong the second according to official statistics. Trading companies seeking to facilitate investment in mainland China have also made significant investments in Hong Kong. There has also been a great increase in the number of investment projects by small and medium-sized companies of the ROC in countries such as Thailand, Indonesia, Malaysia, and the Philippines.

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[5] The plan is often referred to as "APROC."

The rapid economic growth of the past few decades has resulted in significant environmental degradation as companies neglected environmental issues in pursuit of increased productivity and profits. As environmental awareness began to grow in the late 1980s, the government adopted a command-and-control strategy to address pollution problems. In reaction, industry adopted strategies based on end-of-pipe solutions to meet new regulatory expectations. However, moving into the new era, companies now face increasing internal operational pressures as well as changing external conditions including rising energy, raw material, and labor costs, the need for advanced R&D capabilities, the emerging global green procurement market, and new international environmental treaties and conventions. End-of-pipe solutions are increasingly unable to meet the new requirements of stricter environmental regulations and market expectations.

Table 2. Production Value of the Republic of China's Manufacturing Sector

Manufacturing	Production value in 1998	Production value in 2000
Heavy (basic) industries	**70.3**	**105**
Chemical materials	16.2	30.1
Chemical products	5.0	6.6
Oil and coal products	7.5	9.5
Rubber products	2.0	2.6
Plastic products	9.7	11.5
Basic metals	19.4	23.3
Metal products	10.5	14.5
Technology-intensive industries	**79.9**	**120**
Electrical and electronic equipment	55.3	71.2
Precision machinery	1.4	3.6
Machinery	8.6	17.1
Vehicles	14.6	28.1
Traditional industries	**46.1**	**75**
Food	13.1	19.9
Tobacco	0.9	1.2
Textiles	11.8	16.6
Clothing and accessories	1.9	4.1
Skins, furs, and their products	1.5	2.0
Wood and bamboo products	0.6	2.2
Furniture and decorations	1.6	2.5
Pulp and paper	3.7	5.4
Printing	2.2	2.8
Products from non-metal minerals	5.9	8.8
Miscellaneous	**2.9**	**7.4**
Total	**196.3**	**300**

Source: Industrial Development Bureau, *Development of Industries in Taiwan*, Republic of China, 2000.
Unit: US$ billion.

Table 3. Targets for the Manufacturing Industry for the Year 2000

Overall manufacturing industry		Year		
		1986	1995	2000
Production value		US$92.5 billion	US$228.1 billion	US$300.0 billion
Percentage of industrial structure	Basic industries	36%	37.7%	35%
	Technology-intensive industries	24%	35.5%	40%
	Traditional industries	40%	26.8%	25%
Ratio of R&D spending to revenues		0.6%	1.5%	3%

Source: Industrial Development Bureau, *Development of Industries in Taiwan*, Republic of China, 1996.

To reduce the cost of environmental protection, companies need to adopt more advanced strategies such as industrial waste minimization, use of an environmental management system, green design, green marketing, and Green Productivity. At the same time, the relationship between government and industry is also beginning to change from a command-and-control system in which the government plays the guiding role to a partnership in which government and industry cooperate to prevent pollution.

ENVIRONMENTAL PROFILES

Agencies Responsible for Environmental Protection

Primary responsibility for environmental policy is divided between the Environmental Protection Administration (EPA) and the Industrial Development Bureau (IDB). The EPA is responsible for setting and enforcing environmental policy and regulations. The Industrial Development Bureau (IDB) complements the EPA's role by providing technical assistance to industry to improve pollution control and overall industrial efficiency. IDB promotes both end-of-pipe solutions and pollution prevention approaches. The National Council for Sustainable Development (NCSD) is a cross-ministry agency to coordinate integration of environmental protection into all aspects of government policy. To date, the NCSD has demonstrated limited influence over day-to-day policy decisions. Wildlife conservation falls under the purview of the Council of Agriculture and is not discussed in this paper.

Environmental Protection Administration (EPA)

The EPA was established in 1987 and consists of seven bureaus: (1) Comprehensive Planning; (2) Air Quality Protection and Noise Control; (3) Water Quality Protection; (4) Solid Waste Management; (5) Environmental Sanitation and Toxic Chemicals Control; (6) Performance Evaluation and Dispute Settlement; (7) Environmental Monitoring and Data Processing. In addition to the bureaus, the EPA also has two separate institutes which are responsible for environmental analysis and environmental training. The main function of the EPA is to formulate environmental protection policies, strategies, and control measures.

Industrial Development Bureau (IDB)

The IDB was established in 1970. Its main purpose and function is to formulate industrial development policies, strategies, and initiatives. The seventh division is responsible for industrial pollution prevention and providing guidance on industrial safety. The promotion of ISO 14000 series environmental standards and waste minimization has been the primary focus of IDB in recent years. IDB is assisted by three nonprofit technical consulting organizations: the Industrial Pollution Control Corps, the Foundation for Taiwan Industry Service, and the Industrial Technology Research Institute.

National Council for Sustainable Development (NCSD)

The NCSD is a cross-ministry committee chaired by the Vice-Premier of the Executive Yuan. The responsibility of the NCSD is to:

1. Map out an integrated policy for national environmental protection in conjunction with trends in global environmental protection;
2. Promote measures that would allow the ROC to sign, join, and observe international environmental protection pacts, conventions, agreements, and protocols;
3. Coordinate, integrate, promote, oversee, and review all domestic matters related to global environmental protection;
4. Engage in studies on technology and methods for global environmental protection and educate the general public; and
5. Prepare and promote cooperation strategies on matters concerning transnational environmental protection.

Eight working groups have been set up around the themes of: (1) global climate protection and energy conservation; (2) waste management and recycling; (3) ocean, water, and soil resource management; (4) ecology conservation and sustainable agriculture; (5) environment and policy development; (6) trade and environment; (7) sustainable business; and (8) social development.

Environmental Policy, Regulations, and Standards

The ROC employs a combination of policy approaches to managing environmental protection. The following section provides an overview of the various components of ROC environmental policy and programs, including profiles of the specific agencies responsible for implementation.

Foundations of ROC environmental policy

In 1987, the Executive Yuan published "*An Outline of the Current Environmental Protection Policies of the Republic of China,*" which has been the foundation of the government's environmental policy. The outline identifies the following goals:

1. Protect the natural environment and maintain the ecological balance for the purpose of sustaining utilization through all eternity;
2. Pursue a high standard of protection to maintain a healthy, safe, and comfortable living environment for the inhabitants of the Republic of China;

3. Create a rich and healthy country emphasizing both economic development and environmental protection;
4. Promote energy conservation and the concept of pollution prevention in the daily activities of industrial manufacturing, transportation, agriculture, product consumption, and infrastructure development; and
5. Establish and implement an environmental management regime based on the "polluters pay" principle.

Based on the above goals, the government has developed a policy that calls for equal emphasis on environmental protection and economic development in order to achieve sustainable development. The policy further stipulates that in cases where economic development could result in a severe, adverse impact on the environment, environmental protection should receive higher priority.

As a complement to the National Comprehensive Development Plan that was announced in 1996, the EPA designed the middle- and long-term National Environmental Protection Plans which include the following strategies:

1. Improving administrative performance and amending unreasonable clauses in environmental laws and regulations;
2. Establishing a social-economic system with low environmental loading;
3. Applying new technologies to improve environmental protection;
4. Making environmental information publicly available and enhancing communication among stakeholders; and
5. Actively participating in global environmental affairs and pursuing opportunities for international cooperation.

Major environmental laws

Following the establishment of the EPA in 1987, the government passed a number of new environmental laws, regulations, and standards, of which the major ones are:[6]

- Environmental Impact Assessment Act (Dec. 30, 1994);
- Air Pollution Control Act (Jan. 20, 1999);
- Drinking Water Management Act (May 21, 1997);
- Water Pollution Control Act (May 6, 1991);
- Waste Disposal Act (January 19, 2000);
- Toxic Chemical Substances Control Act (Nov. 19, 1997);
- Noise Control Act (Feb. 1, 1992);
- Soil and Groundwater Pollution Remediation Act (Feb. 2, 2000); and
- Public Nuisance Disputes Mediation Act (June 3, 1998).

Incentive programs for industry to improve environmental performance

In addition to the administrative controls devised by the EPA, the ROC also employs economic incentives in its environmental regime. Economic instruments provide incentives to polluters to adopt greener production techniques and/or improve their end-of-pipe treatment. The ROC employs a mixture of incentives as outlined below:

[6] The dates quoted indicate most recent amendment, or if never amended, the date of initial passage.

– *Anti-pollution incentives*

- Manufacturers are eligible for a company-tax credit of 20 percent on expenditures on locally made environmental control equipment and 10 percent on imported equipment;
- Equipment and components designed specifically for prevention and control of air, noise, and water pollution, vibration control, environmental monitoring, or waste processing are exempt from import duties;
- Low-interest loans are available for construction projects related to pollution control (such as waste treatment facilities) and production of related equipment; and
- Air pollution control fees are levied based on the type and amount of air pollutants discharged from stationary sources.

– *Energy conservation incentives*

- Between 5 and 20 percent of any expenditure on energy conservation technology or facilities may be credited against income tax;
- Energy conservation projects qualify for low-interest loans; and
- Devices and systems that reduce energy consumption may accelerate depreciation by two years.

– *Recycling incentives*

- Between 5 and 20 percent of any expenditure on recycling technology or facilities may be credited against income tax.

– *Incentives for water recycling*

- Between 5 and 20 percent of any expenditure on technology or facilities for recycling water used for industrial purposes may be credited against income tax.

Strategies of the Environmental Protection Administration

The expansion of industry, agricultural production, and urban areas has caused significant deterioration in the quality of the environment. The Environmental Protection Administration has a complete range of standards for managing air emissions, water pollution, soil and groundwater quality, and solid waste as well as other environmental aspects. In addition to establishing emissions standards, the EPA has also begun to experiment with market-based tools by levying air pollution fees on both mobile and stationary pollution sources. The EPA has also proposed collecting a water pollution fee starting in 2002 and in July 2000 the Taipei City government began to collect fees per bag for municipal garbage disposal. The EPA and IDB are also planning to adopt a deposit system for industrial waste to ensure that the waste is treated properly. For consumer products, a manufacturer “take-back” system has been operating for over ten years and now covers over twenty major consumer products. The combination of standards and fees encourages industries to adopt GP practices to improve their environmental performance and decrease potential liabilities. The use of fees makes pollution discharge part of the overall production cost, which creates an incentive to reduce waste and emissions. The major environmental control strategies for air emissions, water pollution, and solid waste are described as follows:

– *Air pollution control*

- Control of stationary pollution sources. A multi-stage set of emission standards has been implemented to monitor, regulate, and control emissions from stationary pollution sources such as factories;
- Control of mobile pollution sources. Use of unleaded gasoline to improve exhaust emissions is mandatory. Drivers are also encouraged to maintain their vehicles on a regular basis. The EPA has also developed a set of phased emissions standards which rank among the most stringent in the world;
- Monitoring construction sites. Construction companies are required to prepare an environmental management program for the construction period and regularly inspect their site;
- Promoting the use of clean fuel. All factories are encouraged to use low-sulfide fuel. Starting in 1998, the EPA has also levied air pollution fees based on the type and volume of air pollutants that they emit; and
- Total quantity control. The EPA has begun a pilot program in the central part of the island to set a regional cap on total emissions as the first step towards establishing an emissions trading system. If successful, the plan will be expanded to other parts of Taiwan.

– *Water pollution control*

- Control of point sources. In 1991, the EPA implemented a set of phased effluent standards. Standards were most recently tightened in 1998;
- Sewer system construction. A national sewer plan has been developed, but progress has been slow over the last decade due to budget shortfalls. Top priority has now been given to the construction of sewer systems in areas with serious water pollution;
- Controlling growth of new pollution sources. The EPA has placed restrictions on the establishment and expansion of companies in industries that are highly polluting or energy intensive. As part of the program, a high priority has also been placed on assisting hospitals and pig farms in installing wastewater treatment facilities;
- Remediation. Funds have been established for the clean-up of polluted rivers and harbors; and
- Development of economic incentives. The EPA has proposed levying wastewater discharge fees in 2002.

– *Waste management*

- Promotion of recycling. The EPA has required manufacturers of over twenty listed items to “take back” their products for recycling. In addition, the EPA is also drafting the “Resource Recovery Act” to drive individuals and companies to recycle and use resources in a more sustainable manner;
- Controlling the import and export of hazardous waste;
- Promoting waste minimization within the private sector; and
- Development of waste infrastructure.

The EPA has overseen the construction of over 30 municipal waste treatment/disposal facilities to guarantee proper disposal of municipal waste.

Environmental strategies of the Industrial Development Bureau

As mentioned earlier, IDB's role is to provide guidance and support to industry on strategies for improving environmental performance. IDB's efforts have therefore focused on improving industry's process technology, in-house expertise on pollution control, and management systems. Programs fall under the general categories of:

- Industrial waste minimization;
- Promotion of ISO management tools; and
- General technical guidance and demonstrations.

IDB's environmental efforts began with waste minimization before expanding to include ISO promotion. Programs are described in more detail in the following sections.

Industrial waste minimization

IDB became involved in environmental policy in 1988, when the government identified industrial waste minimization (IWM) as a key national environmental policy goal. The IDB and EPA organized the Joint Task Force for Industrial Waste Minimization in 1989 to implement a five-year Industrial Waste Minimization Demonstration and Promotion Project. The project, initiated in 1990, has targeted different industry sectors for demonstration IWM projects every year. Due to the significant benefits that industry realized through implementation, a second five-year project was started in 1996.

The first Industrial Waste Minimization Master Plan, written in 1991, provides the basic guidelines for the promotion and supervision of IWM in ROC. Guidelines are:

1. Promotion of the concept of waste minimization;
2. Maintaining awareness of international trends and developments in regulations related to balancing environmental protection and industrial growth;
3. Utilization of management and technology-based approaches to the promotion of IWM;
4. Enhancement of research and development related to IWM; and
5. Leveraging of government resources to provide technical assistance to industry.

Each year the Waste Reduction Task Force (WRTF) identifies target industries for waste minimization demonstration projects. Invitations for applications are either published in the media or sent to selected companies. The WRTF does a preliminary screening of the applicants followed by a site visit. Between 10 and 20 plants are selected as the annual demonstration plants and are given technical assistance in project implementation by the WRTF. The selection criteria for demonstration plants is based on:

- Intent of senior management;
- Potential for waste minimization;
- Management system;
- Level of technology;
- Competence in decision-making; and
- Financial support for the project.

Technical assistance is provided by the engineers of either the CTCI Foundation or the Foundation of Taiwan Industry Service (FTIS). Assistance requires close cooperation with the target plant and follows the steps outlined below:

1. Survey facility and collect baseline data;
2. Provide training on IWM;
3. Organize an IWM task force;
4. Design IWM policies and goals;
5. Propose waste minimization options;
6. Screen waste minimization options based on feasibility;
7. Implement the waste minimization plan;
8. Measure progress; and
9. Tracking and reporting results continuously.

Benefits and achievements of IWM

From 1990 through 1995, 89 plants from more than 30 different industries implemented IWM demonstration projects. Records show that the total annual benefits of IWM implementation in the first year exceeded NT$ 1.15 billion in some facilities. Annual benefits of IWM implementation after the first year reached as high as NT$ 750 million (with appropriate follow-up technical and managerial assistance).[7] One of the other important benefits discovered was that IWM can lay a solid foundation for implementing an ISO 14001 environmental management system.

Expanding industrial waste minimization through corporate synergy systems

In 1995, the IDB initiated the first Industrial Waste Minimization Corporate Synergy System (IWMCSS) in TECO's Kuangyin Electronics Plant with assistance from FTIS. Under the program, the plant served as a "core factory" and directly requested its vendors and suppliers to join in an IWM effort. Eventually, 18 out of 51 suppliers ("satellite factories") agreed to participate. The suppliers then received training in IWM and worked together with TECO to develop and implement waste minimization programs. One year later, both the core factory and the satellite factories found that they had obtained significant economic benefits from the program and seen improvement in their environmental performance.

In 1996, the IDB initiated a second IWMCSS in cooperation with the Cheng Loong paper company. Cheng Loong's Ta-Yuan Paper Mill was selected as the core factory and 14 SME suppliers joined the program. Participants included chemical suppliers, waste paper recyclers, machinery vendors, paper products manufacturers, energy suppliers, and a transportation company. Due to the generally positive results of the program, the IDB has continued developing IWMCSS for numerous industry groups with assistance from FTIS and CTCI. As of June 1999, thirteen IWMCSS had been established.

Barriers to implementation of waste minimization

Although the Republic of China's IWM program has made significant achievements since its inception in 1989, it has encountered difficulties in involving SMEs. Common barriers are:

[7] Industrial Development Bureau, *Industrial Waste Minimization in Taiwan*, Republic of China, 1996.

1. The plant owner has a poor understanding of business administration;
2. Companies prefer to adopt end-of-pipe treatments to achieve compliance with regulations, rather than voluntarily implement waste minimization;
3. The production manager might be too conservative to make changes to operating practices out of concern for product quality;
4. The in-house task force personnel become too dependent on the assistance provided by the consultants and cannot maintain the program themselves;
5. The waste minimization program cannot be continuously tracked and maintained; and
6. Insufficient capital to install new equipment or upgrade inefficient processes.

The concept of Green Productivity may help solve some of these problems, since it emphasizes both environmental performance and productivity. It increases factory's productivity through better production management, more sophisticated production technology, reduced energy and raw material consumption, eco-design, and reduced environmental liabilities. Companies are generally more open to promotion of GP than "environmental" programs.

Promotion of ISO 14000

The Bureau of Commodity Inspection and Quarantine (BCIQ) sponsored the first workshop on environmental management systems (EMS) in 1994. In September 1994, learning that EMS might eventually assist the manufacturing sector in improving environmental management, the MOEA and EPA jointly developed a national strategy for promoting the ISO 14000 series of standards. In November 1995, the National Bureau of Standards (NBS) of MOEA developed the corresponding Chinese versions of the ISO standards under the name of the Chinese National Standards (CNS). The eight standards (CNS 14001, 14004, 14010, 14011, 14012, 14020, 14040, and 14050) and Guide 64 were officially published in November 1996.

In 1996, the Committee on Global Change Policy of the Executive Yuan (later changed to the NCSD) formally established an ISO 14000 Working Group. IDB was appointed secretariat to coordinate the resources of related departments to promote and implement ISO 14000. The second five-year IWM project was also expanded to include goals related to ISO 14001.

The Chinese National Accreditation Board (CNAB) was established in 1997 to establish accreditation systems for quality and environmental management in the ROC, achieve mutual recognition internationally, and align the practices of certification bodies with international standards. IDB and EPA have both sponsored grant programs since 1996 to assist companies in establishing environmental management systems. More than 150 plants have received grants and 757 ISO 14001 certificates had been awarded to local businesses as of May 2000.[8]

Environmental management tools: Environmental Performance Evaluation (EPE) and Life Cycle Assessment (LCA)

The first LCA programs in the Republic of China began in 1995 with funding from the National Science Council, IDB, EPA, and Department of Industrial Technology

[8] Data found at: *http://emt.ema.org.tw.*

within the Ministry of Economic Affairs. Over the past five years, more than 15 LCA projects have been commissioned in the ROC. The government is planning to initiate a new five-year LCA program starting in 2001.

In 1997, IDB launched a three-year program to promote EPE techniques. With financial support from IDB and technical assistance from CTCI, four factories have begun developing EPE systems and gathering data. The goal of these projects is to develop evaluation methodologies and indicators suitable to specific industry sectors.

Technical guidance and training

The IDB has sponsored the development of a number of technical consulting organizations to assist industry in developing end-of-pipe solutions. Over the past decade, the emphasis in technical extension work has increasingly shifted towards pollution prevention and waste minimization. The organizations assist the IDB in providing technical guidance to industry and also provide low-cost consulting to individual companies. The primary organizations supported by IDB include the Industrial Pollution Control Corps of the CTCI Foundation, the Foundation of Taiwan Industry Service, and the Industrial Technology Research Institute.

Green Productivity promotion

As part of the growing interest in preventative strategies, the ROC has participated in Green Productivity Demonstration Projects (GPDP) since 1995 at the invitation of the Asian Productivity Organization (APO). Green Productivity is a set of practices that improve environmental performance and production efficiency simultaneously. The approach fits the ROC's long-term economic development goals and IDB has also begun promoting Green Productivity to industries in the Republic of China.

The China Productivity Center (CPC) is the official national productivity organization of the ROC. Since there are already several specialized organizations assisting companies in applying Green Productivity techniques and environmental management systems, CPC has assumed the role of coordinator.

IDB's involvement with GP began in 1994 when the APO Committee on Environment held a meeting in the ROC to discuss the direction of future efforts. The committee decided to adopt a strategy of pollution prevention and control, and to disseminate relevant technologies to industry through demonstration factory/farm projects. Over the past five years, there have been five demonstration factories in the Republic of China: Shen's Art Printing, for the printing industry in 1995; the Solasia Energy Development for the electroplating industry in 1996; the Shuihwa Leather Industrial for the leather industry in 1997; Chenho Iron Works for the machinery industry in 1998; and Process Advance Technology Ltd. (PAT) for the metal finishing equipment manufacturing industry in 1999. Except the still on-going project with PAT, all demonstration projects achieved their targets. The demonstration factories have continuously improved their environmental performance, and the relevant industry sectors have benefited from dissemination of the project results.

Encouragement of private sector initiatives

In response to the need to pursue more sustainable development, the Taiwan Business Council for Sustainable Development (BCSD) was launched on May 16, 1997, with the support of both the private sector and the government. The objectives of BCSD are:

1. cooperate with companies to support national policy, regulations, and infrastructure initiatives that will ensure commercial sustainability in an environmentally conscious manner;
2. To encourage companies to play an increasingly active role in improving environmental performance and eco-efficiency; and
3. To accumulate useful environmental protection and natural resource information for corporate and public use.

A separate private-sector partnership was launched for the chemical industry one year later. Over the past several decades, the chemical manufacturing industry has expanded rapidly in the Republic of China. To improve the environmental, health and safety performance of the sector, the Taiwan Responsible Care Association (TRCA) was founded in January 1998 with the support of the IDB. TRCA has over 50 companies as charter members and assists members in complying with codes of practice regarding environmental, health, and safety management. The codes are developed locally, but must adhere to international Responsible Care standards.

International conferences

Since 1996, the ROC has hosted numerous international conferences related to environmental management strategies. Major conferences are listed below:

- Dec. 9–10, 1996: The First International Conference on Cleaner Production in Chemical Industry;
- May. 8–17, 1997: Cleaner Production and ISO 14000 Training Course for Asia-Pacific Countries;
- Dec 14–18, 1997: Asian-Pacific Conference on Industrial Waste Minimization and Sustainable Development '97;
- Mar. 1–7, 1998: APEC Regional Executive Training Workshop on Cleaner for Textile Dying and Finishing Industry;
- April 8–18, 1998: Environmental Study Tour for Vietnamese Officials under UNIDO Sponsorship;
- May 20–22, 1998: The Fourth Annual International Asia Pacific Responsible Care Conference;
- Sep. 7–11, 1998: Training Program on Environmental Management System and Cleaner Production for the Printed Circuited Board Industry for Asia-Pacific Countries;
- October 7–13, 1998: APEC Training Project: Enhance the Implementation of ISO 14001 EMS for APEC Economics;
- November 1–7, 1998: APEC Training Program on Cleaner Production for the Metal Finishing Industry;
- March 22–25, 1999: APO Cleaner Production Workshop for the Machine Manufacturing Industries;
- March 22–26, 1999: APO Workshop on Green Productivity for NPO's;

- April 7–9, 1999: Republic of China-Canada Environmental Cooperation Program, Workshop on Cleaner Production in the Metal Finishing Industry;
- June 8–11, 1999: APEC Workshop on Cleaner Production;
- May 22–26, 2000: Top Green Productivity Forum for NPO; and
- July 12–14, 2000: International Symposium on Sustainable Small & Medium Sized Enterprises.

Assessment of Small and Medium-Sized Enterprises (SMEs)

Definition and characteristics of SMEs

According to the "Guidelines for Identifying Small and Medium-Sized Enterprises" issued by the Ministry of Economic Affairs (MOEA) in 1995, all firms that have legally completed company registration or commercial registration and meet the following criteria qualify as small and medium-sized enterprises:

1. Manufacturing, construction, mining, and quarrying enterprises with a paid-in capital of less than NT$60 million or fewer than 200 regular employees; and
2. Forestry, agriculture, fishing, animal husbandry, hunting, plumbing, electrical, gas and fuel oil, commerce, transportation, warehouse, courier, finance, insurance, real estate, industrial and commercial service, social service, and personal service enterprises with sales of less than NT$80 million for the previous year or fewer than 50 regular employees.[9]

In 1998, 97.76 percent of the firms in the Republic of China qualified as SMEs and accounted for 7.265 million jobs (69.19% of total employment).[10] In recent years, SMEs' proportion of employment and total sales has been declining due to the general shift in the industrial structure toward capital-intensive and high-tech sectors.

As a result of the ROC's industrialization, rising incomes, and a greater division of labor in industries, demand for service sector products has grown. The service sector has now taken a place in the mainstream of the economy and has become interdependent with other economic sectors. The newly growing industrial and commercial service enterprises in the ROC include consulting, information services, advertising, packaging design, and equipment leasing. SMEs comprise a large proportion of the firms specializing in these areas (see Table 4). The rapid growth of the service sector has had a very positive effect on overall economic growth.

Relationship between SMEs, governments, and large firms

SMEs have occupied a very important position in the industrial structure over the course of the ROC's economic development. Many SMEs supply essential parts, semi-finished products, or services to large firms. However, in light of their small size and limited capital, the government has adopted special guidance agencies and programs for assisting SMEs.

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9 Small and Medium Enterprise Administration, MOEA.

10 Small and Medium Enterprise Administration, MOEA, *White Paper on SMEs*, 1999.

Table 4. Proportion of Small and Medium Enterprises in Commercial and Industrial Service Enterprises

Type of enterprise	Small and medium (%)	Large (%)
Consulting firms	98.00	2.00
Information firms	94.95	5.05
Advertising firms	98.42	1.58
Packaging design firms	99.52	0.48
Equipment leasing firms	99.74	0.26
Average	98.13	1.87

Source: http://www.moeasmea.gov.tw/smea_e05.htm.

A major priority has been on assisting SMEs with R&D. Compared to large firms, SMEs are weak in resource endowment and cannot take as much risk in R&D activities. According to a survey conducted by the Statistical Bureau of the Ministry of Economic Affairs, 45.39 percent of all SMEs conducted R&D activities in 1997, and a further 17.54 percent are expected to undertake R&D activities within the next 3 years. In contrast, 76.23 percent of all large firms have already conducted R&D, and only 15.63 percent have no plans to conduct R&D activities.

Generally speaking, the governmental strategy has been to assist enterprises in obtaining the necessities for operation, broaden financing channels, offer opportunities to participate in government procurement, and encourage good relations between management and labor. During the 1990s, pollution became a more prominent component of overall government assistance efforts. The government has developed a Ten-Part SME Guidance System incorporating the following elements:

1. *Finance and credit*: Assist in improving SMEs' financial structures;
2. *Management guidance*: Provide training in establishment of management systems to improve efficiency and develop human resources;
3. *Production technology*: Provide assistance in upgrading current systems or adopting new technologies;
4. *R&D*: Support individual or joint R&D initiatives among SMEs for new products/technologies;
5. *Information management*: Assist in establishment of information management systems;
6. *Pollution control*: Offer technical guidance in improving pollution control facilities;
7. *Marketing*: Provide market intelligence to support SME efforts to expand market share;
8. *Mutual support*: Guide exchanges and cooperative activities aimed at improving competitive position of SMEs;
9. *Industrial safety*: Provide training on safety systems and assistance in resolution of safety problems; and
10. *Quality enhancement*: Assist SMEs in raising product and service quality and promoting joint efforts among enterprises.

In order to integrate the guidance and service resources provided by the various departments to SMEs, the Ministry of Economic Affairs has established an SME activity center in Taipei as well as service centers Taichung and Kaohsiung.

Significance of SMEs in environmental performance

As industrial development progresses and population density increases, the demand for natural resources from industries inevitably conflicts with demand from people. Industries must fulfill their environmental responsibilities, especially those industries that traditionally have heavily contributed to environmental loading. The Republic of China has an extensive set of environmental regulations covering all aspects of industrial pollution. However, many SMEs are unaware of regulatory requirements. Many often only learn of regulations when they seek permits to expand or alter their facilities. In such cases the enterprise often cannot satisfy expectations, and is then forced to leave machinery and equipment lying idle and incur significant losses. Environmental inspections and evaluations are also often time-consuming and are perceived by SMEs as a significant burden.

Generally speaking, SMEs in the Republic of China have only basic environmental controls. Registered companies in sensitive industry sectors may have basic pollution control equipment, but there are thousands of small, unregulated SMEs throughout the island that do not handle their wastes properly. Given their low amounts of capital and frequently changing product lines, many companies are unwilling to make significant investments in pollution control. Under current regulations, companies that fail to meet standards are subject to notification by regulatory authorities and to subsequent fines. If the warnings and fines have no effect, the company can potentially be forced to close operations. However, the effectiveness of this system depends on the level of enforcement against SMEs, which has historically been weak.[11]

Although SMEs are gradually improving their environmental protection practices, some sectors are now coming under substantial pressure from environmental protection agencies. Large companies are able to solve their own environmental problems, but many of the SMEs that contribute a large proportion of total pollution do not have sufficient resources to do so. Moreover, environmental issues have gradually become global trading issues and are potential threats to Taiwanese industry's competitive position internationally. Since most businesses in the Republic of China are essentially export oriented, SMEs desperately need outside resources to deal with environmental issues. The government is taking responsibility for assisting SMEs in solving environmental problems by offering training and financing for pollution prevention and installation of end-of-pipe controls.

ENVIRONMENTAL PERFORMANCE OF THE METAL FINISHING INDUSTRY

Industry Profile

Metal finishing covers a vast range of operations in which metals are cleaned, treated, and coated. Metal plating, one major application of metal finishing, has more

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[11] Individual sectors have come under significant pressure periodically, but as a whole, government enforcement efforts have focused more on large companies than SMEs.

than 30 years of history in the Republic of China, and has made important contributions to overall industrial and economic development. Traditional metal plating techniques are applied widely around the world. Metal plating applications in the Republic of China can generally be divided into four major categories: decorative plating, industrial plating, plastic plating, and electronic plating. Among these four types, the number of decorative plating shops is the highest, followed by industrial plating shops, which is likely due to the strength of traditional industries in the Republic of China. Recently, many plating shops have gone out of business or moved to mainland China and Southeast Asian countries due to rising labor and environmental costs.

Metal finishing is often ranked as one of the highest polluting industries due to the nature of its processes and the chemical agents utilized. The wastewater generated from the plating processes usually contains strong acids, strong bases, high concentrations of heavy metals, and toxic cyanides. This wastewater, if not treated or disposed of properly, can cause significant environmental damage. Although most plating shops in the Republic of China have now installed wastewater treatment facilities, they often do not operate them and thus continue to cause serious water pollution.

Based on statistical data from the Industrial Development Bureau (IDB), there were over 3,314 metal plating facilities in the Republic of China in 1989, but only 20 percent of them were registered as legal shops. Most plating facilities remain scattered in the suburban Taipei and Changhwa areas, and tend to be small-sized operations (53 percent of them have capital funds of less than NT$ three million and 83 percent of them employ fewer than 10 workers). Shops typically work on small orders with a short turn-around time. Despite their small size, the annual production value of metal plating is estimated at NT$ 5-10 billion, and the total sales value of derivative products may be more than NT$ 500 billion per year.[12]

The Environmental Protection Administration (EPA) has set effluent standards for metal finishers, and enforcement of regulations has significantly improved control of the discharge of plating wastewater. As a further step toward reducing the consumption of chromic acid and cyanide compounds, the government has encouraged the industry to adopt continuous automatic plating and cyanide-free plating techniques instead of manual batch plating and cyanide bath plating. The government has also aggressively promoted the concept of resource recovery and specifically the recycling of chromium and other heavy metals.

The Industrial Pollution Control Corps (IPCC) has established a database of the 283 electroplating shops that have received technical assistance from IPCC over the past 15 years (all of which count as SMEs).[13] To cope with the new trends in industrial development, the electroplating industry must adjust its managerial strategies to improve process efficiency and reduce production costs. Potential options are as follows:

- Install automated equipment to reduce production costs and avoid labor shortages;

[12] Industrial Development Bureau, *Wastewater Treatment and Management of Electroplating Industry* (in Chinese), 1996.

[13] IPCC was established by the CTCI Foundation with the support of the Industrial Development Bureau. IPCC assists the government in providing technical extension services to industry and also provides low-cost consulting services to individual companies.

- Adopt waste minimization technologies to recycle valuable resources and reduce overall pollution load; and
- Introduce foreign technology to improve production techniques, improve process efficiency, and reduce waste discharge.

Key Manufacturing Processes

As mentioned above, metal finishing may cover serial operations in which metals are cleaned, prepared, treated, and coated. The finishing process may vary depending on factors such as the material to be treated, the coating that will be applied, the shape of the work piece, the technique used, and quality requirements. The process may be composed of a few simple steps or may be long and complex. The key manufacturing processes and techniques are listed in Table 5.

Pollutant Sources, Amount of Priority Waste Categories

As mentioned above, metal finishing is highly polluting due to its use of metals and chemical agents which are typically released to the environment through spent solutions, wastewater, sludge, and gaseous emissions. The major pollutants include the following items:

1. *Rinse water*: Comprises the largest proportion of wastewater from metal finishing operations and contains heavy metals and chemical reagents;
2. *Wastewater treatment sludge*: Contains metals such as chromium, copper, nickel, tin, and zinc;
3. *Plating baths*: Contaminated or spent plating bath solutions that cannot be treated on-site;
4. *Process baths*: Etchants and cleaners that are contaminated or spent;
5. *Cleaners*: Nitric, sulfuric, hydrochloric, and hydrofluoric acids used to strip metals from work piece racks or parts;
6. *Miscellaneous solid wastes*: Absorbents, filters, empty containers, aisle grates, and abrasive blasting residues; and
7. *Solvents*: Contaminated solvents generated from degreasing.

Status of Environmental Compliance

Metal finishing plants, regardless of their size, are expected to comply with environmental regulations and standards for air, water, waste, toxic chemicals, noise, and other pollutants. As wastewater is the most significant environmental problem, the effluent standard for metal finishers is listed in Table 6.

Table 5. Key Metal Finishing Processes and Techniques

Process	Techniques
Grinding	Cutting by means of grinding materials
Polishing, brightening	Mechanical polishing Electrolytic and chemical polishing and brightening
Pre-cleaning, stripping	Mechanical cleaning by hand, machine, or blasting techniques Chemical elimination of rust, tinder, and oxide layers Electrolytic descaling
Final cleaning and degreasing	Chemical degreasing Electrolytic degreasing Neutralization
Surface activation	Pickling Blasting
Corrosion protection and hardening (after treatment)	Thermal Mechanical Chemical Passivation
Electroplating	Copper plating Nickel plating Chrome plating Zinc plating Cadmium plating Silver plating Alloy plating Metallization of plastics
Solution deposition	Ion exchange techniques Reduction processes
Hot dip deposition	Galvanizing Other Zn deposition methods Hot-tinning Electro-tinning Other techniques Hot lead coating and other techniques Hot aluminum coating
Diffusion deposition	Chrome evaporation Sheradizing processes Peen plating Alitizing Other diffusion techniques (corrosion protection, hardening)
Thermal spraying techniques	Gas spraying Arc spraying Plasma jet spraying Vacuum deposition Electric vaporization (small range deposition) Inductive vaporization (treatment of larger quantities) Electron beam deposition (large scale coating)

Source: UNEP/IEO, *Environmental Aspects of the Metal Finishing Industry: A Technical Guide*, 1989.

Table 6. Effluent Standards for Metal Finishing Industry

Characteristic	Maximum effluent limitations	Characteristic	Maximum effluent limitations
Effluent temperature	Below 38° C (from May to September) Below 35° C (from October to April)	Total chromium	2.0
pH	6.0–9.0	Hexavalent chromium	0.5
Fluoride (excluding complex ions)	15.0	Organic mercury	Not detectable
Phosphate as calculated by phosphoric radical (III)	4.0	Total mercury	0.005
Anionic surfactant	10.0	Copper	3.0
Cyanide	1.0	Zinc	5.0
Oil and grease (n-hexane extraction)	10.0	Silver	0.5
Soluble iron	10.0	Nickel	1.0
Soluble manganese	10.0	Boron	1.0
Cadmium	0.03	COD	100
Lead	1.0	SS	30

Source: http://www.epa.gov.tw/english/LAWS/.

Most of the metal finishing shops in the Republic of China have installed wastewater treatment facilities. According to a survey conducted by the Industrial Pollution Control Center, only 37 of 57 shops met the 1993 effluent standard (see Table 7). The major area of noncompliance is COD since most of metal finishers still use traditional chemical treatment processes. Seven shops with nickel concentrations exceeding the effluent limit were also identified. It is unlikely that many electroplating shops can meet the 1998 wastewater effluent standard without adopting waste minimization techniques and innovative wastewater treatment technologies.

Table 7. Firms Compliant with the 1993 Effluent Standard

Categories	Industrial electro-plating	Furnishing electro-plating	Electronic electro-plating	Plastic electro-plating	Total	Percentage (%)
Compliant	16	11	5	5	37	65
Non-compliant	6	10	3	1	20	35
Total	22	21	8	6	57	100

Source: China Technical Consultants, Inc, *On-line Recycling System and End-of-Pipe Treatment Technology of Electroplating Industry* (in Chinese), 1996.

Environmental Problems Caused by the Metal Finishing Industry

The potential environmental impacts of metal finishing shops varies significantly depending on the specific production process, degree of automation, scale and location of the plant, and local environmental conditions. The potential environmental aspects and impacts caused by metal finishing industry are:

1. Water pollution from wastewater and spent solutions;
2. Damage to public sewer systems and health threats to sewer maintenance personnel;
3. Groundwater contamination due to seepage;
4. Soil contamination at chemical and waste storage areas;
5. Soil and groundwater contamination caused by improper disposal of surplus chemicals and/or wastewater sludge;
6. Risks to workers and the general public from gaseous emissions;
7. Unsafe reuse of chemical containers;
8. Transportation accidents involving chemicals;
9. Excessive noise and vibration from machinery;
10. Occupational exposure of workers to chemicals and waste residues; and
11. Accidents in the plant involving the release of chemicals.

Over the past 30 years, the metal finishing industry has caused numerous incidents of pollution to the local environment. In the 1970s, numerous incidents of damage to crops and fisheries due to pollution of irrigation water and rivers were recorded. There have also been cases of electoplaters disposing of their wastewater into groundwater aquifers. Illegally dumped wastewater sludge containing hazardous heavy metals or cyanides has also caused soil contamination in many places around the Republic of China.

Green Productivity in Metal Finishing

The goal of preventing pollution is to avoid the generation of waste wherever technically and economically feasible. Examples of some common measures include:

- Avoiding accidents, spills, and contamination;
- Seeking to recover, recycle, reclaim, and exchange wastes as far as is technically feasible;
- Selecting appropriate production equipment, recycle/recovery equipment, and end-of-pipe treatment facilities;
- Educating and training operating personnel and establish a vigilant supervision process; and
- Maintaining equipment properly.

The concepts related to Green Productivity have become ingrained in industry in recent years. The typical techniques related to Green Productivity that have been developed and applied in the Republic of China are listed in Table 8.

In recent years, many metal finishing plants have installed on-line recycling facilities to further reduce waste generation and lower production costs. Some of the on-line recycling techniques and performance data are highlighted in the following sections.

Table 8. Application of Green Productivity Techniques in the Metal Finishing Industry

Technologies	Techniques		Frequency of application
Raw material substitution	Material purification	Use high-purity chemicals	High
		Properly store the chemicals	High
	Material substitution	Eliminate the use of cyanide	Medium
		Use trivalent chromate plating	Low
		Use low pollution degreasing agent	Medium
Process modification	Rational water consumption	Monitor water consumption	Medium
		Monitor water quality in the production process	Medium
	Improve rinsing efficiency	Use counter current rinsing	High
		Use ultrasonic rinsing	Low
		Use spray rinsing	Medium
		Use hot water rinsing accompanied by agitation	Medium
		Use reactive rinsing	Low
		Prolong flow path to avoid short cutting	High
	Drag out reduction	Prolong dripping time	High
		Install dripping pan	High
		Install recovery tank	High
Recycle and reuse	Water recycling	Recycle rinse water	Medium
		Recycle effluent to the process	Low
	Drag out recovery	Evaporation	Medium
		Electrolysis	Low
		Ion exchange	Low
	Waste reclamation	Waste exchange	Low
		Recovery of metals from sludge	None

Source: Author.

Degreasing solution filtration/recycling

Degreasing solution continuously overflows to a grease adsorption unit and is pumped through a filter to remove impurities. The filtrate is then recycled to the bath. The operational performance of the approach is demonstrated in the measurements taken in an electroplating shop that adopted the process (Tables 9 and 10).

Table 9. Performance of Degreasing Solution Filtration/Recycling System (based on one shop)

	Grease *(mg/l)*		**Chemical Oxygen Demand in mg/l** *(COD)*		**Suspended Solids in mg/l** *(SS)*	
	(I)*	**(II)***	**(I)**	**(II)**	**(I)**	**(II)**
Before filtration	6,440	8,370	15,816	21,640	361	479
After filtration	43	167	8,141	12,100	33	64
Efficiency (%)	99.3	98.0	48.5	44.0	90.8	86.6

Source: China Technical Consultants Inc., *Technical Evaluation Report on Filtration/Recycling System in Electroplating Industry* (in Chinese), 1994.
Note: *I and II represent two different effluent samples.

Table 10. Hot Degreasing Bath Lifetime and Variations in Degreasing Agent Composition

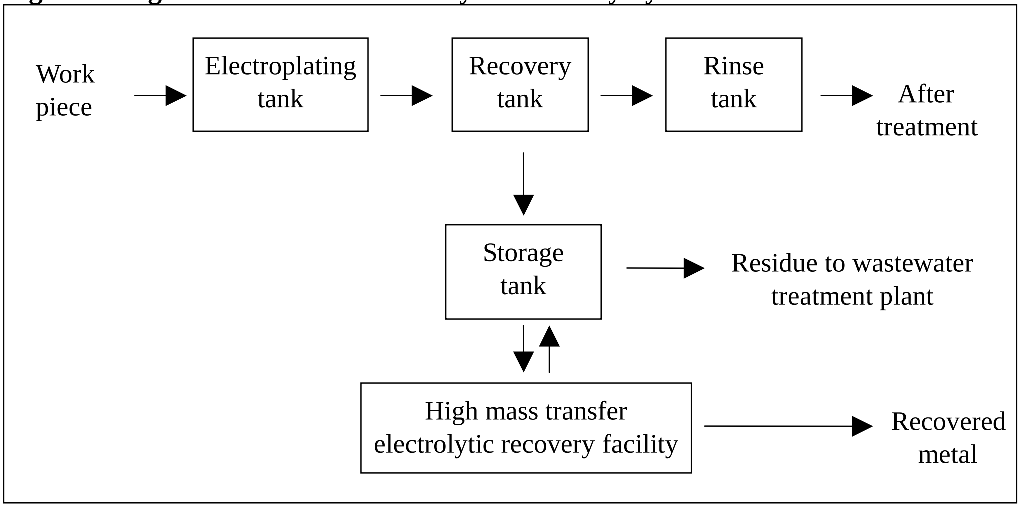
	Degreasing agent make-up	Frequency of tank cleansing	Life time of bath
Before installation	200 kg/month	14 days	3.5 months
After installation	130 kg/month	---	11 months
Performance	35% reduction	---	More than 3 times prolonged

Source: China Technical Consultants Inc., *Technical Evaluation Report on Filtration/Recycling System in Electroplating Industry* (in Chinese), 1994.

High mass transfer electrolytic recovery system

There are two types of high mass transfer electrolysis equipment. The first type uses a highly porous conductive material or web-shaped electrode to destroy the electric double layer in an agitated solution. The second type uses a fluidized bed to destroy the electric double layer to prevent polarization and improve recovery efficiency. The equipment should be installed near the metal recovery tank to reduce the cost of pumping. The liquid surface should be above the top of the recovery tank to avoid accidents caused by back flow of recovered liquor. Figure 1 shows the block flow diagram of the process.

Figure 1. High Mass Transfer Electrolysis Recovery System



A case study shows after 145 hours of electrolysis in 650L solution, the concentration of nickel was reduced from 23,929 mg/l to 2,812mg/l and 13.0 kg of nickel was recovered. Theoretically, under conditions of 100 amperes of current and 145 hours electrolysis, 15.87 kg of nickel can be recovered instead of 13 kg. This means electrolysis efficiency of 0.9 g/ampere and 81.9 percent recovery efficiency. The nickel concentration versus electrolysis time is shown in Table 11.

Table 11. Nickel Concentration Variation During Electrolysis in Case Study

Time *(hours)*	**0**	**7**	**22**	**46**	**70**	**94**	**118**	**142**	**145**
Nickel concentration (mg/l)	23,929	21,731	19,916	10,665	8,469	4,560	3,635	3,172	2,812

Source: China Technical Consultants, Inc., *Project Report of Wastewater Treatment Technology* (in Chinese), 1993.

Drainage and drag out reduction

Most of the contaminants in rinse water come from the drag out of chemicals when work pieces are transferred from the treatment bath to the rinse tank. Volume of drag out depends on numerous factors including:

- The speed of withdrawal;
- The shape of the work pieces;
- Details of barrel perforations;
- The dripping time;
- The concentration of the bath chemicals;
- The viscosity of the bath;
- The temperature of the bath; and
- The position of the work pieces on the rack.

Measures that could reduce the drag out include:

- Frequently inspecting the barrels to ensure that the holes remain clear;
- Extending the dripping time;
- Using air stream dripping;
- Applying vibration or ultrasonic treatment; and
- Adding surfactants to the bath (in some cases).

Reduction of rinse water consumption

Strategies for minimizing water consumption include:

- Optimizing the use of rinse water by installation of flow meters and restrictors to keep the flow rate constant and only permitting authorized supervisors to make adjustments; and
- Automatically controlling the flow rate by installing controllers that interlock with the conductivity monitor in the rinse tank.

Improvement of rinsing effectiveness

Common approaches for improving rinsing effectiveness include:

- Agitating the rinse water by hydraulic, mechanical, air, or ultrasonic methods;
- Agitating work pieces during rinsing;
- Raising rinse water temperature;
- Introducing fresh water into the bottom of rinse tanks;

- Using spray rinsing techniques;
- Introducing intermediate static rinse baths before the final continuous flow rinsing tank; and
- Installing a counter current rinse water cascade with a bottom water supply and a top water run-off for each rinsing tank.

Static recovery rinse

Drag out often accumulates in the rinse tank, which presents opportunities for recovery. The solution contained in the rinse tanks can be used to make up plating bath losses caused by evaporation and drag out. Regeneration of baths can be accomplished by:

- Using filtration or centrifugation to remove impurities, and extend the lifetime of baths. Activated carbon filters can be used to remove dissolved organic impurities and solids; and
- Using ultrafiltration to remove oils from alkaline cleaners.

Water consumption

The level of process water consumption depends heavily on the type of metal finishing, manufacturing processes and techniques, housekeeping, and management practices being employed. The average process water consumption per unit product for each type of plating operation is listed in Table 12. The data is drawn from a survey of 200 electroplating shops conducted by IPCC.

Table 12. Process Water Consumption per Unit Product of the Metal Finishing Industry in the Republic of China

Categories	Decoration plating	Industrial plating	Electronics plating	Plastic plating	Electroplating
Average water consumption per square meter of work piece (l/ m^2)	277.6	154.4	181.4	540.0	231.3

Source: Industrial Development Bureau, *Water Pollution Control of Electroplating Industry* (in Chinese), 1994.

The survey data show that the proportion of process water consumption for pretreatment and electroplating are 40 percent, 50 percent, and 10 percent respectively.[14] In recent years, a great number of electroplating shops have put substantial effort into water conservation and waste recycling. As a result, many Green Productivity techniques have been adopted, including housekeeping improvements, multistage countercurrent rinse, reactive rinse, ion exchange, electrolytic recovery of metals, and evaporation/concentration. The achievements are estimated to have reduced water consumption from pretreatment and electroplating operation by 20 percent and 32 percent respectively and allowed recycling of 10 percent of the effluent from the pretreatment

[14] Industrial Development Bureau, *Wastewater Treatment and Management of Electroplating Industry* (in Chinese), 1996.

process. The average water recycling rate of the electroplating industry is estimated to be 34 percent. Table 13 shows the achievements of the ROC electroplating industry in water conservation.[15]

Table 13. Water Conservation in the ROC Electroplating Industry

		Water conservation measures	**Share of water consumption** *(%)*	**Water recycling rate** *(%)*	**Total volume of water saved** *(millions of m^3/year)*
Pretreatment	Degreasing rinse	- Continual filtration of degreasing bath - Use of multistage countercurrent rinse - Use of reactive rinse	40	20	365.7
	Acid pickling rinse				
Electroplating	Copper	- Installation of recovery tank - Use of multistage countercurrent rinse - Installation of electrolytic recovery system - Installation of ion exchange system - Installation of evaporation/ concentration system	50	32	731.4
	Nickel				
	Chromium				
	Gold				
After treatment and miscellaneous		---	10	---	---
Treated effluent		- Recycling of effluent	---	10	457.1

Source: China Technical Consultants, Inc, *On-line Recycling System and End-of-Pipe Treatment Technology of Electroplating Industry* (in Chinese), 1996.

[15] Statistical data presented in the paragraph is derived from: China Technical Consultants, Inc, *On-line Recycling System and End-of-Pipe Treatment Technology of Electroplating Industry* (in Chinese), 1996.

Solasia Energy Development Co., Ltd.

Solasia was established in 1988 and its factory currently occupies a site area of approximately 800 m^2. Solasia has 10 employees and an annual revenue of approximately NT$ 34 million. Solasia has NT$ 5 million (US$ 183,000) in registered capital.

Solasia's main products are solar panels which are manufactured by electroplating with nickel and chrome, a relatively uncommon way to manufacture solar panels in the ROC. At present, the factory produces 3,000 solar panel pieces monthly, each with a surface area of 2 m^2. Almost all the products are supplied to ten associated downstream solar heater manufacturers. Solasia is the only supplier of this type of product in the ROC, but in the face of growing pressure on the industry sector from the EPA, Solasia hopes to guarantee its long-term position through further improvements in its technology and environmental management practices. As one of the APO's demonstration projects, Solasia worked to aggressively introduce Green Productivity techniques into its factory and reduce the environmental impact of its operations. After one year's effort, the shop had a net benefit of NT$ 2.3 million. In addition to waste minimization, the shop also implemented a 5S program which enhanced employee morale, further improving productivity.

Manufacturing Process

The manufacturing process consists of four major steps: degreasing, pickling, nickel plating, and chrome plating. First, the copper tubes are cut and welded to a copper plate to form the flat absorber plate. The unit is then degreased and plated with nickel and chrome. The manufacturing process flow chart is shown as Figure 2. The nickel serves as the protective layer and the chrome as the solar absorbing medium.

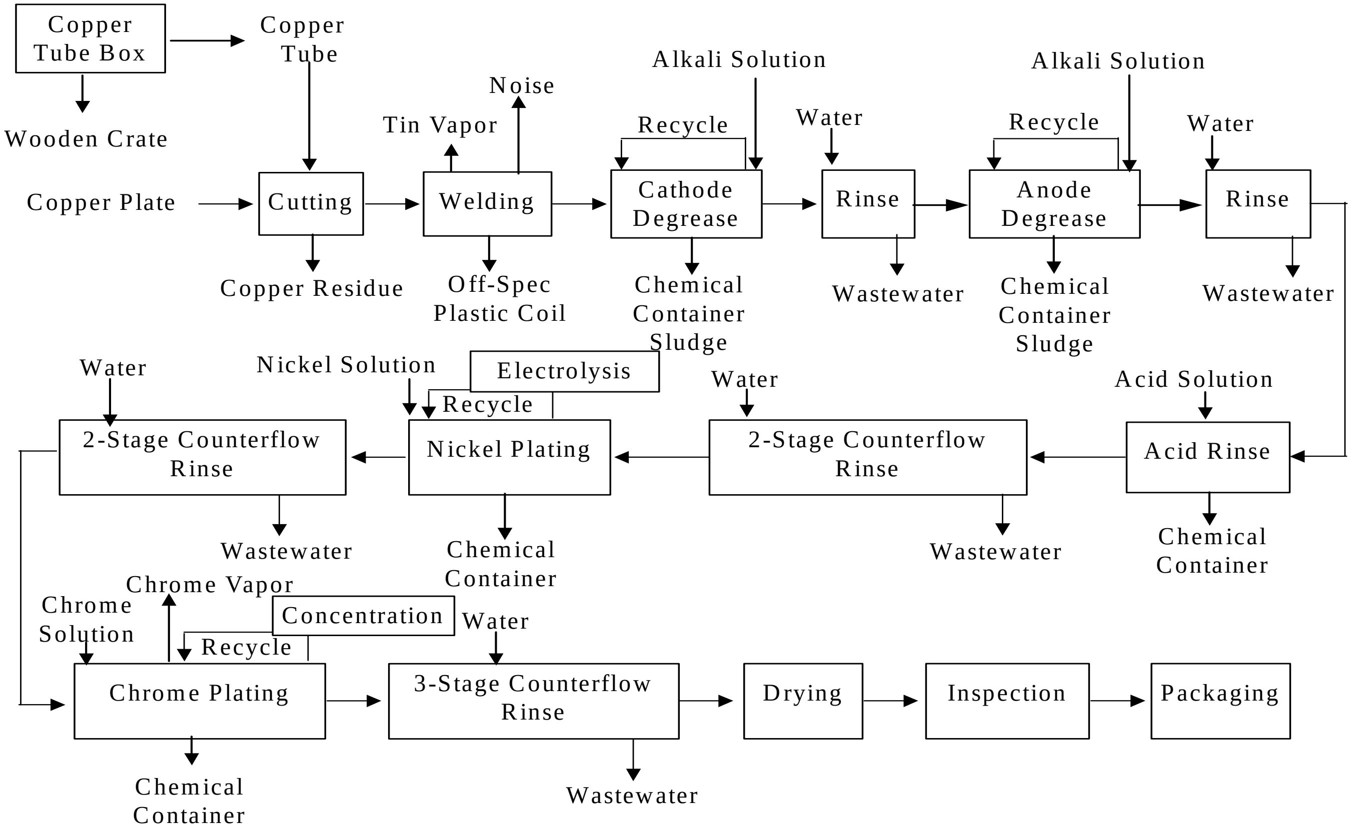
The types and quantities of chemical solutions used for anode and cathode degreasing, pickling, nickel, and chromium-plating processes are listed in Table 14.

Table 14. Consumption Rate of Main Chemical Reagents

Process	Chemical reagent	Consumption rate
Anode degreasing	Alkaline solution	40 kg/month
Cathode degreasing	Alkaline solution	
Pickling	Hydrogen chloride	30 kg/month
Nickel plating	Nickel sulfate Nickel chloride Sulfuric acid	20 kg/month 15 kg/month 30 kg nickel/month
Chrome plating	Chromic acid Oxidizing agent	30 kg/month

Source: APO, *Demonstration Factory/Farm Project Final Report - Solasia Energy Development Co., Ltd.* December 1999.

Figure 2. Solar Panel Manufacturing Process



Pollution Source and Characteristics

The sources of pollution in Solasia can be classified as wastewater, solid wastes, air emissions, and noise. Each source can be characterized as follows:

1. Wastewater includes domestic and process wastewater. Process wastewater contains degreasing rinse water, acid neutralization rinse water, nickel plating rinse water, chrome plating rinse water, leakage testing water, and recycled water containing treated nickel;
2. Solid wastes include the wooden crates used for transportation of copper tubes from Japan, copper residue, defects from the welding operation, plastic coil that is used for coiling tin thread, empty containers for storing chemicals, and sludge;
3. Air emissions include chrome vapor, tin vapor, and boiler discharge smoke; and
4. Noise is produced from the welding operation.

The wastewater periodically includes highly concentrated solution from the bath tanks as well as continuously overflowing rinse water. Accidental leaks and waste solutions containing highly concentrated chemicals can cause very serious environmental problems. Details of the chemical solutions are as follows:

1. *Solution in the degreasing tank*: Degreasing solution contains alkali complex which will be gradually consumed and aged. The optimum dose of alkali complex in the degreasing solution is 50 g/l and has an estimated lifetime of one year. To maintain the effectiveness of the degreasing solution, the specific gravity and pH value of the solution are continuously monitored. The spent degreasing solution cannot be recycled and has to be treated by a contractor;
2. *Solution in the acid bathing tank*: Acid-bathing solution contains acid complex. To maintain the effectiveness of solution, the specific gravity and pH of the solution are monitored to identify the need for dosing supplements;
3. *Solution in the nickel plating tank*: The solution contains nickel electroplating complex. To maintain the effectiveness of solution, the operator continuously measures with a Hull Cell (267cc) and adjusts the solution with dosing supplements; and
4. *Solution in chrome plating tank*: The solution contains Cr electroplating complex. To maintain the effectiveness of solution, the operator monitors the specific gravity and pH and makes adjustments with dosing supplements.

The total amount of process wastewater generated by Solasia is 55.2 m^3/day with a breakdown as shown in Table 15. The composition of the waste streams is shown in Table 16.

Wastewater treatment

The wastewater treatment facility in Solasia includes units for chrome reduction, metal precipitation, and filtration. Activated carbon is also used as polishing treatment for the final effluent. The configuration of wastewater treatment is illustrated as Figure 3.

Table 15. Wastewater Streams in Solasia

Periodic discharge	
Nickel ion exchange tank	1.6 m^3/batch
Nickel plate dip rinse tank	1.6 m^3/batch
Chrome ion exchange tank	1.6 m^3/batch
Continuous effluent	
Spent degrease solution	11.0 m^3/day
Spent acid rinse solution	11.0 m^3/day
Spent nickel rinse solution	11.0 m^3/day
Spent chrome rinse solution (I)	11.0 m^3/day
Spent chrome rinse solution (II)	11.0 m^3/day
Total	**55.2 m^3/day**

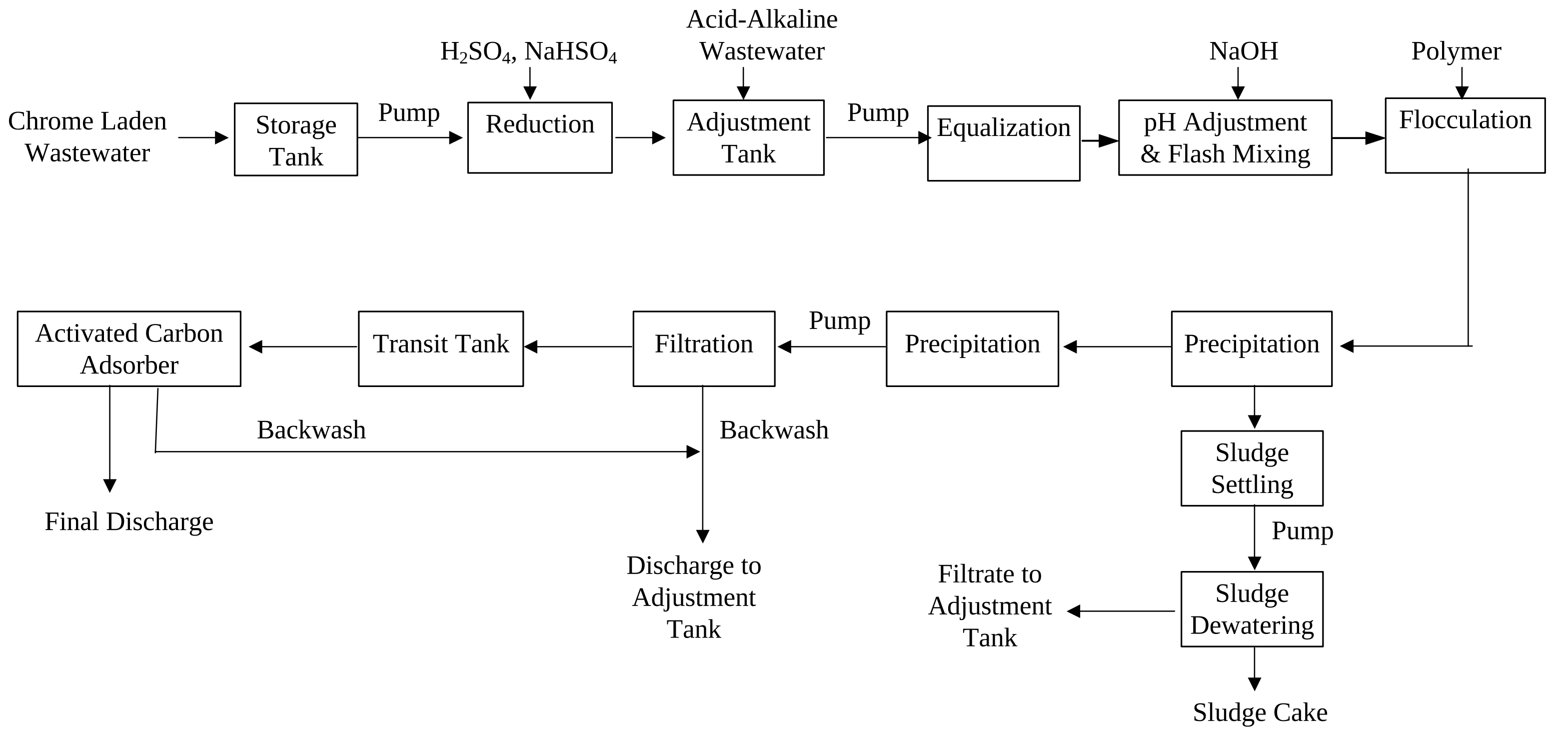
Source: Demonstration Factory/Farm Project Final Report --Solasia Energy Development Co., Ltd.

Table 16. Composition of Waste Streams in Solasia

Waste streams	**pH**	**Suspended Solids** *(mg/l)*	**COD** *(mg/l)*	**Ni^{2+}** *(mg/l)*	**Cr^{6+}** *(mg/l)*
1. Degreasing water（Cathode）	11.57	123	2,400.3		
2. Degreasing water（Anode）	12.78	431	2,436.0		
3. Degreased reused water	12.05	80.5	103.3		
4. Degreasing rinse water		7.4	10.7		
5. Acid rinsing water	2.54	3.8	16.8		
6. Nickel recovery tank（I）	6.99	17.7	145.5	1,700.0	
7. Nickel recovery tank（II）	6.39	5.5	4.8	240.0	
8. Nickel rinse water	6.64	3.7	4.5	21.1	
9. Chromium recovery tank	1.09	54.7			40,950
10. Chromium exchange water	1.77	12.8			1,633
11. Chrome rinse water（I）	3.31	22.6			125
12. Chrome rinse water（II）	6.34	6.7			6.02
13. Treated discharge water	8.00	8	8.2	1.35	0.67

Source: Demonstration Factory/Farm Project Final Report - Solasia Energy Development Co., Ltd.
Note: The above order of sampling follows the manufacturing procedure used by Solasia.

Figure 3. Wastewater Treatment System



Air pollution control

The most significant air pollution comes from the tin vapor emissions that occur during welding. A scrubber has been installed to absorb the chrome vapor, so acid emissions should be effectively reduced.

Implementation Procedure for Green Productivity Program

The Solasia was one of the companies selected in 1996 for an APO Demonstration Project. Participants begin by developing a Green Productivity Plan, which is a vital component of a company's environmental management system, particularly for a manufacturing plant. In order to draft a feasible plan, it is very important to gain the commitment and support of the top management. Once commitment is obtained, a GP task force should be established to conduct a plant survey and assessment to develop detailed and complete baseline information on performance. The assessment data can be analyzed and used as a basis for feasibility studies of different options. Once options have been identified, the task force implements a plan consisting of the selected GP options. The program or plan can be modified or corrected through a continual tracking procedure. The GP implementation procedure used by Solasia is shown in Figure 4.

Green Productivity Measures

After a detailed site survey and assessment, the most significant environmental impacts were determined to result from wastewater discharge. As a result, the major environmental improvement targets were identified as follows:

Process water reduction

The wastewater treatment plant in Solasia was originally designed for treating 2 m^3/day (8 hours) of chrome-laden effluent and 10 m^3/day (8 hours) of normal process effluent. The discharge amounts at the time of the survey exceeded the designed capacity of the treatment plant. As a result, the treated water could not meet the desired standard, and operation and maintenance costs were high because the sand filter and carbon adsorption unit had a shortened service period. Therefore, feasibility studies of zero discharge of chrome-laden effluent, process water reduction, recycling and reuse needed to be conducted.

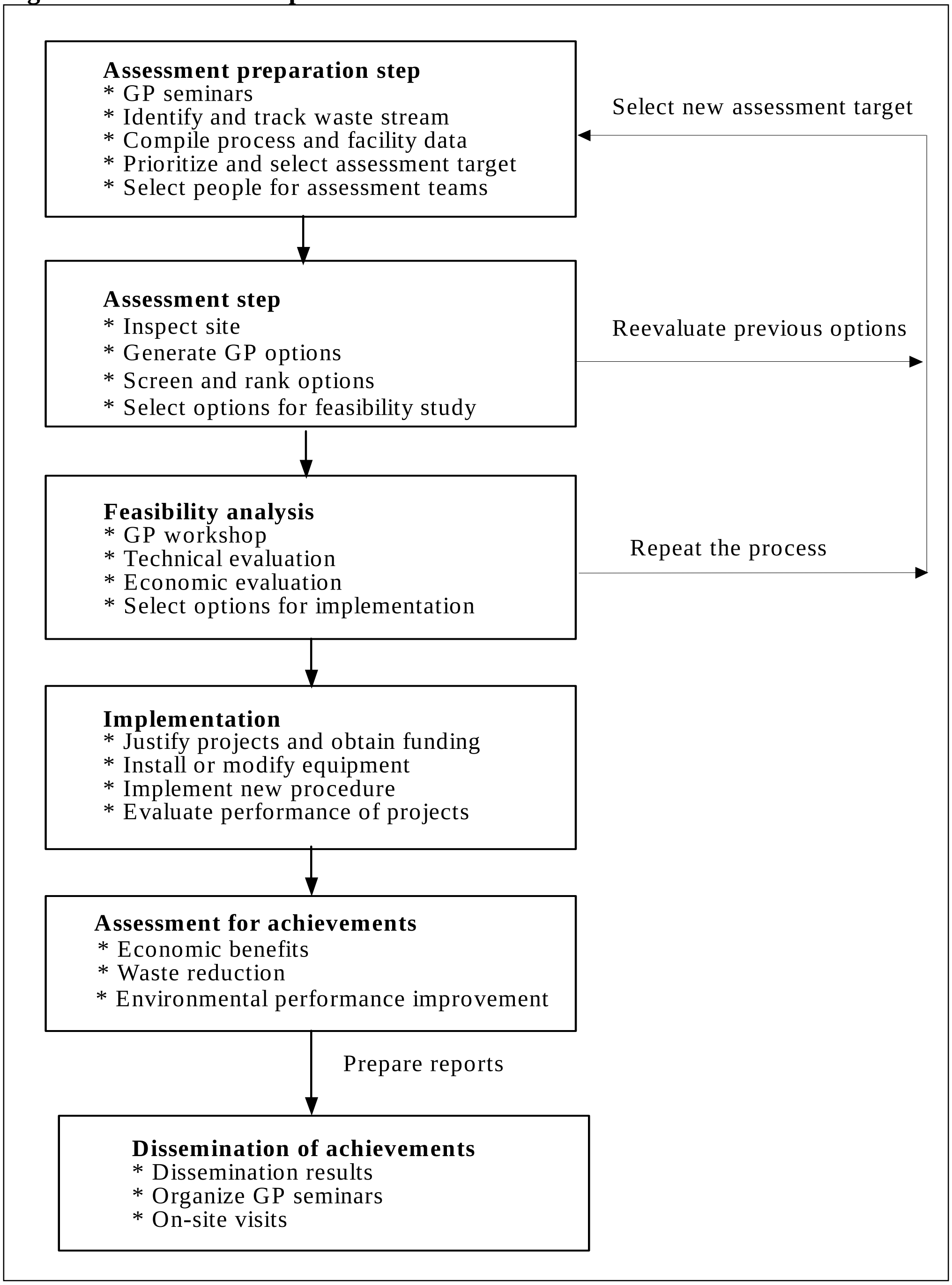
Spent nickel plating solution reduction

To reduce nickel discharge, the efficiency of the fluidized bed electroplating process needed to be improved.

Spent chromic plating solution reduction

To reduce chromium discharge, the chromium recovery through an ion exchanger was considered.

Figure 4. Solasia’s GP Implementation Procedure



Selection of Options

After careful study and assessment, several measures were selected based on the following citeria:

- Benefits to the environment;
- Ability to improve overall productivity;
- Technical feasibility;
- Economic feasibility; and
- Possibility of completion within one year.

Any improvement project that required two years or longer was classified as a long-term project. Projects related to achieving regulatory compliance were given higher priority.

The GP measures that were implemented in Solasia are illustrated below:

1. To minimize water consumption in the rinsing operations, the factory installed a multi-stage countercurrent rinse system in each major process. As a result, wastewater generation from the plating process line was reduced from 55 m^3/day to 22 m^3/day;
2. To reduce wastage of raw materials, the factory installed an electro-winning system for nickel recovery, an evaporator for chrome recovery, and a high efficiency wastewater treatment facility. About 40 kg of Ni can be recovered each month from the electro-winning tank and 30 kg CrO_3 is recovered from the evaporator each month. Effluent quality is now always within EPA standards;
3. To maintain water quality for rinsing process use, Solasia has installed an advanced ion exchange system which consists of three ion exchangers followed by a filter. The system also helps reduce overall water use;
4. To ensure the quality of effluent, Solasia has installed a wastewater treatment facility with pretreatment, rapid mixing, flocculation, precipitation, and tertiary treatment (active carbon adsorption); and
5. The water from the chromium exchange tank is now concentrated and then recycled to the electroplating tank. Only a small amount of wastewater from the second chromium-rinsing tank is drawn to the wastewater treatment facility by overflow to enhance the rinsing effect.

Other suggestions for future areas for improvement were:

- Labeling the working area of electrical hanger in the copper cutting area;
- Collection of scattered solid waste in the copper cutting area;
- Minimization of vapor emissions while welding with tin;
- Better raw material inventory management;
- Reduction of noise in welding operations;
- Planning emergency response measures and compiling Material Safety Data Sheet for hazardous materials;
- Reduction of the amount of nickel discharged;
- Recycling degreasing liquor; and
- Recycling rinsing water.

Benefits and Achievements

Although the results of the first stage of GP promotion were considered important, the sum of the environmental problems faced by Solasia was more than the company could handle at once. Therefore, the benefits of long-term GP implementation become the major incentive driving continued implementation of the program. Assessment results for three of the more easily quantified schemes are listed below.

Scheme 1: Reducting the amount of nickel discharged

The plant recycled nickel using a fluidized bed electrolyte facility which had a very low efficiency (only 68.3 percent) that resulted in high concentrations of nickel ion (10,652 mg/l) in the electrolytic residue. To control the concentration of nickel ion and reduce the loading of the wastewater treatment unit, it was necessary to increase the amount of cathode board and adjust the current density to 100 A/m^2. Efficiency rose to 80 percent or higher and also increased the amount of recycled nickel. If the electrolytic time is simultaneously extended, the concentration of nickel ion in the electrolytic residue could be further decreased. The cost analysis of this scheme is shown below.

Hardware investment (A): None.
Operating cost per year (B): Supplemented dose (Alkaline Liquor): 2,000 NT$.
Turnover benefits (C): Increasing the recovery efficiency from 68.3 percent to 80 percent can lower the concentration of electrolytic residue to 3,133 mg/l and increase the amount of nickel recovered each year: (10,652 mg/l - 3,133 mg/l) x 8,800 l/month x 12 months/Year = 794 Kg. The step can also reduce the cost of nickel purchases by 238,200 NT$ per year (794 Kg x 300 NT$/Kg = 238,200 NT$).
Net benefit per year (C - B): 236,200 NT$.
Payback period A/(C - B): Immediate.

Scheme 2: Recycling of degreasing liquor

In the past, for the treatment of the degreasing liquor, most of the degreasing liquor was blown back to the degreasing tank with an air knife when the basic structure was raised from the tank, and then after a while, the structure was moved to the next tank. After surveying the plant, it was suggested that despite reducing drag out of degreasing liquor, the air knife likely was increasing the COD in the tank. The resulting impurity was shortening the lifetime of the degreasing solution. The installation of a simple degreasing filter extended the lifetime of the degreasing solution from one year to five years. The cost analysis of this scheme is shown below.

Hardware investments (A): Degreasing filter facility (x 2): 50,000 NT$.
Pipeline construction: 2,000 NT$.
Operating cost per year (B): Maintenance (include change of filter): 2,000 NT$.
Power: 10,000 NT$.
Turnover benefits (C): Prolong the lifetime of degreasing solution to 5 years or longer and increase the effectiveness of degreasing. Savings from lower

degreasing dose costs: 5 m^3/Year x 1000 l/m^3 x 100 NT$/l x 4 Years = 2,000,000 NT$.

Net benefit per year (C - B): 1,988,000 NTD.

Payback period A/(C - B): 10 Days.

Scheme 3: Recycling of rinsing water

Because the plant was equipped with a recovery facility for nickel and chrome, opportunities to reduce water usage were very limited. After surveying the site, it was suggested that it would be preferable to treat the rinsing water with several ion exchangers in series and then recycle the treated water to the rinsing tank. The cost analysis of this scheme is shown below.

Hardware investment (A): Ion exchange towers: 500,000 NT$. Pipeline construction: 10,000 NT$. Rinsing holding tank: 5,000 NT$.

Operational cost per year (B): Maintenance (include the recovery of resin): 20,000 NT$; Power: 10,000 NT$.

Turnover benefit (C): Reduce water consumption by 15 m^3/day and also lower wastewater volume. Water consumption savings per year: 15 m^3/day x 330 working day/year x 7 NT$/$m^3$ = 34,650 NT$. Savings on wastewater treatment per year: 15 m3/day x 330 working day/year x 7 NT$/$m^3$ = 34,650 NT$.

Net benefit per year (C - B): 39,300 NT$.

Pay back period A/(C - B): 13 Years.

Table 17. Summary of Cost-Benefit Analysis

Action	Impact	Investment cost	Savings	Balance
Reduction the amount of Ni discharged	Save nickel material Reduce treatment costs Reduce sludge volume	NT$ 2,000/yr	NT$ 238,200/yr	NT$ 236,200/yr
Recycling of degreasing liquor	Save raw materials Prolong the bath life Reduce down-time	NT$ 52,000 + NT$ 12,000/yr	NT$ 2,000,000 /yr	NT$ 1,988,000 /yr
Recycling of rinsing water	Save water Reduce discharge	NT$ 515,000 + NT$ 30,000/yr	NT$ 69,300/yr	NT$ 39,300/yr

Source: Demonstration Factory/Farm Project Final Report – Solasia Energy Development Co., Ltd.

Summary

With the support of top management, the environmental protection task force not only has continued to implement Green Productivity, but also has undertaken industrial health and safety, quality management, and implementation of an environmental management system. Several of the practical measures adopted by Solasia that proved to be successful were:

- Chromium recovery by ion exchange;
- Improved housekeeping, such as the 5S movement;

- Treatment of waste copper scraps;
- Purchase of fire protection and life-saving equipment;
- Installation of an advanced wastewater treatment system;
- Recycling of packaging materials and containers;
- Establishment of quality management system (ISO 9002 certified in 1998); and
- Establishment of environmental management system (ISO 14001 certified in 1998).

The total annual benefits of Green Productivity implementation were estimated to be NT$ 2,250,000. Although some objectives could not be accomplished during the project period, Solasia is relying on ISO 14001 to monitor its environmental performance to ensure continual improvement.

CONCLUSION

Environmental pollution problems have grown from being regional to global issues. Traditional end-of-pipe treatments are no longer cost-effective in meeting new standards. Moreover, pollutants are not eliminated, but are merely transferred from one environmental medium to another. Pollution prevention and cleaner production have been widely accepted as the most cost-effective and practical methods for solving pollution problems. Green Productivity is a strategy that aims to reduce industrial pollution by combining both pollution prevention and end-of-pipe treatments. GP is an essential step for any company preparing to enter the era of sustainable development.

The metal finishing industry has played an important role in the ROC's industrial development. In the face of the evolution of the industrial structure from traditional industries to technology-intensive and valued-added industries, the quality of the ROC's electroplating industry must also be upgraded and shops must improve their process technologies and quality management. At the same time, they cannot neglect the environmental protection issues that are receiving growing attention around the world. Because of the limited land area and high population density in the ROC, environmental quality is very easily damaged by pollution. If the hazardous substances in electroplating wastewater and sludge are not treated or disposed of properly, they will pose significant threats to ecosystems and human health. It is very clear that the metal finishing industry should adopt Green Productivity strategies and establish ISO 14001 Environmental Management Systems to reach the goal of sustainable development.

For more advanced GP programs, the technology required in the ROC may include:

1. Environmentally friendly chemicals as substitutes for toxic and/or high pollution loading chemicals;
2. Cost-effective sludge drying systems for reducing the cost of sludge treatment and disposal;
3. Technology for recovering or reusing heavy metals in wastewater sludge; and
4. High-efficiency water recycling processes to reduce wastewater discharge.

The metal finishing industry in the Republic of China will benefit if APO can continue to provide the experts and technologies regarding the above-mentioned matters.

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THAILAND

Prasert Tapaneeyangkul, Ph.D.
Head/Advisor
Hazardous Substance Control Bureau
Industrial Works Department
Ministry of Industry
Bangkok

COUNTRY PROFILE

Agricultural Production

The agricultural sector plays an important role in the Thai economy both as an employer and as a supplier of inputs to key industrial sectors. Roughly 60 percent of Thailand's labor force is employed in the agricultural sector. However, the growth of employment in other sectors has exceeded that of agriculture over the last several years. Large differentials in productivity and incomes exist between the agricultural, industrial, and service sectors, posing a problem for policy makers trying to balance issues of income distribution and equity.

Thailand's rapidly growing industrialization will not reduce the importance of food production in the economy, as 25 percent of the manufacturing industry is still related to agriculture. The country is currently broadening its range of agriculture-based exports by adding new products such as frozen seafood, poultry, fresh and processed fruit and vegetables to the more traditional exports of rice, maize, rubber, sugar and tapioca.

Industrial Sector

The early stages of industrial development in Thailand began in 1939, driven by the goal of import substitution. Since the 1940s, Thailand's industrial structure has undergone significant changes and has now become primarily export oriented. The food industry is oldest industry sector in Thailand and has played a significant role in the economy even as Thai industry has diversified. In recent decades other industry sectors have overtaken the food industry in size and growth. From 1987 to 1993, the highest growth sectors were automobiles, machinery, metal, electrical appliances, computers and electronics, leather products, and textiles. The basic industries (e.g., cement, petrochemical, refineries, and steel) also grew very rapidly. The manufacturing sector maintained constant high levels of growth from the mid-1980s until 1997 due to rising foreign and local investment. Growth remained strong until the decision to change from a fixed exchange system to a managed-float system set in motion the events that led to the financial crisis and subsequent collapse of the economy. Table 1 shows the production value of ten of Thailand's major industrial sectors.

Table 1. Export Value of Major Industrial Products

No.	Sector	**Value** *(in million Baht)*
1.	Electronics	558,746
2.	Textiles	209,281
3.	Rice	86,803
4.	Automobiles and parts	68,353
5.	Canned seafood	67,952
6.	Gems and jewelry	57,357
7.	Natural rubber	55,413
8.	Plastics	40,788
9.	Air conditioners and parts	32,419
10.	Transformers	26,023

Source: Ministry of Commerce, *National Export Statistics*, 1998.

Following the economic crash in 1997, the Thai government established a National Industrial Restructuring Committee to salvage the industrial sector. The economic crash revealed fundamental weaknesses in key aspects of Thailand's industrial sector. To improve the long-term competitiveness of Thai industry (especially SMEs), the committee developed an Industrial Restructuring Plan comprising the following elements:

1. Enhance production capability and processes to improve cost and delivery competitiveness;
2. Adjust technologies and machinery in targeted industries;
3. Increase skilled labor to support industrial growth;
4. Strengthen of small and medium small supporting industries;
5. Develop product, product design, and international marketing capabilities;
6. Decentralize labor-intensive activities to rural/regions;
7. Promote foreign investment in industry using advanced technologies; and
8. Control polluting industries and promote of cleaner technology.

With the economic recovery underway, the Ministry of Industry also commissioned the preparation of a Master Plan for Industrial Development 2010. The plan outlines the policy framework and measures necessary to lay the foundation for future development in four groups of industries:

- *Frontier exporting industries*: The leading light export industries such as textile/apparel, gems and jewelry, shoes, and processed foods;
- *Emerging industries*: High technology industries such as electronics, computers, automobile parts and components;
- *Basic and supporting industries*: Sectors such as iron and steel, chemicals, rubber, cement, and construction materials; and
- *Industries for local communities and rural areas*: Pottery, wooden furniture, and jewelry.

To date, international trade policies have been Thailand's major instrument for attracting and directing foreign direct investment and technology transfer among the major economic sectors. The measures that affect the pattern and the structure of Thai industries include trade taxes as determined by the Finance Ministry as well as import and price controls under the direction of the Ministry of Commerce. Industrial protection is evident in Thailand and has allowed industry to obtain stronger profits while operating at high costs. Industries under domestic protection are unlikely to be able to compete in the international market in the future.

Service Sector

Banking and financial services are the leading industries in the service sector. Over the last two years, the baht has fluctuated from 35 to 56 baht to the U.S. dollar. Since 1997, the Bank of Thailand has undertaken several measures to clamp down on foreign exchange speculation and has now stabilized the baht at a rate of approximately 37 baht to the U.S. dollar. Among measures taken were tighter enforcement of retail foreign exchange transactions at local banks, with on-site inspections of trading rooms of commercial banks and authorized money-changers. The central bank also announced that capital controls which had split foreign exchange trading into onshore and offshore markets would be lifted. Previously, local banks had been prohibited from lending baht to offshore counterparts, in effect draining offshore liquidity and denying baht to speculators.

Tourism is also a key industry in the service sector and has been expected to play a key role in rebuildng Thailand’s foreign exchange reserves. In an effort to attract more visitors, 1998-1999 were declared “the Years of Amazing Thailand,” but the tourism industry is facing a challenge with the sharp drop in foreign visitors to the region, particularly Asian tourists. Although the weak baht has become attractive for Western visitors, the chances of the country reaching the target of 16 million tourists during the two-year Amazing Thailand campaign appear unlikely. Nevertheless, Thailand has performed far better than most other countries in the region, where the numbers of visitors have also been declining.[1]

ENVIRONMENTAL PROFILE

Environmental Loading by Industry

According to the Factory Act of 1992, factories are divided into three types:

1. Small factories that do not cause any environmental or safety problem. Normally they employ not more than 20 workers or install machinery not more than 20 horsepower. No permit is required;
2. Medium-size factories that employ between 21 and 50 workers or install machinery between 21 and 50 horsepower. No permit is required either. However, owners must notify the authorities prior to operation; and
3. Large factories or factories that cause environmental or safety problems by their nature. Normally they employ more than 50 workers or install machinery more than 50 horsepower. A permit is required prior to factory construction.[2]

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[1] *Bangkok Post*, Economic Review, 1998.

[2] SMEs with highly polluting processes would be considered Type 3 factories under the Thai

In 1997, there were 123,521 factories with a total investment of 1.65 trillion baht registered with the Department of Industrial Works (see Table 2). In total, there were approximately 3 million employees in the industrial sector. Of the registered factories, 2,500 were situated within Thailand's 29 industrial estates.

Table 2. Regional Distribution of Factories in Thailand

Region	Type 1	Type 2	Type 3	Total
North	7,889	3,255	8,296	19,440
Middle	6,491	11,623	35,195	53,309
North-east	38,658	3,872	8,216	40,746
South	3,154	1,418	5,454	10,026
Total	46,192	20,168	57,161	123,521

Source: Department of Industrial Works, Ministry of Industry.

Bangkok is the industrial center of the middle region with 21,003 factories. Samut Prakan is the second most industrialized area with 6,100 factories and Samut Sakhon is third with 2,830 factories. The total investment in the middle region is approximately 1.39 trillion baht, which constitutes more than 80 percent of industrial investment in Thailand.

The manufacturing sector is the largest generator of hazardous waste, accounting for 90 percent of the approximately 2 million tons generated annually (see Table 3).[3] Hazardous waste generation is expected to grow to 6 million tons per year by 2001. Two thirds of industrial hazardous waste is generated by the basic metal industry and the remainder is produced in small quantities by fabricated products, transportation equipment, electrical appliances, electronic components, chemical products, textile, and printing and publishing industries. Heavy metal sludges and solids, followed by acid waste, pose the greatest environmental risks in Thailand. In 1996, Thailand utilized an estimated 12.24 million tons of chemicals, of which 3.4 tons were imported and 8.84 tons were manufactured.

Table 3. Hazardous Waste Quantity in Thailand

Source	1995	1996
Industry	1,100,000	1,600,000
Agriculture	10,800	n/a
Service industry	126,150	n/a
Hospital, clinic	122,400	n/a
Port and ship	121,950	n/a
Community	18,900	28,000

Source: Ministry of Science, Technology and Environment.
Unit: Tons/day.

The Thailand Development and Research Institute reports that the bulk of biodegradable waste is generated by sugar mills (29 percent), pulp and paper mills (20

classification system.

[3] Hazardous waste figures are estimates from the Report on Hazardous Waste in Thailand, conducted in 1989 by Engineering Science (consulting firm). Hazardous waste volumes were calculated based on number of workers in facilities using U.S. data as a reference point.

percent), and the rubber industry (18 percent). The remainder is contributed by the beverage industry, tapioca industry, slaughterhouses, the canning industry, and the tannery industry.

Biological oxygen demand (BOD) from industrial sources stands at approximately 25 percent of the total BOD and currently amounts to 0.5 million tons annually (see Table 4).[4] BOD is expected to increase to 2 million tons by the year 2010. It has been estimated that achieving a 70 percent treatment of the current level of BOD would cost 361 million baht per annum, approximately 1 percent of the GDP produced by the industries that generate BOD.

Table 4. BOD Discharge to Major Rivers, 1997

Source	Chao Praya	Ta Chin	Mae Klong
Household	367.5	102	59
Industry	105	120	82
Agriculture	24	95	57
Business and service	9.5	n/a	n/a

Source: Ministry of Science, Technology and Environment.
Unit: Tons/day.

The major sources of air pollution in Thailand are power plants, oil refineries, petrochemical and steel industries. The most significant pollutants are considered suspended particulate matters (SPM), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), and odors.

Key Environmental Agencies

The primary environmental policymakers in Thailand are the National Environmental Board (NEB), the Ministry of Science, Technology, and Environment (MOSTE), and the Pollution Control Committee (PCC). The NEB is the highest body and sets goals for ambient environmental quality in Thailand. The job of establishing pollution control standards is shared by MOSTE and the PCC.

National Environmental Board

The National Environmental Board is chaired by the Prime Minister with the Permanent Secretary of MOSTE as Secretary to the Board. The board can submit to the cabinet plans for enhancement and conservation of the national environmental quality. The board also supervises the Environmental Fund and prescribes environmental quality standards for water resources, atmospheric ambient air, noise and vibrations, and other environmental concerns.

Ministry of Science, Technology, and Environment

Although MOSTE takes broad responsibility for managing the environmental concerns of Thailand, other governmental agencies at the national and local levels are also authorized to develop relevant regulations in their respective domains. Since the scope of the authorities of many governmental agencies may overlap, standards issued by separate agencies may be conflicting. In such cases, MOSTE's standards prevail unless

[4] Department of Industrial Works, 1986.

the inconsistency is expressly authorized by the act and its subsequent regulations. However, standards issued by agencies must also be at least as stringent as those of MOSTE.

Another key function of MOSTE is to oversee the implementation of Thailand's Environmental Impact Assessment (EIA) report system. MOSTE (with the approval of NEB) determines the types and sizes of projects or activities that have significant enough environmental impact to require submission of an EIA report. The Office of Environmental Policy and Planning within MOSTE is responsible for reviewing EIA reports and is supported in the process by a committee of experts. The office has 120 days to make a decision to approve or reject the report. Once the report is approved, the relevant agencies must grant permission for implementation of the project or activity. If an EIA report has been rejected for any reason, it can be resubmitted following the necessary amendments.

Pollution Control Committee

The PCC is chaired by the Permanent Secretary of MOSTE. The committee consists of the Director-Generals of other environmentally related departments in the various ministries.[5] The Pollution Control Department is the working arm of the committee. The mission of the PCC is to prescribe emission and effluent standards for the control of air pollution, wastewater, and solid waste including hazardous waste from point sources.

Local management

Under the National Environmental Quality Enhancement and Conservation Act, areas specified by the NEB to have an aggravated pollution problem are designated as a Pollution Control Area (PCA). Each provincial governor in the PCA is authorized to prescribe a more stringent set of emission and effluent standards within the PCA to control and reduce the pollution. The governor is also obliged to submit a mitigation plan and appropriate financial budget to the MOSTE.

Environmental Legislation

The Thai Constitution of 1997 marks a significant point in Thailand's history as it is viewed as a true "people's constitution." The Constitution Drafting Assembly was composed of 99 members: 76 delegates from each province, 8 political scientists, 8 legal experts and 7 experienced politicians selected by the Parliament. Unlike previous constitutions, the drafting included public hearings in all 76 provinces to incorporate citizens' opinions and views. The Constitution contains 336 articles, including innovative measures for the restructuring of the country's political environment.

On the issue of the natural environment, the Constitution promotes and supports public participation in environmental management and conservation. The Constitution specifies individual and community rights and removes the state's sole decision-making power over natural resource management. The Constitution recognizes the rights of public and local communities to protect the environment and to utilize natural resources sustainably.

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[5] There are five ministries with departments related to the environment: Ministry of Interior, Ministry of Industry, Ministry of Public Health, Ministry of Agriculture, and MOSTE.

In addition to the basic rights guaranteed by the Constitution, Thailand has also developed a legal framework of 13 laws to manage environmental issues. The three most significant laws are the National Environmental Quality Enhancement and Conservation Act, the Factory Act, and the Hazardous Substances Act.

National Environmental Quality Enhancement and Conservation Act (1992)

The NEQA was originally passed in 1975 and then revised in 1992. Key aspects of the revised act include:

- Broadening the scope of environmental and pollution control;
- Upgrading the National Environment Board into an active policy-making center;
- Creating a more restrictive environmental standard-setting system;
- Providing polluters incentives to clean up their wastes;
- Instituting criminal sanctions for violations; and
- Establishing the Environmental Fund to provide loans or grants to support construction of waste treatment facilities and other environmental activities.

The Environmental Fund was created to promote the Polluter Pays Principle and is considered to be one of the most powerful incentive tools in Thailand. The fund provides grants to governmental agencies and low-interest loans to both public and private sectors for the installation of waste treatment facilities. It also requires that the grant or loan be used specifically for the purpose of enabling the recipient to meet the environmental standards and requirements established under the NEQA or other related laws.

The NEB, with the advice of the Pollution Control Committee, establishes service fees for all central wastewater treatment plants or central waste disposal facilities that are constructed with government funding, including grants from the Environmental Fund. Any organization that illegally discharges or disposes of its wastes is liable for a penalty of four times the cost of the service fees until full compliance with the law is achieved. Organizations required to have their own on-site waste treatment facilities but fail to do so and illegally discharge their waste into the central waste treatment plant are subject to a daily fine of four times the costs of normal operation of such an on-site facility plus any damages to the central treatment plant or disposal facility resulting from their illegal activities.

A party that possesses a point source of pollution planning to install an on-site treatment facility, whether or not required to do so by law, is entitled to apply for reduction of import duties for any necessary machinery, equipment, or materials which are not available in Thailand. They may also request permission to bring in foreign experts and specialists for the construction and operation of the facility if such qualified persons are not available in Thailand. The income foreign specialists earn for the construction and operation of the facility may also qualify for exemption from taxation in Thailand.

Violators of the NEQA are subject to strict civil liability except under three circumstances: Force majeure or war, acts done with government approval, or damages resulting from an act or omission by a victim or their party who is either directly or indirectly responsible for the damages. The violators are liable for all damages resulting from contamination, including any expenses incurred for the clean-up as well as the value of any natural resources destroyed or damaged in the process. Criminal liabilities for violations range from one month to five years imprisonment and/or fines of 10,000 to 500,000 baht.

The Factory Act (1992)

The Department of Industrial Works (DIW) under the Ministry of Industry is responsible for the implementation of the Factory Act. The act empowers the department to regulate factories to prevent disturbance, damage, or danger to the public or the environment. The Minister of Industry can prescribe the following:

1. The location and description of factories;
2. The categories and types of machinery and equipment to be used in the operation;
3. The qualified and specialized personnel (e.g., engineers and scientists) to be hired in the factories;
4. Operational safety measures or pollution abatement measures;
5. Emission and effluent standards for air, water and other media;
6. Requirements for record keeping and documentation concerning daily operations;
7. Submission of regular reports on waste treatment facility operation, material safety data sheets, and information pertaining to radioactivity; and
8. Worker occupational health and safety measures.

The act empowers the Minister to declare the Industrial Operating Areas in which factories do not require operating permits. Thailand's industrial estates are also considered "Industrial Operating Areas" under the Factory Act. The main purpose of the clause is to concentrate establishment of factories in a limited area and reduce the impact of manufacturing operations on communities. In addition, establishing and operating centralized waste treatment facilities in Industrial Operating Areas or Industrial Estates facilitates monitoring and inspection by government agencies.

In the event that a factory causes disturbance, damage, or danger, the DIW is empowered to issue a corrective order including a specific time-frame for corrective action. If the factory still ignores the order or poses a serious danger, it will be closed down.

The DIW is entitled to use the Environmental Fund to install a waste treatment facility or improve existing facilities if the factory refuses to do so. The factory will then be obliged to pay back the entire cost plus a penalty of 30 percent per annum.

Section 9 in the act establishes the privatization of factory and machinery audits and inspections. If a third party performing an audit or inspection falsifies the report, he shall face the maximum criminal liability of two years imprisonment and/or a 200,000 baht fine.

Violators of the Factory Act are subject to stringent criminal liability. The penalties range from 6 months to 4 years imprisonment and/or fines of 20,000 to 400,000 baht.

The Factory Act plays an important role in promoting GP by empowering the DIW to prescribe utilization of environmentally sound processes as part of the conditions of the operating permit. For example, pulp mills are required to install pulp cookers equipped with oxygen delignification to lessen the BOD loading. In addition, the bleaching chemical used by mills must be elemental chlorine-free to avoid dioxin emissions. Textile dyeing mills must use low-liquor-ratio machines and non-toxic dyestuffs. The caustic soda process in the chlor-alkaline industry must be ion-exchanged membrane. The DIW has already developed eight sector-specific guidelines on GP/CP.

The DIW is in the process to amending the Factory Act to empower the department to apply and enforce economic instruments in accordance with the “Polluter Pays Principle.” The first planned instrument will be an emission charge eventually to be followed by a pollution management fee. The economic instruments will serve as an important catalyst for GP since companies will have a direct incentive to minimize waste to reduce fee payments. This issue will be discussed in detail in the section on incentives.

The Hazardous Substances Act (1992)

This act is another significant piece of Thailand’s legislative framework. The Hazardous Substances Act empowers the Ministry of Industry to oversee all activities concerning the import, processing, manufacturing, export, and disposal of hazardous substances. The Ministry of Industry works in cooperation with the Ministry of Agriculture and Cooperatives, the Ministry of Defense, the Ministry of Interior, the Ministry of Public Health, and MOSTE. These Ministries oversee the activities of the Committee on Hazardous Substances (CHS), which was established under this act and chaired by the Permanent Secretary of the Ministry of Industry.

The Minister of Industry, with the advice of the CHS, is responsible for prescribing the names or criteria for hazardous substances, types of hazardous substances, periods of application, and agencies responsible for the control of hazardous substances. The relevant ministries then administer all other regulations concerning safety precautions to prevent danger in the handling, use, and disposal of hazardous substances. Hazardous substances are grouped into four classifications, ranging from those that are banned outright to others that must simply comply with specific stipulations within the Hazardous Substance Act prior to production, import, export, or possession by a party. If use of a hazardous substance requires permission, an application can be submitted to the authority appointed by the minister responsible for said substance. Permits will typically expire within three years and must be renewed prior to expiration. Continued use of the substance after a submission for renewal is valid despite lapse of the first permit. All use of such a substance must cease if renewal is denied for any reason.

Injuries caused by a hazardous substance will expose the producer, importer, carrier, or possessor of said substance to civil liability so long as the injuries were sustained without force majeure or fault of the injured party. The same liability is imposed upon the seller of the substance and the party who delivers it. These liabilities, however, are subject to a three-year statute of limitations from the date the injuries are discovered. Criminal liabilities range from one month to ten years imprisonment and/or fines of 1,000 to 1,000,000 baht.

Long-Term Environmental Policy and Planning

The National Economic and Social Development Plan (NESD) forms the framework for all policy and planning related to development. The NESD covers natural resource management and environmental protection in accordance with the NEQA. The NESD is supplemented by two additional long-range plans: The Enhancement and Conservation of National Environmental Quality Management Plan (1997–2016) and the

Environmental Quality Management Plan (1999–2006). The former is a framework for the conservation of the environment and incorporates environmental quality management plans covering various sectors. The Environmental Quality Management Plan establishes the framework for coordination among the various government agencies, state enterprises, and relevant parts of the private sector, as well as the implementation structure for environmental conservation at the provincial level.[6]

The plan for the next twenty years (1997–2016) includes the following goals:

- Mitigate the problems of degradation of soil, forests, water, mineral, energy, marine and coastal natural resources and the quality of water, air, noise, waste management, toxic/hazardous waste management, and land-use management;
- Rehabilitate natural and cultural environments and communities;
- Raise public environmental awareness and the use of technology to conserve the environment;
- Reform government agencies that manage natural resources and improve the networks between relevant government agencies in order to improve their efficiency and effectiveness;
- Amend outdated environmental laws and regulations; and
- Promote a paradigm shift to sustainable environmental development.

As part of the last point, the Thai government is seeking to promote a new approach to environmental management emphasizing the concept that "Prevention is Better Than a Cure." Cleaner Production, Cleaner Technology, and Pollution Prevention have been promoted vigorously as preferable to conventional end-of-pipe pollution control solutions.

Since the Earth Summit in Rio in 1992, environmental issues have become an international priority. Thailand ratified the Rio Declaration consisting of 27 principles on environment and development. The Declaration and Agenda 21 provides a comprehensive action plan for sustainable development. The Ministry of Industry and MOSTE are the lead agencies for various international issues such as the Montreal Protocol (CFCs), Basel Convention (hazardous waste), Kyoto Protocol (climate change), and biodiversity.

Policies, Programs, and Incentives

The NESD currently states that environmental management shall be in accordance with the "Polluter Pays Principle." The conventional end-of-pipe method is still the most common strategy to control pollution, but the Thai government has been working to incorporate various economic instruments such as pollution fees and technical guidance programs into policy to drive a paradigm shift towards cleaner production.

Economic instruments

Thailand already employs a number of economic instruments to control pollution. Examples include:

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[6] Ministry of Science, Technology, and Environment, *The Enhancement and Conservation of National Environmental Quality Management Plan (1997–2016).*

1. Product charges such as the excise taxes currently levied on petrol. Unleaded gasoline and low sulfur content diesel fuels pay less excise tax;
2. User charges on wastewater are collected in some cities and in all industrial estates having a central wastewater treatment plant;
3. User charges on garbage and night soil collection in most cities, municipalities, and rural administrative districts;
4. User charges on industrial waste and hazardous waste treated in government and government-private joint venture facilities;
5. Exemption from import taxes on waste treatment machinery and equipment or materials for the facility operation which are not available in Thailand. Companies may also bring in foreign experts and specialists concerning the construction and operation of the facility if such qualified persons are not available in Thailand;
6. Penalties in terms of fines and/or imprisonment for violators against any environmental acts; and
7. Subsidies through the environmental fund to provide grants for governmental agencies to install central waste treatment facilities. In addition, the Environment Fund also offers low-interest loans to both municipalities and the private sector.

Developing economic instruments to impove industrial pollution management is one of the top priorities of the DIW. As part of a more ambitious initiative, the Department of Industrial Works in collaboration with GTZ (Deutsche Gesellschaft fuer Technische Zusammenarbeit GmbH) of Germany hired the Thailand Environment Institute to study and develop appropriate economic instruments for Thailand. After thorough study, two methods were identified:[7]

1. *Emission charges*: The Department will levy fees on industries which discharge or emit their wastes into the environment regardless of whether or not their emissions already meet regulatory standards. The charge is calculated to take into account the damages or effects caused to the environment and to human health by the discharges. The first group of factories targeted will be Type 3 facilities. In order to encourage factories to maximize their efficiency in handling and reduce waste, the charge will be higher than the cost of operation of a waste treatment facility. During the initial stage, the emission charge will be applied to industrial wastewater. The rate is based on the total amount of wastewater and the loading of each pollutant parameter in the effluent standard. The charge calculation has six variables. Effluent that meets regulatory standards will be charged a lower fee than wastewater discharges that fail to met requirements. The charge system is scheduled to begin in 2002.

   Case 1: Effluent does not meet standard
   $Charge = 4.52Q + 18.48BOD + aNHP1 + bNHP2 + cHP + Mag$

[7] Department of Industrial Works, *Development of Economic Tools in Industrial Management*, Thailand Environment Institute, 1997.

Q	= Quantity of wastewater discharged (m^3/day)
BOD	= BOD loading discharged (kg/day)
A	= Coefficient charge for NHP1
B	= Coefficient charge for NHP2
C	= Coefficient charge for HP
NHP1	= Physical parameters: pH, color, odor, and temperature
NHP2	= Loading of COD exceeding standard[8]
HP	= Loading of hazardous pollutant exceeding standard
Mag	= Management fee

Case 2: Effluent meets the standard
Charge = 0.452Q + 1.848BOD + 0.1 bNHP2 + 0.1* cHP*

2. *Pollution Management Fee (PMF)*: The PMF is designed to function as an incentive for factories to reduce waste at source. The fee will be applied only to factories with a significant environmental impact and will be equal to the cost of the waste treatment facility. A portion of the fee will be reimbursed if companies decide to install/upgrade waste treatment facilities or improve the production process. The rest will be kept by the DIW to compensate for damage already caused by the factories. The rate of PMF is subject to change according to the specified length of time. The purpose is to stimulate the owners to take appropriate actions to mitigate their environmental impact. Ultimately the most efficient way to improve performance is to modify the production process or change source inputs. The fee is structured to reflect changes in both. The DIW is planning to launch pilot projects with three different industries: tanning, palm oil, and tuna fish canning. The PMF will be calculated as follows:

   *PMF = IP*CR*(1-ef)*{1+(F/100)}*A*

IP	= Input or raw material used per year
CR	= Cost of waste treatment/unit of raw material per year
ef	= Efficiency of waste treatment facility
F	= Inflation rate per year
A	= Incentive factor

Programs to promote pollution prevention strategies

From 1990 to 1995, the concept of using pollution prevention strategies was intensively promoted in Thailand by the United States Agency for International Development (USAID). The awareness program targeted the following industries:

- Textile bleaching, dyeing, printing and finishing industry;
- Pulp and paper mill;
- Iron and steel industry;
- Chemical industry; and
- Food industry.

[8] COD = chemical oxygen demand.

The program successfully raised awareness about pollution prevention strategies and stimulated the first steps towards a paradigm shift away from end-of-pipe treatments in the targeted sectors. It significantly enhanced cooperation between public, private sectors, academia, trade associations, and NGOs. The program has stimulated a number of technology transfers and generally help improve regulatory compliance.

GTZ of Germany has been assisting the DIW in designing sector-specific guidelines for preventing pollution and minimizing waste at the source. The program has been in effect for four years and has completed guidelines for eight sectors.

DANCED of Denmark is currently supporting the Department of Industrial Works in building human resource capacities. The department has established a division called the "Cleaner Technology Unit" (CTU), which is the first of its kind in Thailand. The CTU has already begun a series of strategic capacity-building initiatives.[9]

The first goal of the program is to build in-house knowledge of cleaner technologies throughout the DIW and especially within the CTU to enable DIW to become a partner with Thai industry. DIW seeks to develop sufficient expertise to outline and implement policies and action plans for promoting cleaner technologies as well as provide a high level of support during project implementation. Training and education activities to enhance understanding of the CT concept and strategies and industrial development will be implemented.

Second, DIW will promote the CT concept as an integrated part of its permitting, control, and enforcement functions. Promotion of CT to industry will require networking between DIW, other government agencies, industry, academia, and private institutions to develop a new role for DIW as a cooperative partner. Such an approach will require changes in attitude inside the DIW as well as within industry. In addition, DIW must develop a promotional program in cooperation with industry, including awareness raising, information dissemination, workshops, seminars, and other components.

Third, DIW will assist industry in implementing CT. DIW must develop sufficient resources in terms of manpower and funding for R&D or demonstration projects to guide industry through CT assessments and the identification of options.

DANCED also worked with the Federation of Thai Industry and the Thailand Environment Institute to carry out CT activities with companies from three industries.[10] The project was undertaken in 1996–1997 and involved 42 factories from the textile dyeing, food processing, and electroplating industries. The activities included waste audits, environmental management system training, demonstration projects using cleaner technology equipment, information dissemination, and outreach efforts.

Since 1996, ISO 14000 has been actively promoted among all of Thailand's exporting industries. Thailand ranks first among ASEAN countries and fourth within APEC in obtaining ISO 14001 certification, with over 140 certificates already issued. To provide incentives for companies to pursue certification, the DIW is considering reducing the number of inspections to certified companies and, in some cases, allowing pure self-monitoring. In addition, DIW will also likely offer immediate renewal of permits and may reduce operating permit fees by 50 percent.

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[9] Vildrik, Soren, *Inception Report: Cleaner Technology Capacity Building in DIW*, DANCED, DIW/CTU, Carl Bro International, 1998. Also, Behrndt, Klaus, *The Outline of a CT Policy Plan for Thai Industry*, 1999.

[10] Cleaner Technology Newsletter, 1998.

In 1999, the Pollution Control Department hired the Thailand Environment Institute to develop Industrial Environmental Performance Indicators for the food canning industry, pulp industry, electronics industry, and power plants. The survey results will include pollution intensity per unit of production and resource consumption per unit of production. The electronic industry will likely measure intensity in terms of sales value due to the diverse nature of its product offerings. The final benchmarking was completed at the end of 1999. Industry has already shown a keen interest in environmental performance evaluation (EPE) methodology and has sought to incorporate EPE into its environmental management strategy.

Environmental Performance of SMEs

More than 90 percent of Thai industry can be classified as SMEs.[11] Overall, SMEs face a number of challenges in maintaining good environmental performance. A great number of SMEs can not employ a full-time environmental manager. In some cases, the owner must work to some degree in all positions, often resulting in environmental matters becoming a very low priority at best. The economic crisis in particular has worsened the situation as SMEs have become even less willing to invest in environmental improvements. In addition, many SMEs use low-tech, polluting processes and may not be able to easily upgrade to a cleaner technology.

Recognizing the challenges faced by SMEs, the Ministry of Industry has allocated approximately 36 billion baht for loans to assist SMEs under the National Industrial Restructuring Plan (NIRP).[12] The NIRP consists of promotion of strategies for preventing and minimizing pollution in SMEs and the relocation of firms to areas with better environmental management infrastructures. In addition, the Department of Industrial Works, the Federation of Industry, and the Thailand Environment Institute jointly carried out a series of demonstration projects specifically targeted at SMEs. The program has been successful in terms of improving environmental performance in SMEs. During the past two years, the program has helped 42 factories achieve a satisfactory level of environmental performance. A total of 185 cleaner technology options have been identified, and 62 have been implemented. Of the 62 options, 25 have been selected for partial financing by the government. The projects have resulted in:[13]

- Fuel savings: 80%;
- Energy savings: 60%; and
- Chemical savings: 80%.

In addition, workers at the factories were trained in establishing on-going management systems to help them continue identifying opportunities to improve performance and simultaneously save money.

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[11] SMEs are defined as manufacturers with investment capital of not more than 200 million baht and/or not more than 200 workers.

[12] Department of Industrial Promotion, Ministry of Industry.

[13] *Cleaner Technology Newsletter*, 1998.

ENVIRONMENTAL PERFORMANCE OF THE TEXTILE BLEACHING, DYEING, AND FINISHING INDUSTRIES IN THAILAND

Introduction

The textile industry was the leading export sector from 1986–1996 before slipping to number two over the last three years. In 1997, the export value of the textile industry reached 170.3 billion baht which accounted for 9.4 percent of total exports. The textile industry has significantly eased the national trade deficit during the current economic crisis. In 1996, the sector enhanced Thailand's added value by 234 billion baht and employed 1,143,930 workers or 30 percent of the total workforce of the industry.

In 1994, the number of man-made fiber, spinning, weaving, knitting, dyeing, and finishing, and apparel factories totaled 4,790 with 91.3 percent (4,371) located in Bangkok and its surrounding areas. The remaining 8.3 percent are scattered throughout the country.[14] Over 90 percent of textile factories are SMEs.

Manufacturing Process

The typical process for pretreatment, dyeing and finishing of cotton and cotton-blended fabric is as follows:

> *Material from weaving → Singe → Desize → Wash → Scour (knits enter here) → Wash → Bleach (white cotton or blend fabric exits here) → Wash → Mercerize → Wash → Predrying & Drying → Dyeing pad → Pre-drying → Fixing (steam) → Washing → Predrying & Drying → (Dyed synthetic goes to heat set to become finished fabric) → Printing → Dry → Cure → Pre-wet → Finish → Predrying → Cure & heat set → Finished fabric.*

Primary inputs

Textile wet processing involves a variety of raw materials. The primary materials are as follows:

- Yarn (cotton, polyester);
- Basic chemicals:
  - Caustic soda;
  - Salts;
  - Acids; and
  - Oxidizing agents;
- Dyestuffs;
- Soaping agents;
- Auxiliary (wetting agent);
- Finishing agents;
- Lubricants;
- Oil;
- Gas; and
- Electricity.

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[14] National Industrial Development Committee, *Industrial Restructuring Master Plan (1998-2002)*, June 1998.

Major Environmental Problems for the Sector

Major environmental problems for the industry are:

- BOD;
- Toxicity;
- Acidity/Alkalinity;
- Metals discharge; and
- Air emissions.

Sources of BOD

The first wet processing step is desizing of woven fabrics except for singeing, which does not produce a significant wastewater stream. The BOD values of size materials listed in several sources range from 20,000–650,000 mg/l. Starch size has BOD of 500,000–600,000 mg/l; alginates and modified starches, 100,000–500,000 mg/l; and synthetic sizes, 10,000–30,000 mg/l. In addition, starch is generally removed with enzymes that have BOD over 10,000 mg/l. The removal of synthetic sizes is accomplished with hot water and alkali (depending on the situation) so that the removal system does not normally contribute to BOD load. In a typical operation, desizing would contribute approximately 50 percent of the total BOD load from preparation for woven fabric but not knits.[15]

Other factors are auxiliary components of size mixtures that are commonly used in the operation. Components of commercial mixed-size formulations include:

- Size (starch, CMC, PVOH, PVAc, etc.);
- Humectant (urea, diethylene glycol, etc.);
- Lubricant (wax or oil);
- Antistat;
- Biocide;
- Glycerin; and
- Wetter.

–Scouring

The scouring process removes oil, wax, and other impurities. Scouring wastes generate a large portion of BOD load in the waste streams from preparation processes. However, this step still accounts for less than 50 percent of the total load.

Synthetic oils and waxes include winding emulsions, paraffin wax, knitting oil, coning oil, and other lubricants. These materials have significant BOD. They range from 10,000–1,660,000 mg/l. The BOD of surfactants varies widely, with natural soap being the highest. The fatty acid and its salts alone have BOD over 1 million mg/l.[16]

–Bleaching

The BOD from continuous bleaching operations contributes less than 5 percent of the total for the entire textile mill.[17]

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[15] Smith, Breant, *Identification and Reduction of Pollution Sources in Textile Wet Processing,* 1986.
[16] Ibid.
[17] Ibid.

–Dyeing

Dyeing processes vary in the amount and type of wastes produced. Continuous dyeing methods including pad batch dyeing generally use much lower quantities of chemicals and water than exhaust methods.

The source of BOD in continuous dyeing is the soap-off chemical (surfactant) and the dyeing auxiliaries used in the pad bath, which may wash off. Continuous process waste streams are easily segregated for heat recovery. The waste from continuous dyeing is mainly wash water in which the chemical content is low compared to desizing or scouring wastes or spent batch dye liquors. Therefore, batch dyeing has more potential for improvement.

The batch dyeing has problems with spent dye liquors. The BOD values of dyeing auxiliaries are 20,000–530,000 mg/l.[18]

–Finishing

Finishing is a continuous process that produces little or no wastewater except noncontact cooling and some wash water. One potential source of BOD is dumping of unused finish mixes containing resins, catalysts, weathers, softeners, builders and other materials. The BOD ranges from 20,000–1,000,000 mg/l.[19]

Toxicity

The toxic materials generated or used in the textile process include:

- Metals;
- Non-biodegradable surfactants; and
- Toxic organic materials.

–Metal

According to the America Dyestuff Manufacturers Institute, metals can be present in varying amounts in different dyes. Common metals include arsenic, chrome, copper, cadmium, cobalt, lead, mercury, and zinc. Thai manufacturers have predominately shifted to dyes containing no heavy metals.

–Surfactants

Surfactants are used in wet processing and frequently contribute to aquatic toxicity problems. The EPA development document for textile effluent guidelines states that manufacturers should seek to use biodegradable detergents. However, this advice has been frequently ignored in practice because mills rarely have degradability data for surfactants.

Acidity/Alkalinity

Textile mills have several sources of acids and alkalis. Normally the effluent gives an overall pH around 10–11.[20]

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[18] Ibid.
[19] Ibid.
[20] Ibid.

Desizing only contributes marginally to alkalinity/acidity of waste streams. The contribution of these continuous desizing processes can be a significant portion of total alkalinity.

Scouring and bleaching of synthetics use small quantities of alkali, but scouring of cotton requires large amounts. For continuous process, it is possible to neutralize or reuse waste streams.

The dyeing process varies in acidity/alkalinity depending on the substrate and dye class.

Air emissions

There are several places in textile operations where air emissions are generated:

- Hot air dryers;
- Dyeing machines;
- Storage tanks;
- Warehouse areas; and
- Fugitive emissions.

The finishing process generates air emissions from high temperature drying and curing ovens. Emissions typically contain volatile compounds of finishing mix or volatile residues remaining in fabrics from prior processing. Proper preparation of dyeing and finishing agents can reduce the waste. The emphasis has been on air emission abatement equipment rather than source reduction. Abatement equipment operation can be combined with heat recovery from air exhaust to provide a return on investment.

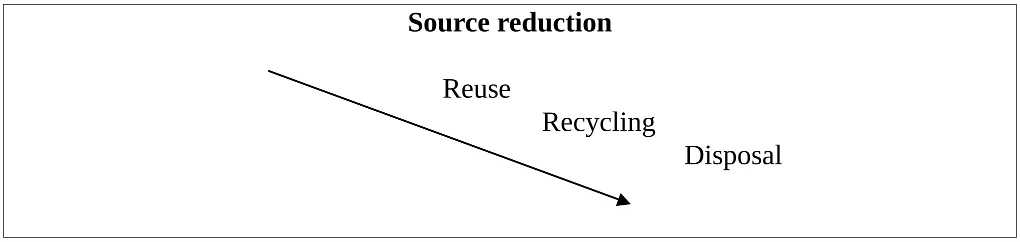
Acetic acid is sometimes emitted from bulk storage tanks, dyeing machines, or dryers.

Formaldehyde may be emitted from resin storage tanks, finished fabric warehouses, dryers, and curing ovens.

GP at the Sector Level

The textile dyeing industry utilizes a large quantity of water, chemicals, and energy. Based on government data, it is considered to be one of the most polluting industries in terms of organic and inorganic load. GP will play a vital role in enhancing productivity and environmental performance, which will help the sector to survive in a fiercely competitive market showing signs of decline.

The waste management hierarchy emphasizes prevention of pollution at the source as the best option. Source reduction programs should be examined carefully based on their impact on costs compared with their potential to reduce waste. Where source reduction of wastes is not practical, opportunities for reuse should be explored. Uniformity of materials is necessary to make reuse successful. Counter current washwater flow is a good example of reuse. Recycling material is the third-most efficient waste management option. Recycling is different from reuse in that energy normally is required to convert the waste into a usable form. For wastes that cannot be reduced, reused, or recycled, treatment and disposal in an environmentally sound manner should be undertaken. In general, however, reducing the generation of wastes is the most efficient method for tackling pollution control.



Checklist for suitability of waste management options[21]

Technical
- Is appropriate technology available and usable with modification?
- What major equipment modifications are needed?
- Are major waste modifications or pretreatment needed?

Environmental
- How will waste be reduced in volume or hazard?
- Will secondary releases, now or in the future, result in new air, water, or solid waste pollution problems?
- Could the technology result in new worker safety problems?

Regulatory
- Will the technology result in wastes of less regulatory concern?
- Can permits realistically be obtained in a reasonable timeframe for the technology?
- Will additional regulations be imposed that could result in additional air, water and solid waste controls?

Public acceptance
- Will the use of technology to reduce the waste at the proposed location be acceptable to the citizens (or political groups) affected by the operation?

Economic
- What is the cost compared with other technologies?

GP audits can identify inefficient resource use, thereby presenting a concise list of options to consider. Successful GP implementation can include:

- Process modification;
- Use of alternative methods;
- Chemical and water conservation; and
- Chemical screening and substitution.

[21] US EPA, *Manual Best Management Practices for Pollution Prevention in the Textile Industry*, 1996, p. 79.

Process modification

Continuous preparation in the scouring and bleaching process has a greater potential for waste stream reuse since the waste is continuous, constant in terms of characteristics, and easy to segregate from other waste streams.

Examples of waste stream reuse in a bleach unit include:

- Recycle J-box or kier drain wastes to saturator;
- Use of countercurrent washing; and
- Use of washer waste from scour operation for batch scouring.

The cold pad batch sets a good example for GP. The benefits include primarily eliminating the need for salt or specialty chemicals in the dyebath, thus reducing costs and pollution generation. The fabric is impregnated with liquor containing premixed fiber reactive dyestuff and alkali. Excess liquor is squeezed out on the mangle. The fabric is batched onto rolls or in boxes, and covered with plastic film to prevent absorption of CO_2 from the air. The fabrics are then stored for two to twelve hours. The product is then washed off. The method is simple, flexible, and speedy and can be applied to both woven and knit fabrics. Frequent changes of shade are not the problem because reactives remain water soluble, making cleanup easy. *Cotton Incorporated* undertook a study that demonstrated pad batch dyeing for cotton, rayon, and blends conserves energy, water, dyes, chemicals, labor, and floor space. Water consumption for pad batch dyeing with beam wash-off is typically under two gallons/pound of dyed fabric, compared to 20 or more on atmospheric becks for the same fiber-reactive dyed shades. Energy consumption is 2,000 BTU/pound for pad batch compared to 9,000 BTU/pound for becks. Chemical use and associated BOD and COD loadings for waste streams can be reduced up to 80 percent compared to becks. Labor costs are also reduced. Two workers per shift can dye 200,000 pounds of fabric per five-day week. The quality of pad batch dyeing is much better than other dyeing systems. The US EPA manual *Best Practices for Pollution Prevention in the Textile Industry* states that pad-batch dyeing offers many advantages over conventional dyeing processes including:[22]

- No salt or chemical specialty agents are needed, which reduces waste as well as chemical and wastewater treatment costs;
- More efficient use of dye leaves less color in the wastewater and reduces water and energy consumption (fixation of 92–97 percent);
- Dye quality is more consistent in terms of even color absorbency, colorfastness, and lower defect levels;
- Pad-batch dyeing can be used on wovens or knits in many constructions;
- The simplicity and flexibility of the system allow for use of available equipment-becks, beams, and continuous equipment for washing; and
- Pad-batch dyeing requires a low capital investment and offers overall cost savings in dyes, chemicals, labor, water, and other areas.

[22] EPA/625/R-96/004, *Best Management Practices for Pollution Prevention in the Textile Industry*, 1996, p. 165.

Water conservation

Water conservation often offers the most opportunities for cost savings and improving pollution management. Often mills leave hoses open, fail to turn off cooling water when the machinery is not in operation, or are slow to fix broken or missing valves. Current practice to conserve water is to recover or segregate wastewater streams. Once-through noncontact cooling water can be recycled back to a clear well or water supply to the mill for significant water savings.

In addition, there are now several "low liquor ratio" dyeing machines available. The liquor ratio is the amount of water (in mass) in the exhaust dyebath compared to the amount of fabric (in mass). Ratios range widely between machine types. In addition to conserving water, low liquor ratio dyeing machines also lead to significant energy savings as the heating of dyebaths typically accounts for the major portion of the energy consumed in dyeing.

Chemical screening and inventory control

Raw material quality control is essential in waste management. Undesirable wastes can result from raw material components and their impurities (e.g., metal contents of certain dyestuffs). Manufacturers must screen the chemicals used and evaluate them according to a wide range of health and environmental impact criteria, including:

- Hazardous waste characteristics;
- Availability of safer alternatives;
- Biodegradability;
- Heavy metal content;
- Potential for accumulation in the facility;
- Potential for release to the environment;
- Hazard potential when mixed with other chemicals;
- Proposed manner of use;
- Final disposal of the chemical; and
- Hazard potential to the final customer, particularly infants.

Current trends are towards the banning of fabrics manufactured with processes using hazardous chemicals. In Germany and most of the EU countries, imported apparel or fabric must comply with the Oeko-Tex standard. In Thailand, benzidine-based and chrome dyestuffs are prohibited in dyeing mills and dyestuff manufacturers.

Reuse, recycle and recover

In textile mills, recovery systems are often used to extract components of waste streams. Typical examples are heat recovery, caustic recovery, and size recovery. Continuous processes such as mercerization and continuous washing are easily adapted to incorporate recovery techniques. Many mills already apply wastewater heat recovery systems using heat exchangers and hot water storage.

Size accounts for the largest portion of chemicals used. Normally size is removed from the fabric. Therefore, size recovery offers the greatest potential for chemical recovery. Another area for recovery is through mercerization, which assists in caustic soda recovery. The process involves treating cotton fabrics with concentrated sodium hydroxide of 15 percent or more and can reclaim up to 98 percent of the caustic soda used.[23]

Counter current washing is often practiced by introducing raw water into the last wash of the washing series. The wastewater is then circulated from the last step to the next preceding step and so on up the line. The cleanest fabric is washed with the cleanest water and the most contaminated fabric is washed with the dirtiest water. The system leads to huge savings in water use (see Table 5).

Table 5. Water Savings from Countercurrent Washing

Number of washing steps	Water savings *(%)*
2	50
3	67
4	75
5	80

Source: US EPA, *Best Management Practices for Pollution Prevention in the Textile Industry*, 1996.

Benchmarking

There are several sources of information indicating water usage and pollution intensity per unit production. Professor Brent Smith of the Department of Textile Chemistry, School of Textiles, North Carolina State University has undertaken a number of research projects on the subject. In addition, the US EPA has sponsored several studies to benchmark performance in the textile industry. The data includes studies from 1979 and 1986, but the benchmarks are still relevant for studying Thailand's textile industry. Key benchmarks are outlined in Tables 6–10.

Table 6. Water Consumption per Unit Product

Subcategory	Water usage *(l/kg)*
Woven fabric finishing	78.4–113.4
Knit fabric finishing	69.2–135.9
Carpet finishing	46.7
Stock and yarn finishing	100.1
Nonwoven manufacturing	40.0

Source: US EPA, *Document EPA 440/1-79/0226*, October 1979.

Table 7. Raw Waste per Unit Product

Subcategory	BOD	COD	TSS
Woven fabric finishing	22.6–45.1	92.4–122.6	8.0–14.8
Knit fabric finishing	22.1–27.7	81.1–115.4	6.3–6.9
Carpet finishing	25.6	82.3	4.7
Stock and yarn	20.7	62.7	4.6
Nonwoven manufacturing	6.7	38.4	2.2

Source: US EPA, *Document EPA 440/1-79/0226*, October 1979.
Unit: kg of waste/kg of product.

[23] Hunt, Robert G. and Metzler, Suzanne Chestnut, *Final Report: Industrial Resource Recovery Practices: Textile Mill Products Industries*, US EPA, 1982.

Table 8. BOD Contributions from Textile Processes

Process	Pound BOD/100 pound fabric
Singe (woven only)	0
Desize (woven only) Enzyme/starch Starch/CMC mix PVOH or CMC only	 67 20 ~0
Scouring	40–50
Bleaching Peroxide Hypochlorite	 3–4 8
Mercerizing (no caustic recovery) (with caustic recovery)	 15 6
Heat setting (synthetic only)	~0

Source: Brent Smith, *Identification and Reduction of Pollution Sources in Textile Wet Processing*, 1986.

Table 9. Dyeing Machine Water Consumption per Unit Product

Dyeing machine	**Water consumption** *(gal/pound fabric)*
Continuous	20
Beck	28
Jet	24
Jig	12
Beam	20
Package	22
Paddle	35
Stock	20
Skein	30

Source: Brent Smith, *Identification and Reduction of Pollution Sources in Textile Wet Processing*, 1986.

Table 10. Breakdown of Water and BOD Generation by Process *(% of total waste)*

Process	**Water** *(%)*	**BOD** *(%)*
Desizing	5	22
Scouring	1	54
Bleaching	46	5
Mercerizing	2	0
Dyeing	8	5
Printing	7	6
Washing off	30	1
Finishing	1	7

Source: J.R. Provost, *Effluent improvement by source reduction of chemical and in textile printing,* 1992.

There is limited benchmarking data available that is specific to Thailand's textile industry. Tables 11–14 show the results of surveys on water and energy consumption undertaken by the Asian Institute of Technology from 1996–1998. The study on energy consumption surveyed 32 factories and the study on environmental data surveyed 22 factories.

Table 11. Specific Fuel Consumption in Thai Textile Industry

Type of mill	Range of consumption
Spinning	0.26–3.22
Printing	0.14–0.73
Weaving	2.2–2.5
Dyeing and finishing	14.32–63.9

Source: Asian Institute of Technology, *Energy and Environmental Indicators in the Thai Textile Industry,* 1999.
Unit: GJ/ton of product.

Table 12. Specific Electricity Consumption in Thai Textile Industry

Type of mill	Range of consumption
Weaving	5.7-5.8
Dyeing and finishing	0.28-12.6

Source: Asian Institute of Technology, *Energy and Environmental Indicators in the Thai Textile Industry,* 1999.
Unit: MWh/ton of product.

Table 13. Water Consumption in Thai Textile Industry

Type of mill	Range of consumption
Man-made fiber production	4.4-30.7
Weaving mills	10.3
Printing mills	11.9-62.5

Source: Asian Institute of Technology, *Energy and Environmental Indicators in the Thai Textile Industry*, 1999.
Unit: m^3/ton of product.

Table 14. Wastewater Generation in Thai Textile Industry

Type of mill	Range of consumption
Man-made fiber production	2.7-27.4
Weaving mills	8.48
Dyeing and finishing	
Yarn only	114.8-166.4
Fabric only	115.7-140
Yarn & fabric	67–166.7
Integrated textile mills	107.7-183.3
Printing	10.7-62.5

Source: Asian Institute of Technology, *Energy and Environmental Indicators in the Thai Textile Industry,* 1999.
Unit: m^3/ton of product.

As already discussed, the Thai textile dyeing industry has already begun undertaking a number of steps to reduce pollution at the source. Table 15 presents a brief overview of standard practices in the textile dyeing industry and their frequency of application in Thailand.

Table 15. Pollution Prevention Practices in Thai Textile Industry

Practice	High	Moderate	Low	No
Built-in bath reuse on dye machine	×			
Caustic and size recovery		×		
Chemical dosing system			×	
Continuous knit dyeing range		×		
Control, automation, and scheduling management system		×		
Countercurrent washing	×			
Heat recovery systems	×			
Humidity sensors and advanced controls for drying	×			
Incinerator dryers				×
Low bath-ratio dyeing systems	×			
Mechanical finishing		×		
Pad-batch dyeing machines for fiber-reactive dyes	×			
Quick-change pads on continuous ranges		×		
Low add-on finishing	×			
Water recovery systems	×			
Vacuum system for chemical recovery		×		
Computerized color matching system	×			
End-of-pipe treatment	×			
Environmental management system		×		

Source: Interviews with The Association of Thai Textile Bleaching, Dyeing, Printing, and Finishing.

CASE STUDY

Company Profile

Thana Paisal R.O.P. was established in 1961 and is located on Sukhumvit Road, Samutprakan Province, about 40 kilometers east of Bangkok. The success of Thana Paisal made it a champion in strategies to prevent pollution in the bleaching and dyeing of yarn, woven fabric and canvas for shoes and upholstery. Current production ranges from 4.5 to 8.9 tons per day or 400,000-800,000 square yards per month. The company employs a workforce of 150 people.

Motivation to Improve Environmental Performance

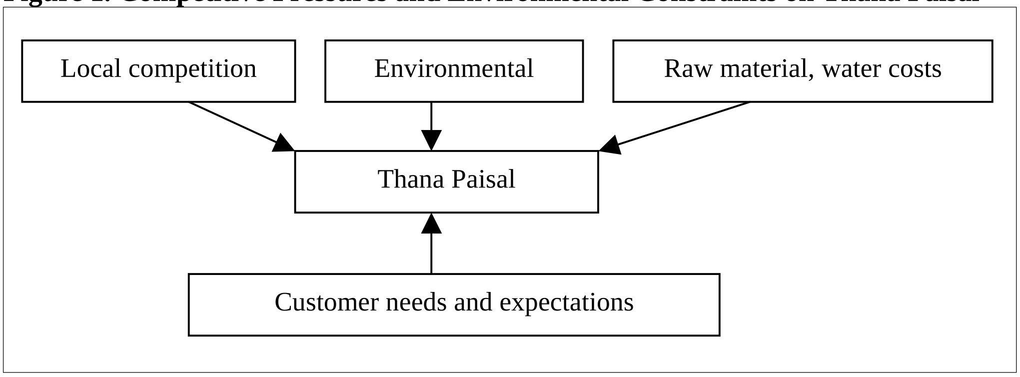
In the early 1990s, Thana Paisal faced problems in maintaining product quality and proper treatment of wastewater. Customer requirements were becoming increasingly stringent. Requirements included: no shade variation on the finished fabric, evenness of color, fastness to washing and light, ever-shortening lead time (from 30 days down to 4 days), improved service at a lower price, and reduction of the suppliers' environmental impact. In addition, new regulations for textile dyeing mills were announced in 1991, leaving most factories no choice but to upgrade their wastewater treatment capabilities. Regulations included measures such as:

- Mandatory installation of wastewater color removal unit;
- Inclusion of observation pond with live fish in wastewater treatment system;
- Effluent BOD 5 days, $20^{o}C$ not exceeding 1 kg/day;
- Location of the mill far from the water intake for water supply; and
- Use of non-toxic dyestuffs (non-azo dyes).

Many factories were unable to comply with the new regulations. The situation coincided with a boom in the textile industry which saw the expansion of a number of existing mills as well as the establishment of a number of new mills. Faced with the need to improve industry performance, The Textile Club under the Federation of Thai Industries sought technical assistance in pollution prevention implementation from the United States Agency for International Development (US AID) and the United States Environmental Protection Agency (US EPA). The Textile Bleaching, Dyeing, Printing and Finishing Association was then formed to help its members improve their environmental performance.

Mr. Pilan Dhammamongkol, the General Manager and owner of Thana Paisal, felt uncomfortable with the amount of pollution generated by the mill. The textile dyeing industry had already developed an image among the general public as a major polluting industry and had seen a series of increasingly stringent rules and regulations passed by regulatory agencies to control the sector. Mr. Pilan was determined to comply with environmental regulations, but also to remain competitive in terms of quality, delivery, and cost. He felt that the only way to remain in business for the long-term was to meet environmental regulations while still meeting customers' needs (see Figure 1).

Figure 1. Competitive Pressures and Environmental Constraints on Thana Paisal



Initial Approach: End-of-Pipe Improvements

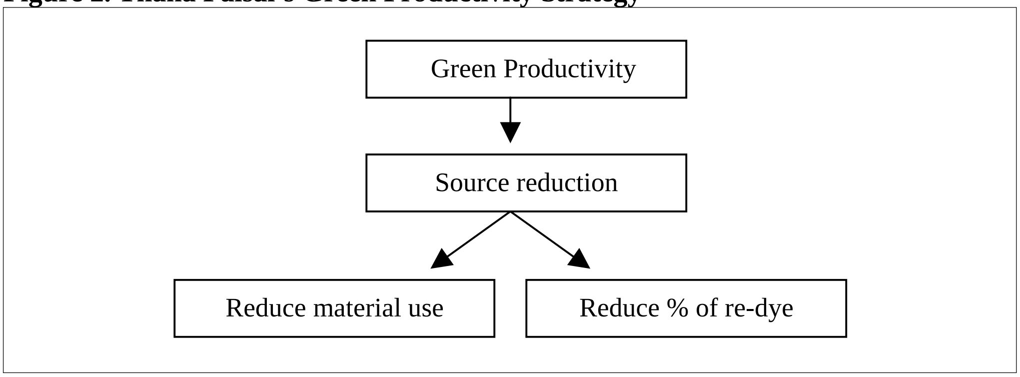
At the start of the process, Thana Paisal viewed pollution control as a cost and burden, but was forced to take action to upgrade its systems due to the new regulations. The company's first attempts to improve pollution control focused on enhancing end-of-pipe controls and relied primarily on trial and error of technologies. Mr. Pilan began to aggressively gather information on technologies and techniques in wastewater treatment through conferences, seminars, and workshops. The company expended large sums on upgrading and modifying its facility, but was still not able to meet the regulatory requirements.

In 1993, Thana Paisal learned a key lesson about the importance of environmental management systems and pollution prevention techniques in controlling pollution. In 1993, the Federation of Thai Industries began to develop programs to help its members improve their performance by joining demonstration projects on cleaner production (CP). USAID brought technical experts on CP to Thailand to audit a number of dyeing mills including Thana Paisal. Through the audit, the company was introduced to new concepts and approaches in prevention as an alternative to conventional end-of-pipe treatment techniques. Subsequent trips to Brazil, the USA, and Switzerland introduced Thana Paisal to the Textile Institute, US EPA, CP practices used in overseas dyeing mills, low liquor ratio dyeing machine manufacturers, and non-toxic chemical and dyestuff manufacturers. The company began to realize that dyeing mills in the developed countries were able to cope with stringent standards by simply integrating pollution prevention practices into their daily operations. The basic starting points were good housekeeping, proper raw materials selection, modification of the production process, and maintaining an environmental management system. In contrast, dyeing mills in Thailand were still only concentrating on improving the wastewater treatment process.

Shift to Prevention

The company's target and main approach are shown in Figure 2:

Figure 2. Thana Paisal's Green Productivity Strategy



Based on this new paradigm, Thana Paisal began to integrate waste prevention programs into plant operations. The main problem for most mills is that the quantity of re-dye creates additional and unnecessary wastewater, increases production costs, and delays delivery. Therefore, the company chose to focus its efforts on reducing the percentage of re-dye as well as decreasing the overall amount of materials used.

The first step was to eliminate use of toxic chemicals and dyestuffs such as benzidine-based dyes, chrome dyes, and formaldehyde. Next, the company began to evaluate strategies to increase efficiency of raw material and energy use and minimize other wastes. As a first attempt to address efficiency issues, the company purchased a machine called “Evac.” The machine proved to be highly efficient in recovering leftover chemicals for reuse in the process as well as extracting excessive moisture. However, after a trial period of over a year, the company did not have any idea of the amount of savings brought by the installation of the Evac. The company then began to develop its internal data-gathering and analysis capabilities. As the company began to gather increasingly detailed data on raw materials usage and production in systematic manner, additional inefficiences and potential improvements became apparent. The development of the data gathering system helped the company to identify opportunities to reduce costs by applying preventive strategies with little or no investment.[24]

One example was the company’s success in reducing its re-dye ratio. Historically, the company used to be obliged to re-dye up to 17.8 percent of its products. Re-dye led to significant amounts of wastage in terms of water, chemicals, dyestuffs, energy, time, manpower, and eventually wastewater treatment. Estimated losses due to re-dyeing totaled approximately 5 million baht per year. The company undertook research to identify the causes of re-dye and experimented with different possible solutions to the problem. Over the course of one and a half years, the company lowered re-dye to 7.45 percent and has since reduced re-dye to 2 percent.

Building the Team and Human Resources

With initial efforts resulting in success, the company decided to expand the effort by formally establishing a “Cleaner Production Safety Team (CPS).”[25] The CPS was responsible for developing policies to reduce the percentage of losses at each step in the production process, including reducing resource usage, accidents, and risk to workers. The team held monthly meetings to report on their progress and set their goal as continual improvement.

Implementation Steps:

- Set up team;
- Implement good house-keeping campaign;
- Collect data to identify source and quantity of waste at each stage;
- Monitor regularly;
- Closely coordinate program;
- Emphasize preventive measures and timely correction of problems; and
- Supervise the factory as a team, instead of leaving it to an individual.

During the program implementation, the company created additional programs such as “Safety Help Environment (SHE),” which was separate from the CPS. The team was reformulated after an initial period and team members were enrolled in training courses. Eventually, the company was able to substantially reduce the risk of accidents.

[24] The company referred to this as the “low or no cost principle.”

[25] The methodology used by the team was very similar to the current opportunity assessment techniques used in association with GP.

After the success of SHE, the company continued expanding its programs with the formation the “Training Five S (TFS).” Over time, the company found that the five S was fundamental to strategies to prevent pollution.

The workers as a whole were very important to the process and in particular to the success achieved in reducing re-dye from 17.8 percent to 2 percent. The team worked together to constantly suggest and discuss ways to systematically reduce the amount of loss at each step of the process. The result is that not only has there been a net boost in production efficiency, but there has also been a significant change in the workers’ attitude. The company found that workers were receptive to the new paradigm and eager to search for new ideas and solutions. Overall, the program helped to significantly boost worker morale.

The success in engaging the workers was achieved by helping them understand and accept the new paradigm through the following strategies:

1. Promotional campaign to change workers’ attitude towards waste;
2. Orientation for all workers on CP;
3. Training in CP techniques and skills; and
4. Strengthening internal communications as well as public relations.

The company’s strategy to promote preventive strategies was different from that in other companies. Thana Paisal did not emphasize techniques and skills at the beginning, but rather focused on cultivating a positive attitude towards prevention of pollution within the company. The initial efforts at building understanding made it easier for the workers to accept GP and begin applying it to their operational responsibilities. Thana Praisal found that maintaining progress required continuously promoting the exchange of ideas and emphasizing the importance of strategies to prevent pollution. The company organized frequent meetings to demonstrate successes in implementation and to praise the workers. The company made sure never to blame the workers for mistakes, but instead focused on taking corrective action and developing preventative measures. The management realized that if the workers were blamed, they would not reveal the real cause of the mistake. The workers were encouraged to suggest new ideas and measures and were proud when their new ideas were implemented.

The Key to Success

The company’s success was due to two factors. The first was the technical improvements that have been illustrated in this chapter. The second crucial factor was management improvement and its success in coordinating all the staff to work towards a common set of goals. Following the successes of the CPS team, the management eventually established an EMS team to replace CPS and oversee systematic implementation of CP/GP. The company’s management approach was based on the following concept:

1. P = Plan;
2. O = Organize;
3. D = Direct; and
4. C = Control.

The management established an environmental policy to provide a long-term vision to the company as follows:

- Excellence in environmental management;
- Compliance with all Thai environmental regulations;
- Maximum efficiency of resource usage including: energy, water, and other raw materials;
- Minimum generation of waste materials;
- Providing a safe working environment; and
- World-class best practice for textile bleaching, dyeing and finishing.

To drive policy implementation, Thana Paisal developed an EMS that explicitly incorporated the following principles:

1. Minimize waste at the source to save water, energy, dyestuffs and chemicals;
2. Wherever possible, reuse waste within the process or for another beneficial use;
3. Reduce the potential of risk and accidents and look for safer ways to conduct our operations;
4. Learn and understand the environmental and safety regulations which are applicable to the company. Ensure that factory procedures are in accordance with regulations and statutory requirements and ensure that staff and workers are properly trained to achieve these goals;
5. Explore the relationship between trade and environment;
6. Encourage all staff and workers to share responsibility for environment and safety; and
7. Ensure good public communication with neighbors, other factories and the general public.

The company established an EMS team to take the lead in implementation of the system. The team leader was Mr. Pilan, the General Manager and owner. The rest of team consisted of:

- Assistant team leader;
- Data manager;
- Production manager;
- Quality control manager;
- Wastewater treatment manager; and
- Maintenance manager.

The company set up operation control in the following manner:

1. Team leader holds monthly meetings in a relaxed and friendly atmosphere;
2. Production section reports on the CP plan, recent actions, and results;
3. Q.C. section reports on the percentage of re-dyeing and identifies solutions to re-dyeing problems;
4. Maintenance section reports on preventive maintenance programs for machinery and other equipment and program results;

5. Wastewater treatment section reports on wastewater operation and laboratory results; and
6. Data section evaluates all statistics and results.

The company modified its production process as illustrated in Figure 3.

Results of the Program

After successful implementation, the company created the "Quick Response Program" to help drive the company towards continual improvement.[26] The program aimed for prompt delivery to customers and improving inventory control (i.e., minimum stock.) The QRP required cooperating closely with customers to exchange information and production plans, and transfer management techniques.

The next major task for the company will be to tackle energy conservation. The first target will be a 30 percent reduction in use, which will require machine modification and heavy investment. The company will likely develop a phased work plan combining implementation with ongoing evaluation.

The intangible benefits of the prevention strategies were improved management practices. The program motivated the employees to become more confident and cultivated a highly positive attitude towards their work. The improved worker attitude and morale also helped the company perform during the economic crisis. Last but not least, the program also helped enhance other improvement programs that were implemented concurrently (i.e., EMS, SHE, and five S).

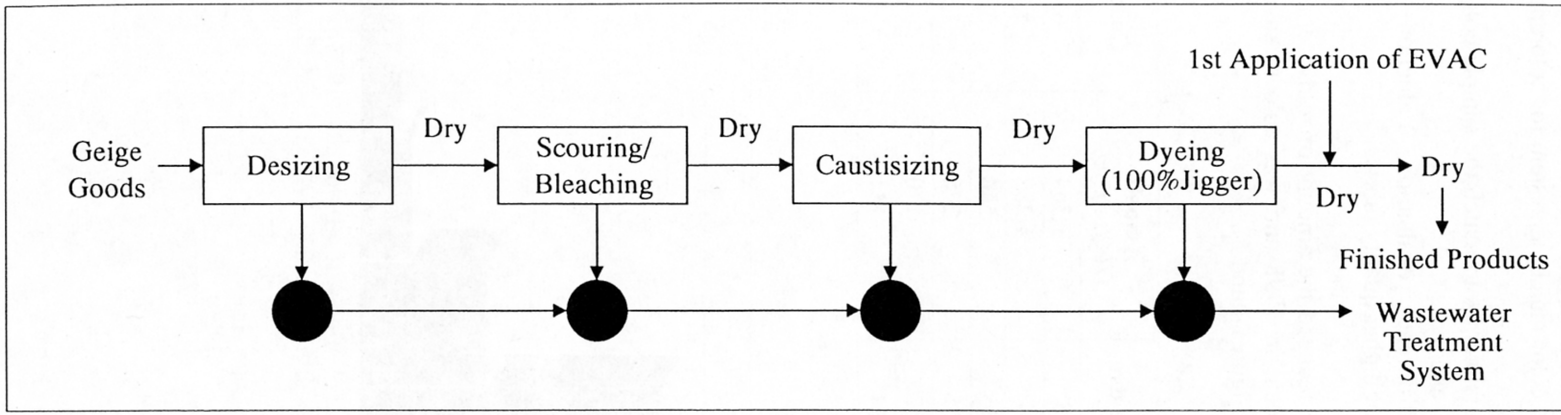
Specific results included:

1. Improvement in the production process from 100 percent jiggers for bleaching and dyeing to cold pad batch (CPB) 60 percent, pad-jigger 20 percent, and open jigger 20 percent. The need for salt in chemical specialties from the dyestuff decreased, thus reducing BOD load from 500 mg/l to 300 mg/l. Total water consumption also decreased from 100 l/kg of fabric in 1992 to 73 l/kg of fabric in 1999;
2. Introduction of new technology including:
   - Installation of vacuum system (evac) in the desizing, scouring and bleaching operations;
   - Reduction of wet pick up to 50 percent;
   - Prevention of contaminants from entering the washwater leading to 6 percent decrease in energy use and 50 percent reduction in water consumption; and
   - Enabling of wet-on-wet process leading to 6% decrease in energy consumption in drying process.
3. Reduction of water consumption by 50% in continuous process by introducing counter current washing (see Table 17); and

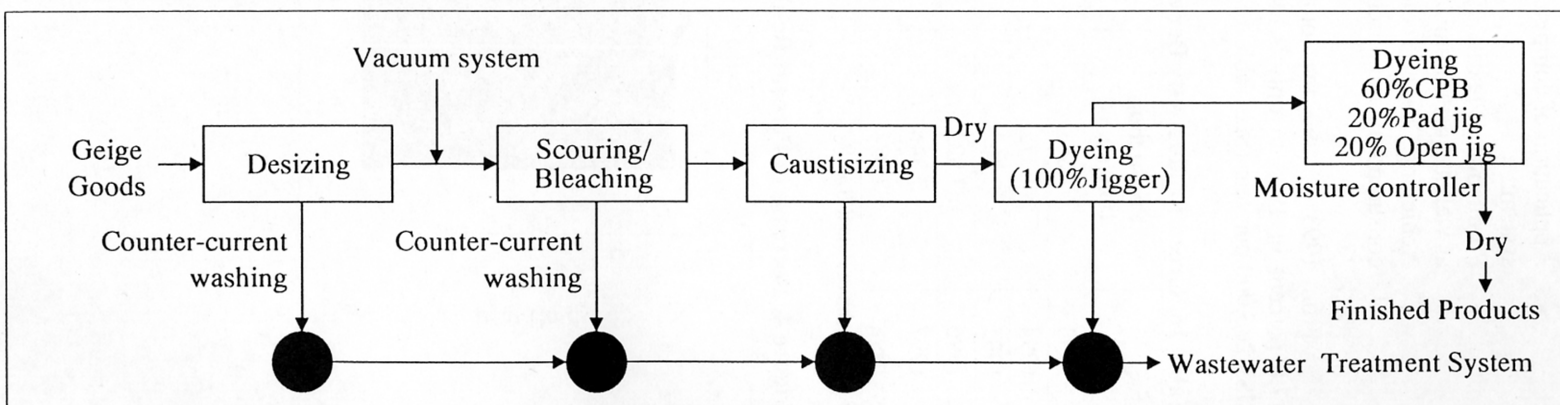
[26] Most Thai dyeing mills seek to prolong delivery time as for up to 30–45 days due to the need to re-dye. However, due to success of the CP program, Thana Praisal was able to shorten delivery time to 4–10 days giving them an advantage over their competition.

Figure 3. Comparison of Original and Redesigned Production Process

Original Production Process



New Production Process



4. Optimization of chemicals and dyestuffs by:
   - Application of computerized color matching system for colorant formulation system;
   - Production of textile dyestuffs recipes to match the sample colored material as well as cost minimization; and
   - Achieving better color difference evaluation, reduction in dyestuff consumption, and purchase of higher quality fabrics.

From 1993 to 1999, the company reduced the amount of re-dye drastically from 17.8 percent in 1993 to only 2.14 percent in 1998 and was able to save more than US$ 206,000 per year (See Table 16 and Figures 4 and 5).

Table 16. Green Productivity Benefits

Year	Production 1000 sq. yd	% Re-dye	Amount *(1000 sq. yd)*	Cost *(baht/yr)*
1993	7,663	17.8	1,364	6,138,392
1994	7,372	17.4	1,282	5,772,962
1995	7,302	7.45	544	2,448,030
1996	7,923	3.15	278	1,251,432
1997	7,345	2.32	170	766,870
1998	7,028	2.14	151	691,326

Source: Thana Paisal R.O.P.

Figure 4. Decrease in Percent Re-dyed

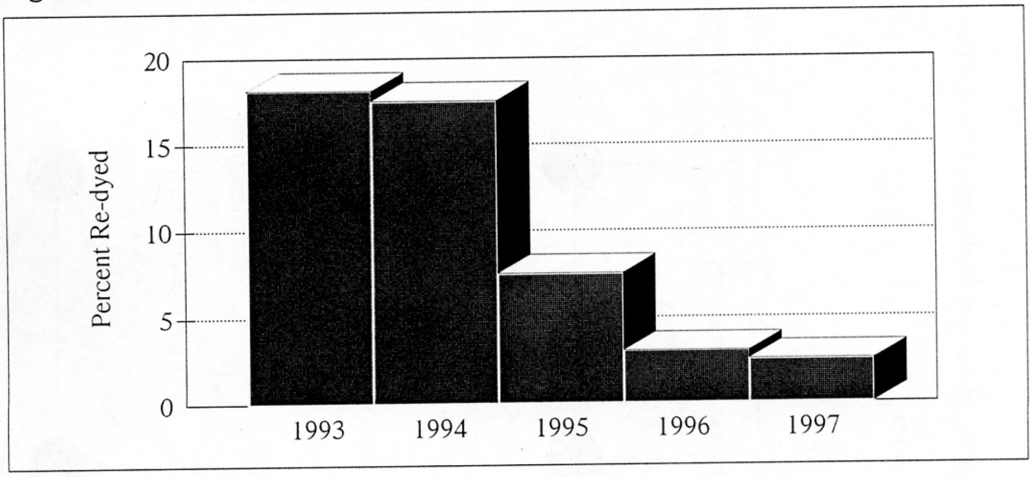


Figure 5. Cost of Re-dyeing

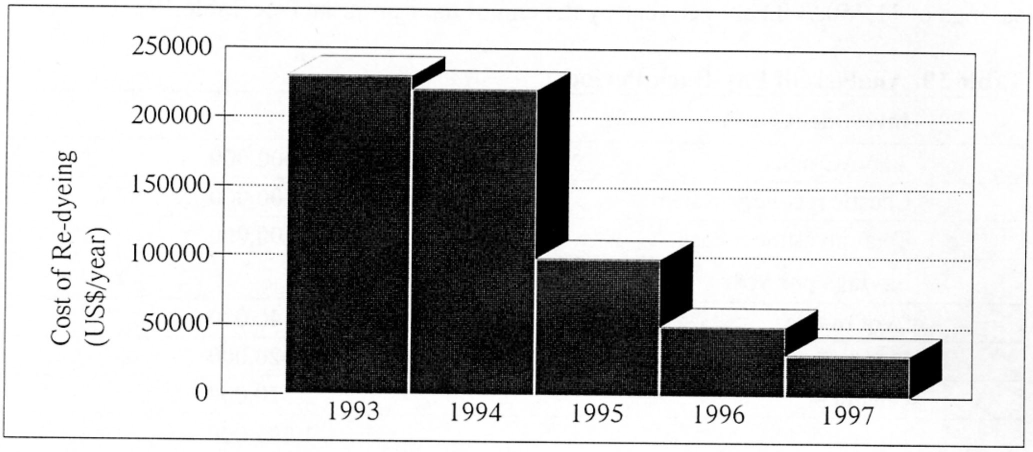


Table 17. Comparison of Water Consumption[27]

Process	Exhaustion *(jigger)*	Counter current system	Counter current system plus
EVAC desizing	24	12	6
Scour/bleach	48	12*	6*

Source: Thana Paisal R.O.P.
Unit: liters of water/kg fabric.
Note: *Cold Pad Batch (CPB) bleaching.
Dyeing: Jigger Liquor ratio = 1:5; CPB Liquor ratio = 1:1

Thana Paisal has been investigating company performance data of on chemical, dyestuffs, water and oil fuel consumption per unit production over the last two years. Table 18 shows the performance comparison between 1997 and 1998.

Table 18. Performance from 1997–1999

	1997	1998	1999[a]
Chemical (g/kg fabric)	755	519	446
Dyestuffs (g/kg fabric)	26	19.1	12.4[b]
Water (l/kg fabric)	88	84	na
Oil fuel (l/kg fabric)	1.085	0.948	na
Electricity (kWh/kg fabric)	0.418	0.426	na

Source: Thana Paisal R.O.P.
Notes: a - Six month average.
b - Changing to new and more effective dyestuff of CIBA.

[27] Table 17 demonstrates the two-stage modification of the production process. The first stage was from exhaustion (jigger) to the counter current system. The second stage added an EVAC to the counter current system. In total, the modifications resulted in reducing water usage by 50 percent compared to

In total, Thana Paisal invested approximately 5,600,000 baht and accrued a total savings of 11,750,700 baht per year by the end of their program (see Table 19).

Table 19. Analysis of Pay-Back Period

Investment costs	
2 EVAC units	3,000,000
Caustic recovery system	2,600,000
Total investment cost	5,600,000
Savings per year	
% of re-dye	5,440,000
Dyestuff	2,420,000
Chemical	2,320,000
Energy	1,397,000
Water	63,700
Wastewater treatment	110,000
Total savings	**11,750,700**

Source: Thana Paisal R.O.P.
Unit: Baht.

Sharing Experiences with the Public

Thana Paisal's success earned it recognition as a "Model Company" which led to collaboration with international agencies on several projects including:

- USAID 1992–1993 Cleaner technology
- CDG 1993–1994 Pollution prevention and control
- Green Aid Plan 1995–1997 Wastewater treatment technology
- DANCED 1996–1998 Implementation of cleaner technology
- AUSAID 1997–1998 EMS implementation

RECOMMENDATIONS

The government must take an active role in promoting GP. National policies on environmental protection should be revised to fall in line with the philosophy and concept of GP. The current environmental regulatory framework including the Factory Act still emphasize the end-of-pipe approach. Laws should be amended to become more stringent, with heavier penalties complemented by serious and effective enforcement. Gradually, higher standards will pressure industry to shift from an end-of-pipe control paradigm to that of GP in order to be able to comply with the standards.

Pricing policies are another set of useful incentives to catalyze industry's adoption of GP practices. The government must reduce subsidies on water and energy prices to encourage more efficient use. Tax incentives for cleaner technology must be developed in

conventional washing.

the short term. Financial institutions should give priority to companies that adopt GP practices by offering preferential interest rates on loans.

Beyond government, other organizations have a significant role to play. Academia must integrate GP into the curriculum. Public interest groups and environmental organizations have an important role to play in education, training and R&D, and in shaping the future environmental attitudes necessary for a sustainable socio-economy. Awareness campaigns and GP programs must be aggressively promoted. The existing GP information network must be expanded as much as possible to facilitate the exchange of ideas and practices. Environmental stewardship awards can be offered to encourage industry to be "good citizen." Last but not least, ISO 14000 should be used as a tool to enable industry to become more competitive in the international market while simultaneously enhancing environmental conservation.

End-of-pipe Wastewater Treatment

The design and performance of the company's original wastewater treatment system were as follows:[28]

- Treatment system type: Aerated lagoon.
- Surface area: 6,000 square meters.
- Wastewater quality: Influent BOD 5 days, 20^{o}C = 576 mg/l and effluent BOD 5 days, 20^{o}C = 94 mg/l (Standard 20–60 mg/l); effluent did not meet regulatory standards.
- Efficiency 83.7 percent.

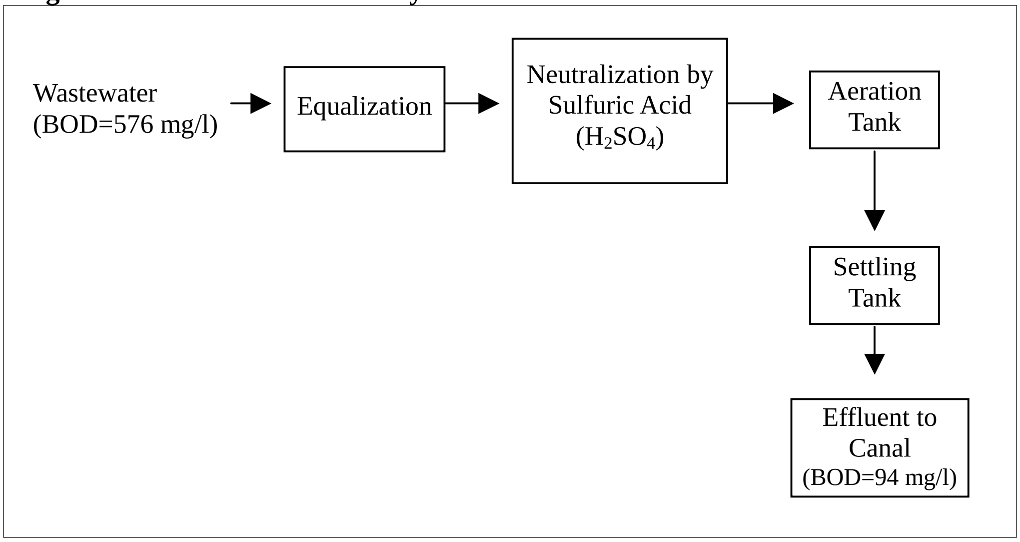
The company then decided to install a new wastewater treatment system which has proved to be very efficient. The design and performance were as follows:

- Treatment system type: Activated sludge.
- Surface area: 2,600 square meters.
- Wastewater quality: Influent BOD = 235–375 mg/l, COD = 524–1,190 mg/l, SS = 38-144 mg/l, and effluent BOD = 6.6–11 mg/l, (Standard 60 mg/l), COD = 84.8–148 mg/l (Standard 400 mg/l), SS = 6–18 mg/l (Standard 50 mg/l); effluent met regulatory standards.
- Efficiency 97.1 percent.
- Investment cost: US$ 500,000 (Investment cost in the new wastewater treatment plant came from the savings generated through CP implementation).

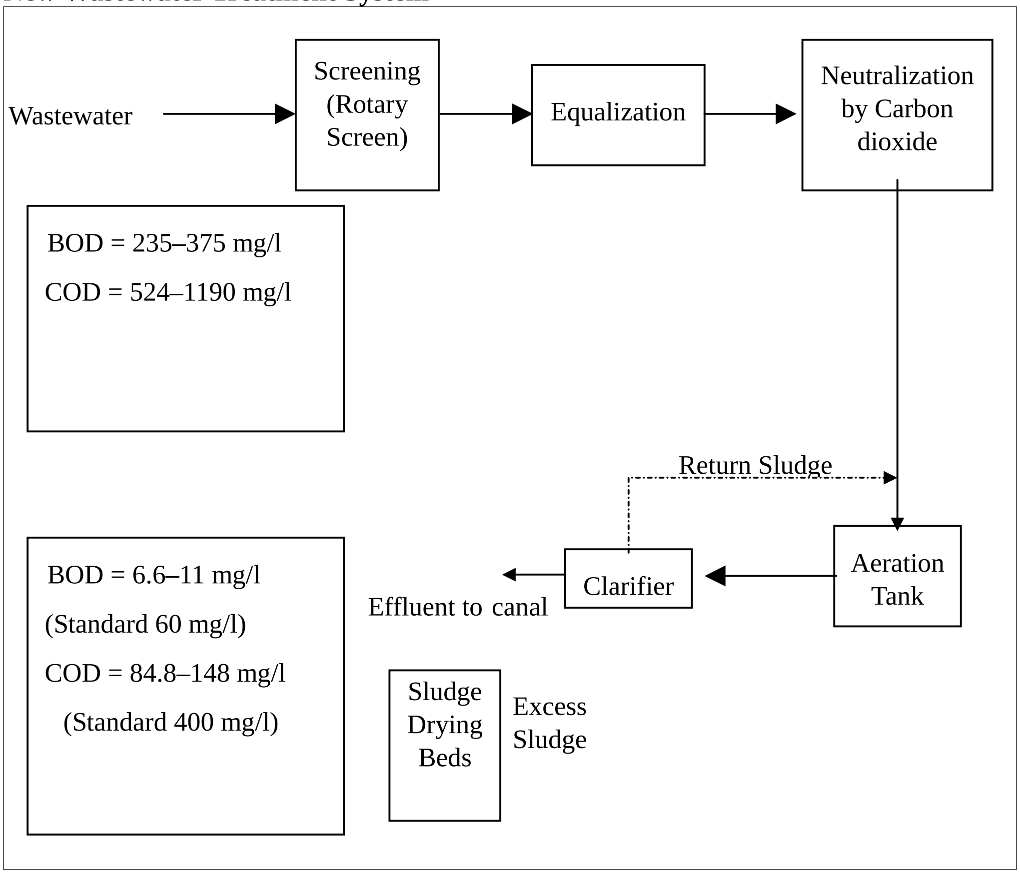
With the installation of the new system, wastewater treatment costs decreased from 10.5 baht/m^3 to 8.5 baht/m^3 according to Thana Paisal.

Appendix 1. Thana Praisal Wastewater Treatment Systems

Original Wastewater Treatment System



New Wastewater Treatment System



VIETNAM

Trinh Thi Thanh, Ph.D.
Chairman, Department of Environmental Technology
Environmental Faculty, Vietnam National University
Hanoi
Tran Yem
Master, Faculty of Environmental Science
Hanoi National University, Hanoi
Nguyen Thi Bich Hang, M.E.
Director, Directorate for Standards & Quality
Vietnam Productivity Center, Hanoi
Luong Quang Huy
Assistant, Faculty of Environmental Science
Hanoi National University, Hanoi

COUNTRY PROFILE

National Economy, People, Government and Administrative System[1]

Geography

Vietnam stretches along a 3,200-kilometer section of the South China Sea, extending from China in the north to the Gulf of Thailand in the south. Vietnam shares borders with Laos and Cambodia in the west. The country's population, estimated at 77 million at the end of 1997, is growing at an average annual rate of 2.1 percent. Almost 80 percent of the people are based in the rural areas. Vietnam's natural resources include limited but productive agricultural land, oil, coal, and a variety of mineral resources, hydroelectric potential, forests and marine resources. The total land area of the country is approximately 331,100 km^2. About 23 percent of the land is cultivated and 30 percent is classified as forest and woodland. The climate is predominantly tropical, but subtropical northern areas experience cool winters.

National economy and quality of life indicators

Despite significant economic progress in recent years, the population of Vietnam is still relatively poor, with an average per capita GNP of US$ 320 in 1997. The first Vietnam Living Standards Survey, undertaken between 1992 and 1993, concluded that 50 percent of the population was poor, as defined by an internationally comparable poverty line based on expenditure on food and basic non-food goods basket. At the same time, however, Vietnam has achieved a high level of social development. According to UNDP's Human Development Report 1997, Vietnam ranks 121st out of 175 countries

[1] The information in this section was based on the UNDP Development Cooperation Report 1998.

based on a composite “human development” index of life expectancy, educational attainment and income.

Vietnam’s average life expectancy of 66 years in 1994 was also well above the average of 62 years for all developing countries and the average of 50 years for least developed countries (LDCs). The country achieved an adult literacy rate of 93 percent in 1994, compared with 70 percent for all developing countries and 48 percent for LDCs. Infant mortality is encouragingly low at 43 deaths per thousand live births, in spite of underdeveloped health-care facilities and limited access to safe water (only 22 percent of the population have access to adequate sanitation and 43 percent to safe water).

Government and political structure

Following reunification, the government attempted to organize the country’s political and economic systems along orthodox Soviet lines. The shift towards a market-oriented economic system in recent years has coincided with some less dramatic changes in the political structure. Following the adoption of a new constitution in 1992, the National Assembly has received enhanced legislative and oversight powers.

The government of Vietnam currently comprises four levels of administration: (i) central; (ii) provincial and urban authorities (Hanoi, Ho Chi Minh City, Haiphong, and Da Nang); (iii) urban precincts and rural districts; and (iv) urban wards and rural communes. In total there are 57 provinces, four urban authorities, 600 districts, and 10,225 communes (8,859 of which are rural). Each commune contains an average of five villages.

National Economy

The structure of the Vietnamese economy has changed dramatically in recent years as a result of the government’s market liberalization policies. Changes have occurred in the composition of GDP and employment, the composition of foreign trade, and the direction of foreign trade and investment flows.

While all sectors have grown steadily since the implementation of major economic reforms in 1989, above-average growth rates in services and industry have led to a relative decline of agriculture’s contribution to the GDP. The agricultural sector’s share of the GDP (including forestry and fishing) declined from 42 percent in 1989 to 26 percent in 1997. Paddy production dominates agricultural output and rice is the major agricultural export. Vietnam has moved from being an importer of rice to becoming the world’s second largest rice exporter in 1997, behind Thailand, and surpassing the United States, exporting approximately 3.6 million tons of rice worth US$ 860 million.

Industry and services, which have been growing rapidly in recent years, increased their respective shares of the GDP to 32 percent and 43 percent by 1997, an increase from 23 percent and 38 percent in 1990. The mining industry has been growing in importance in recent years. In 1997, 9.7 million tons of crude oil were exported. The production of coal stood at 10.5 million tons in 1997, of which 3.5 million were exported. The potential for exploitable hydroelectric power generation is estimated to be seven times the amount currently produced. Hydroelectric plants currently generate approximately 70 percent of the power produced in Vietnam. The industrial sector in Vietnam has also been experiencing a significant structural change, with heavy and mining industries losing their share of total output to the emerging manufacturing sector. The share of heavy and mining industries’ products fell from 37 percent in 1992 to 26 percent in 1997.

Vietnam’s employment structure is typical for an agrarian economy, with 71 percent of the labor force still employed in the agriculture sector, 14 percent in industry and construction, and the remaining 15 percent in the service sector. Furthermore, most of the labor force is unskilled. Skilled labor in the non-state sector accounts for just 2 percent of the total, while only 7 percent of labor in the agriculture sector is skilled. Job creation opportunities are very limited. Official figures indicate that 800,000 jobs have been created per year between 1990 and 1995, largely in the growing private sector. An unofficial estimate showed that the overall unemployment rate (including both official and disguised) is about 20 percent.

Trade development, improved access to inputs, increased investment in agro-processing, upgraded irrigation systems, the adoption of efficient and more environmentally friendly technologies, and the development of extensive farming networks are needed for strong and sustainable growth. Vietnam had 9.9 million hectares of land classified as forest and woodland in 1994. The long coastline and major inland waterways and irrigation systems hold considerable promise for the development of sea and river products. Export revenues from aquatic products reached some US$ 760 million in 1997 (a 17 percent increase), despite setbacks in production due to unfavorable weather conditions last year. The Vietnamese economy has also become increasingly open in recent years, with trade in goods and services (exports plus imports) amounting to nearly 80 percent of GDP in 1997. Exports and imports have grown rapidly in recent years, and the product composition of trade has shifted considerably.

The direction of Vietnam’s trade flows has also changed dramatically in recent years. Since 1990, trade with the countries of the former Council for Mutual Economic Assistance countries (CMEA–largely the countries of the former Soviet Union and Eastern Europe) has dwindled to negligible amounts, while trade with the convertible-currency area has grown by an average 34 percent per year. Total trade was estimated to reach US$ 19.9 billion in 1997. Asia remains the single most important market for Vietnam, accounting for 68 percent of total exports (44 percent to East Asia and 22 percent to Southeast Asia). The lingering effects of the 1997–1998 financial crisis on the region’s export markets continue to be felt in Vietnam.

Recent Developments

The performance of the Vietnamese economy has been quite impressive in recent years despite limited assistance from the outside world. This has been largely due to the country’s strong supply-side response to economic reform. Real GDP growth has averaged close to 8 percent per annum since 1989. In 1997, real GDP grew some 9 percent, contributing to a total GDP valued at VND 295,696 billion (or US$ 25 billion). By sector, growth was relatively broadbased and led by industry and construction (13.2 percent) and services (8.6 percent). Growth in agriculture, forestry, and fishing was also positive at 4.5 percent despite devastating consequences in 1997 from Typhoon Linda, especially in the Mekong Delta, the main base for agriculture production.

In general, development prospects for Vietnam are still strong. However, some worrying signs, which should not be underestimated, have appeared in the economy recently. The government budget deficit, which had declined to around 1.0 percent of GDP in 1995, re-emerged in 1997 at 3.5 percent of GDP. The trade deficit, which set a record high of nearly US$ 4 billion in 1996, was brought down to US$ 2.5 billion in 1997.

Foreign Investment and Development Assistance

Vietnam's economic reform process coupled with the country's widening "open door" policy and its rapidly improving international relations have led to a significant rise in foreign financial interest from both private and official sources in recent years.

According to the 1996–2000 Public Investment Plan, the government hopes to attract some US$ 13 billion of realized foreign investment to help finance its development strategy to the year 2000.

Foreign investment has been promoted aggressively. The first Foreign Investment Law approved by the National Assembly in 1987 has been revised many times. The latest amendments were adopted in November 1997 and in many other follow-up legal documents. This new legislation reflects the government's new orientation towards a more selective approach to foreign direct investment (FDI) projects and its efforts towards more substantive streamlining of foreign investment procedures and practices.

More incentives in terms of tax holidays, exemptions from duty, income tax, land rental payments, and forwarding losses are given to foreign-invested enterprises, especially those which are export oriented. Administrative procedures have been improved. Some selected local authorities are now given the right to approve investment licenses to foreign investors. Paper work has also been simplified.

Despite some obvious achievements, much has to be done to attract more FDI and improve its quality. Only around one-third of the committed capital has been applied so far, partly due to continued cumbersome bureaucracy and procedures facing foreign investors. In Vietnam, estimates on the size of FDI-related debt range anywhere from 20 to 70 percent of reported FDI inflows. The structure and quality of FDI is also one of the big concerns that the government has officially raised recently. There is evidence that foreign investment has been directed to capital-intensive import-substitution activities rather than labor-intensive export production.

This would undermine the benefits of FDI and make it unsustainable. Today, it is widely accepted that for an effective FDI policy, the general business environment is much more important than specific incentives, and the latter can work only if they are appropriately combined with the former. Therefore, it is important for Vietnam to create a more favorable general business environment by embarking on a more comprehensive and deeper reform program.

Another main source of external development finance for Vietnam is Official Development Assistance (ODA). The government is hoping to mobilize some US$ 7 billion of ODA (along with some US$ 21 billion of domestic savings and US$ 13 billion of FDI) to finance its development strategy in the five-year period up to the year 2000. Since the largest portion of future ODA is likely to go into infrastructure, the deepening and improvement of the Public Investment Program (PIP) process, which began in 1996, will be critical for guiding both the government and donors in using ODA most effectively for the country's development. In August 1997, the government issued a Decree on Management and Utilization of ODA aimed at streamlining procedures for the approval and implementation of ODA.

ENVIRONMENTAL PROFILE

Brief Overview of Environmental Development in Vietnam

1980–1985

At the start of 1980, there was no single office responsible for environmental protection and pollution prevention and management. Through a series of national and international seminars, environmental protection concepts were introduced into Vietnam and environmental science courses were established in universities in Hanoi and Ho Chi Minh City. At the time, the country faced a serious lack of informational materials, monitoring data, and experts with advanced degrees.

1985–1990

The period was marked by economic crisis and the beginning of Vietnam's economic reform program. Awareness of environmental issues was still limited among scientists, technicians, and government officials. A few research centers had begun conducting studies on resource utilization, but environmental issues still did not receive significant priority. This period saw the first national program for environmental protection (Program 52-D) and the introduction of the concept of Environmental Impact Assessment.

1990–1994

The early 1990s saw a number of important events that established the environmental infrastructure in Vietnam. The Ministry of Science, Technology, and Environment (MOSTE) was officially formed and given responsibility for environmental and resource management. The second national research program on environmental protection (KT-02-1990/1995) was also initiated. The program included 17 projects carried out by 30 leading universities and research institutions located throughout Vietnam. These projects were divided into four groups:

- Environmental monitoring: 2 projects;
- Environmental engineering: 5 projects;
- Ecosystem management: 6 projects; and
- Socio-economic surveys: 4 projects.

The Law on Environmental Protection was enacted in January 1994 and the framework for Vietnam's Environmental Impact Assessment regulations was also established.

1994–Present

Since the promulgation of the Law on Environmental Protection, significant strides have been made in Vietnam, particularly in the environmental sciences, environmental management and technology, and the application of Green Productivity (GP) practices. Research on the current state of the environment and natural resources is underway in every province, and pollution controls have been implemented for industry to ensure safe working environments. Rural environmental sanitation measures to protect the ambient environment for farming communities now incorporate more sophisticated scientific and technological solutions.

Official courses in environmental sciences are now found in universities throughout the country. In addition, there have been numerous television programs on the importance of protection of the environment and Vietnam's natural resource base. Awareness of environmental pollution and its potential consequences has improved among the population.

Industry is also now implementing better routine management of its wastes, and the number of companies able to find financing for pollution treatment facilities has been growing. In Hanoi and Ho Chi Minh City, several large companies have already built waste treatment facilities, which have brought significant benefits for the community.

Environmental Agencies

MOSTE was established in 1992 to oversee environmental management and sustainable development efforts on a national level. This ministry is responsible for:

- Formation of strategy, policies, and plans for environmental protection;
- Implementation of regulations, rules, and standards for environmental protection;
- Observation and collection of data on environmental quality and analysis of trends;
- Development of guidelines for EIA implementation, environmental inspections, and emergency management;
- Organization and implementation of research tasks to support the development of science and technology for environmental protection and sustainable development; and
- Coordination of international cooperation for environmental protection.

Within the MOSTE, the National Environmental Agency (NEA) is responsible for environmental protection and generally helping the ministry supervise environment management research programs at the state level. Departments of Science, Technology and Environment (DOSTE) within provinces and cities are responsible for environmental protection within their territory.

Environmental Policies

In 1985, the Vietnamese government developed the National Program for Environmental Protection with the help of the International Union for the Conservation of Nature (IUCN) and published the "National Strategy for Natural Resource Protection." This strategy outlined five important tasks:

1. To protect ecosystems, particularly forests, midlands, plains, freshwater areas, estuaries, and open seas;
2. To protect biological diversity;
3. To use renewable resources in a controlled manner and protect non-renewable resources;
4. To ensure environmental quality for the people of Vietnam; and
5. To carry out the tasks related to the protection of the global environment.

In 1990, the State Committee of Science, with assistance from the United Nations Development Program (UNDP), the United Nations Environment Program (UNEP), IUCN, and SIDA, developed the "National Plan for Environment and Sustainable Development."[2] The National Plan included establishing an environmental policy and regulatory structure, a blueprint for forming offices and instruments to manage the national environment, and plans to develop a National Strategy for Sustainable Development. The National Plan included seven specific areas for action:

1. Urban development and pollution control;
2. Comprehensive management of watersheds;
3. Comprehensive management of estuaries and coastal zones;
4. Protection of submerged saline soils;
5. Protection of biological diversity;
6. Formation of national parks and natural preserve areas; and
7. Treatment of wastes.

The National Plan also incorporated proposals for a National Strategy for Environmental Protection, including a framework for the management of environmental issues at national, regional and local levels.

Laws and Regulations

Vietnam has developed a number of major laws and decrees to manage environmental issues, including:

- The Law on Environmental Protection;
- The Law on Land (issued in 1989, and completed in 1993);
- The Law on Protection and Development of Forests (issued in 1991);
- The Decree on Health Protection of People (issued in 1989);
- The Decree on Mineral Resources (issued in 1989); and
- The Decree on Sea Products (issued in 1988).

In addition, on February 25, 1993, the Prime Minister issued the Instruction 73 Decree on "Tasks to Be Done in Environmental Protection." Based on the decree, MOSTE issued Circular Letter 1485-Env on September 10, 1993 establishing temporary guidelines for conducting Environmental Impact Assessments for development projects.

Environmental standards

In Vietnam, there are now several standards related to ambient environmental quality as well as environmental hazards in the workplace. Standards have been issued by MOSTE, the Ministry of Health, and the Ministry of Aquaculture as well as state industries such as the Vietnam Coal Corporation. The most important Vietnamese environmental standard is the Vietnam standard issued in 1995 by MOSTE. This standard actually is a set of 10 standards numbered VNST 5937-1995 to VNST 5946-1995. The standard will be discussed in further detail later in this paper.

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[2] MOSTE has now assumed the duties of the State Committee. The plan was officially announced on June 12, 1992.

Environmental Impact Assessment (EIA)

Inspired by the goal of prevention of major environmental impacts, the Council of Ministers stated in 1985 that "all major development projects must be carefully examined from the aspect of environmental protection, and should include practical measures for this protection." In 1990, the National Environmental Research Program (NERP) presented a detailed proposal for EIA procedures in Vietnam to the State Committee for Sciences.

In February 1993, the Prime Minister of Vietnam issued Instruction 73 Decree concerning "the urgent tasks of environmental protection." The instruction required that all major development projects prepare an EIA report. On the basis of that Instruction, MOSTE issued Guideline No. 1485-Env on EIA implementation. From 1995 to 1998, MOSTE issued guidelines for specific types development projects such as road construction, thermoelectricity, hydroelectricity, food processing, etc. In practice, there have been difficulties in EIA report implementation, primarily due to a lack of cooperation by industry and limited financial resources to support EIA work.

Environmental Planning

Environmental planning refers to guiding socio-economic development with a concern for environmental protection in order to achieve sustainable development. During Vietnam's socio-economic management under central planning, the government planned distribution of production capabilities as well as development for economic regions and provinces. Some districts also planned for socio-economic and cultural development, although such efforts did not pay sufficient attention to environmental protection.

In several environmental studies carried out by the authorities in recent years on topics such as the state of the environment, urban development, water supply and drainage, and environmental impact assessments, environmental planning is mentioned, but has not played an important and systematic role. This is beginning to change, however, and the NEA is preparing new guidelines and regulations for environmental planning.

Environmental Compliance by Industry

The rate of industrialization in Vietnam has been increasing rapidly. As of March 1997, 2,034 foreign-invested projects had been licensed with a total invested capital of VND 28,176 billion, of which 8 billion had been disbursed.

Industrial solid waste

Sources of solid waste generation have been fully surveyed in 39 of Vietnam's provinces.

Table 1. Overview of Solid Waste Generation, 1995–1997

Source	Industry		Hospitals		Domestic		Total
	Tons per year	%	Tons per year	%	Tons per year	%	Tons per year
1995	3,709,239	53.3	77,697	1.2	3,162,360	45.5	6,949,247
1997	7,750,226	48.8	156,670	1.0	7,966,607	50.2	15,873,503

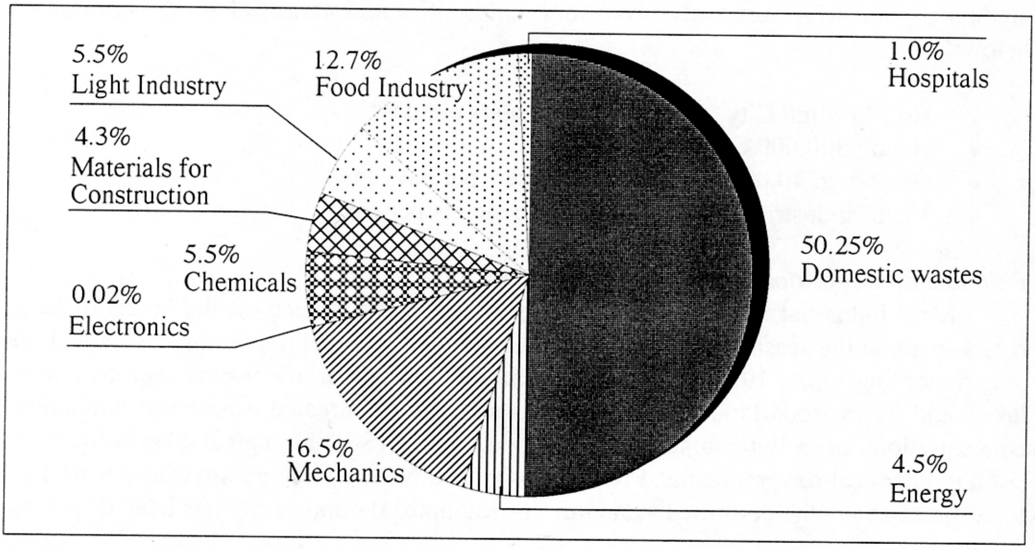
Source: UNDP-Vietnam, 1998.

Survey results indicated that industrial waste accounted for 48.7–53.3 percent of all waste, and domestic waste represented about 45.5–50.3 percent of the total. Waste from hospitals, however, was only a small proportion of the total (see Table 1 and Figure 1).

The 1998 Environmental Status Report prepared by MOSTE states:

> *The solid waste condition is a complicated problem. Collection of industrial and urban solid waste has not been improved; on average only 40-60 percent of the total amount of solid waste is collected. In some towns solid waste collection is 20-30 percent of total amount. Every kind of solid wastes is mixed and buried in the same place. In Hanoi, only 463,550 cubic meters of solid waste are collected while the amount that needed to be collected is 835,850 cubic meters. In Dongnai province, the biggest industrial area in Vietnam, the amount of domestic solid waste collected is only 140 cubic meters daily, the equivalent of 20-30 percent of the total amount (data collected by Bienhoa Environmental Service, 1998). Most industrial zones and urban areas have not got proper treatment facilities for hazardous waste while the amount of urban and industrial wastes is increasing rapidly. Hazardous properties of solid wastes have also been increasing, especially in Hanoi. In 1995, the portion of plastic, PVC, and PE contained in domestic waste is 1.7 percent, that of metal and waste metal boxes is 1.2 percent. By 1997 these figures had increased to 4.1 percent and 5.5 percent respectively.*[3]

Figure 1. Breakdown of Solid Waste Generation by Type



Source: UNDP-Vietnam, 1998.

Industrial wastewater

Most industrial growth has been concentrated in Hanoi, Hai Phong, Quang Ninh, Quang Nam - Da Nang, Hue, Ho Chi Minh City, Bien Hoa, and Vung Tau.

[3] MOSTE, *The Environmental Status of Vietnam*, Hanoi, 1998.

Water pollution caused by domestic and industrial sources is a problem in some urban areas, especially Ho Chi Minh City and Hanoi, and is expected to get worse. Wastewater collection and treatment are expensive and Vietnam does not have sufficient financial resources to address all the problems immediately.

Much of Vietnamese industry uses outdated technology that requires large amounts of water and raw materials, and factories are often located near residential areas. Factories and enterprises often discharge wastewater directly into the public sewage systems without any pre-treatment or control. Of particular concern is the practice of companies in industries such as textiles, garments, and chemical production of dumping hazardous wastes directly into the public sewage system. Recently, some companies have made efforts to upgrade their waste treatment technologies, especially in industrial zones and new investment projects. At the moment, approximately 30 in Ho Chi Minh City have wastewater treatment plants.[4]

Wastewater flow

Available information is inadequate to make a detailed assessment of industrial wastewater flows, treatment, or disposal methods. However, environmental specialists have estimated that industrial wastewater flow as a percentage of industrial water consumption varies from 14 percent to 70 percent. The amount of industrial wastewater generated in Vietnam was estimated at roughly 5 million cubic meters per day. The energy (thermal-electricity plants), paper, and brewery industries are estimated to account for 60 percent of the total.

In order to provide an overview of the wastewater problem in Vietnam, data on the amount of industrial wastewater from four major cities and industrial zones is presented below:[5]

- Ho Chi Minh City: 400,000 cubic meters per day;
- Hanoi: 300,000 cubic meters per day;
- Haiphong: 40,000–50,000 cubic meters per day; and
- Viettri industrial zones: 70,000 cubic meters per day.

Pollutant concentration and loading in Vietnam

Most industrial areas and big cities in Vietnam are located on the banks of large rivers or along the seashore. Untreated wastewater is disposed directly into rivers and the sea. According to the 1998 Environmental Status Report, surface waters such as ponds, lakes, and rivers around industrial zones are receivers of untreated wastewater containing concentrations of pollutants such as suspended solids (SS), biological oxygen demand (BOD), chemical oxygen demand (COD), NO_2, and NO_3, which are anywhere from five to 20 times above the permitted standard. For example, Haiphong city has been disposing

[4] National Environment Agency (NEA), *Environmental Management of Industrial Estates in Vietnam,* The Asian Environmental Conference, 22-23-1999.

[5] Data drawn from several sources. MOSTE, *The Environmental Status of Vietnam*, Hanoi,1999. MOSTE, *Industrial Zone Planning for the Red River Delta to the year 2010*, Hanoi, September, 1995. NEA, *Environmental Management of Industrial Estates in Vietnam. National Research Program on Environmental Protection (KT-02), Environmental Protection and Sustainable Development, Proceedings from the National Seminar on Environmental Protection and Sustainable Development*, Hanoi, October, 1993.

of 70 tons of grease and oil, 18 tons of acid, 92 tons of chlorine, 17.6 tons of heavy metals (including lead, nickel, mercury, etc.) and 13,940 tons of suspended solids into watersheds and the sea on a regular basis.[6]

Another area of concern is pollution from oil extraction. As of the end of 1991, production of raw oil had reached 9 million tons annually and production likely increased significantly through the 1990s. In 1992, approximately 170,000 tons of drilling wastewater was discharged into marine coastal areas due to oil exploration activities.[7]

Hazardous substances are a significant concern and it has been estimated that industrial sources have been disposing approximately 290,000 tons of hazardous substances into watersheds annually.[8]

Major cities are also having an increasing impact. For example, Hanoi discharges 300,000 cubic meters wastewater into watersheds daily. Hanoi's wastewater annually includes 3,600 tons of organic substances, 317 tons of grease and oil, 10 tons of heavy metals, detergents, and other hazardous waste.[9]

Water quality

Vietnam has more than 2,000 rivers with a total volume exploited annually of about 860 billion cubic meters. The biggest rivers are the Red and Mekong Rivers, as mentioned in the first chapter. The Red River system has a watershed of 169,000 km^2, of which 86,000 km^2 lie in Vietnamese territory. Data and information collected from water-quality monitoring stations in the watershed indicate that turbidity, color, and suspended solid content change rapidly between seasons.

The impact of pollution from urban areas and industrial zones has had an alarming effect on Vietnam's surface water. Most rivers in Vietnam are now classified as "B class."[10] According to the MOSTE report, rivers in southern Vietnam are much more polluted than those of the north.[11] Water quality of southern rivers is characterized by high acidity, the most serious of which is the Longan River (approximately pH 3.5–4.7). Other rivers in Cantho, Minhhai, Tiengiang, Kienan, Dongthapmuoi, and Ho Chi Minh City have pH readings lower than their counterparts in central and northern Vietnam, but are still within the permitted standard.

Lakes, ponds, and canals in urban areas such as Hanoi, Ho Chi Minh City, Haiduong, Bac Ninh, Bac Giang, Hue, Dongha, Danang, and Quangngai are affected by industrial wastewater and have concentrations of BOD and COD 5-10 times above the permitted standard for A-class receivers and 3–4 times above the standard for B-class receivers.[12]

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6 MOSTE, *The Environmental Status of Vietnam*, Hanoi, 1998.
7 MOSTE and World Bank, *Report on Environmental Survey of Seven Provinces/Cities of Vietnam,* Hanoi, 1994.
8 Ibid. Also, *The Environmental Status of Vietnam,* 1998.
9 Tran Hieu Nhue, *The Status of Water Environment and Solid Waste in Urban and Industrial Areas in Vietnam,* Hanoi, The University of Construction Press, 1998. Also, Dinh V. Sam, N.H.Toan, *Review on Industry and Industrial Environment of Vietnam,* Hanoi, NEA / MOSTE, 1995.
10 Under TCVN 5942-1995, surface water that can be used for drinking is considered A class, whereas water that can only be used for other purposes is classified as B class.
11 *The Environmental Status of Vietnam.* 1998.
12 Ibid.

Water quality in coastal zones

SS, COD, oil and grease and zinc were all found in coastal zones in Vietnam during an investigation carried out from 1997–1998. Oil, COD, and zinc were common in the central region of the country, while SS, COD, oil, coliform, and zinc were prevalent on the southern coast.[13] (See Table 2.)

Marine water quality has also undergone changes as seen by rising temperature (0.5°C), lower pH (0.01), and increase in suspended solid concentration a four-fold from 1996 to 1998. In addition, the presence of insecticides increased 10 times during the same period, but still remains within the permitted standard. Areas near oil extraction sites have seen additional impacts, particularly in the Gulf of Vungtau in the south and Halong Bay in the north.[14]

Table 2. Water Quality in Vietnamese Coastal Zones in mg/l

Location	COD	BOD	NH_4	PO_4	Oil	Zn^{2+}	Pb^{2+}	Cu^{2+}
Baichay (Halong Bay)	6.81	3.05			0.25 0.66	0.0213	0.21	0.009
Doson (Haiphong)	3.21	1.29	0.04	0.03	0.21 0.46	0.0295	0.12	0.0152
Samson (Thanhhoa)	2.24	0.90		0.07	0.23			
Nhatrang (Khanhhoa)		1.20		1.62	0.32			
Vungtau (Baria)	6.08	2.94	1.25		0.38			

Source: Environmental Status Report, 1997.

Air Pollution

According to national monitoring data collected in 1997 and 1998, high concentrations of dust were found in urban areas and industrial zones. However, hazardous gases such as SO_2, NO_2, and CO were only emitted in industrial zones.

Particulates

Virtually all of Vietnam's cities suffer from dust pollution that is 1.5–3 times higher than the permitted standard. In suburban areas that are far from highways and industrial zones, dust concentrations are lower than the permitted standard (on average of 0.2 mg per cubic meter). National surveys showed that 13 out of 16 cities suffered from dust pollution that exceeded standards by at least 1.5 times. The worst results showed dust levels 20 times higher than the permitted standard. Urban communities near industrial zones were markedly worse than other areas.[15]

Hazardous gases

According to national monitoring data, concentrations of SO_2, NO_2, and CO in all residential areas and suburban areas met the permitted standard. High concentrations of those gases are found in industrial zones and highways. Data on SO_2 collected from industrial zones located in urban areas showed that the Haiphong cement company, a

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[13] *Environmental Management of Industrial Estates in Vietnam.*
[14] *The Environmental Status of Vietnam*, 1998 and 1999.
[15] Sam and Toan, *Review on Industry and Industrial Environment of Vietnam*.

brick factory in Laocai, Thuongdinh industrial zone in Hanoi, Tanbinh and Phuoclong industrial zones in Ho Chi Minh City exceeded the permitted standard by 1.5–2.5 times.[16]

Air pollution and acid rain

There has been only one acid rain monitoring station operating in Vietnam since 1995. In 1997, 435 rainfall samples were collected and 130 of them (29.9 percent) had a pH lower than 5.5. Acidification of rainwater worsened from 1996 to 1997 by a factor of seven.[17]

Working environments

Based on investigation by the Labor Institute, the Labor Union, and the Institute of Hygiene and Labor, dust and hazardous gas concentrations in many factories are many times higher than the permitted level, especially in ore and deposit screening, cement, and metallurgy factories.

Environmental Compliance by Industry

As noted above, Vietnamese industry is still small despite the achievements reached through the reforms started in 1986. In parallel with the development of large cities, industries in many different sectors have also begun to grow. Increasingly impacted by the open market, some enterprises have been unable to compete and have been forced to operate below capacity or close down. At the same time, new facilities have been built using more modern processes and technology. The growth of the private sector has also resulted in an increase in the number of small and medium-sized enterprises (SMEs). Managing environmental issues for SMEs has proven increasingly difficult.

Energy industry

Energy capacity reached 9,276 billion kWh consisting of 26.53 percent from coal, 68.35 percent from hydropower, and 5.12 percent from oil and gas. In the future, a number of new hydropower stations will be built and the ratio of hydropower will rise to 74.6 percent. However, the use of coal and natural gas will also continue to expand due to economic necessity. A number of GP options should be considered, such as reducing the percentage of sulfur in oil, improving the burning process, and using electronic dust filtering before emissions go into the stack to decrease pollution. Currently, thermal-electric stations discharge 4,062 tons of dust, 7,470 tons of NO_x, 3,040,00 tons of CO_2, 16,540 tons of SO_2, and 529 tons of slag.[18]

Mining, drilling, and metallurgical industries

There are 559 mines in Vietnam, including 108 metal mines, 45 gold mines, 16 jewelry mines, 125 coal mines, and 265 metalloid mines. Vietnam has a wide variety of mineral resources distributed throughout the country. A total of 3,500 locations with ore

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[16] Ibid. Also, *The Environmental Status of Vietnam,* 1998.

[17] *The Environmental Status of Vietnam*, 1998.

[18] MOSTE, *Industrial Zone Planning for the Red River Delta to the year 2010,* Hanoi, September, 1995.

have been discovered in Vietnam with 80 different types of minerals. Currently, 300 mines and 30 types of minerals are active, focusing on the following materials:[19]

- *Coal:* Quang Ninh mine's reserves are 3.5 billion tons. Every year 3 million tons are removed with old technologies resulting in heavy pollution;[20]
- *Apatite:* In Lao Cai area, 300,000 tons of apatite are removed every year with old technology, and the site is now being expanded; and
- *Oil and gas*: Activities are concentrated on territorial waters in the south. In 1992, crude oil output reached 5.5 million tons. In the early stages of development, leaking oil was a common problem. To date, Vietnam does not have any petrochemical refineries.[21]

Mining areas cannot be refilled, and the amount of waste soil and earth is huge in operations such as the coal mines in Hongai and Campha. Over five years, the mines can generate 117 million tons of waste soil and earth. In the Cocsau coal mine, waste soil and earth have spilled onto 200 ha of agricultural and residential lands along Highway18. As a result, the highway must be moved closer to the coastline.[22]

Air pollution in the mining industry is a very serious problem, and dust concentrations in coalmines range from 20–200 mg/m^3. Dust concentration along access roads to mining areas is also 10 times above permitted standards when water spraying is used and as much as 100 times higher when water spraying is not used.[23]

Mining activities are also causing significant damage to water resources in many areas due to sedimentation. Suspended solids not only pollute surface water quality in mining areas, but also contain heavy metals, mercury, and other hazardous chemicals.

Chemical and fertilizer industries

The chemical and fertilizer industries were first established in Vietnam in the 1960s. Because there is no developed petrochemical industry in Vietnam, the chemical and fertilizer industries mainly produce inorganic compounds such as H_2SO_4, HCl, NaOH, super phosphate, urea, and NH_3. Industrial zones have been formed in Lam Thao, Vietri, Bac Giang, Bac Ninh and Dong Nai provinces. 240,000 tons of H_2SO_4 are annually manufactured, of which 180,000 tons are manufactured from pyrite. All production is by one-layer catalysis and has a low transformation efficiency and generates large amounts of waste. Each year, 4,347 tons of SO_2 are disposed.[24]

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[19] *The Environmental Status of Vietnam.* Hanoi: 1998 and 1999.
[20] *Industrial Zone Planning for the Red River Delta to the year 2010.*
[21] *The Environmental Status of Vietnam,* 1998.
[22] *Environmental Protection and Sustainable Development,* 1993. Also, *The Environmental Status of Vietnam,* 1998.
[23] Ibid. (both sources)
[24] CEFINEA/NEA, *Guideline on Environmental Impact Assessment of Textile Project,* Ho Chi Minh City, MOSTE, 1999. Also, National Research Program on Environmental Protection (KT-02), *Environmental Protection and Sustainable Development,* Proceeding of the National Seminar on Environmental Protection and Sustainable Development, Hanoi, September, 1995. Also, *The Environmental Status of Vietnam,* 1998.

- HCl output is about 10,000 tons per year and a portion of the output is dumped in rivers due to a lack of customers.[25]
- NaOH output is about 8,000 tons per year, most of which is used by the paper industry.[26]
- Thermal-phosphoric fertilizer output is 180,000 tons per year. This production results in the release of fluorine in the form of 11,745 tons of Na_2SiF_6. Fluorine is mostly discharged into the air.[27]
- Nitrogenous fertilizer output is 90,000 tons of urea per year produced by a process using anthracite and coal gasification under normal pressure in a fixed grating furnace. Recovery efficiency is low, and pollution includes cyanide, arsenic, phosphate, phenol, and goudron oil.
- The paint industry has a capacity of about 7,000 tons per year and is concentrated mainly in Hanoi and Ho Chi Minh cities. The primary products are oil paints using different types of solvents. This type of product causes environmental pollution when used. The present trend is to manufacture water-based paints, which causes less pollution.[28]

Light industry

The textile industry contributes approximately 65 percent of the gross industrial production value of light industry. State-owned enterprises produce 100 million meters of cloth annually. There are also a number of private enterprises. Most of the existing textile mills are equipped with old machines. The majority of raw materials are imported, including the 410 tons of dyestuffs consumed annually. The textile industry comprises spinning, weaving, and dying. Chlorine and its compounds are mainly used to whiten. Wastewater from dyeing contains chlorine, sulfate nitrate, HCl, H_2SO_4, and alkaline.[29]

Within the paper industry, there are currently 90 factories operating, most of which are equipped with technology from the 1950s and 1970s. Recently, some factories have tried to replace their old machines. Total capacity is 65,000 tons of pulp and 160,000 tons of paper per year, but the industry only operates at 60 percent of capacity. Over 80 percent of paper products are manufactured by chemical method, and chlorine is used for bleaching. The pulp industry requires a large amount of wood and bamboo (manufacturing one ton of paper uses 8 tons of wood, equal to the amount of wood taken from 20 ha of forest).[30]

Construction materials industry

Five large-scale cement factories have been built with a capacity of 45,650,000 tons per year, and there are more than 53 local plants with vertical sharp kilns. In addition, the Dap Cau Glass Plant produces 1,000 tons of glass per year. Thousands of brick plants are located around the country.[31]

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[25] CEFINEA/NEA, *Guideline*. Also, *Environmental Protection and Sustainable Development,* 1995.
[26] CEFINEA/NEA, *Guideline.*
[27] *The Environmental Status of Vietnam,* 1998.
[28] *Environmental Protection and Sustainable Development,* 1995.
[29] Trinh Thi Thanh and others, *Environmental Impact Assessment for Existing Facilities,* Hanoi Textile company/case study, Hanoi, October, 1997.
[30] Ibid.
[31] Sam and Toan, *Review on Industry and Industrial Environment of Vietnam*.

Cement manufacturers use the wet method except for Hoangthach and Hatien II, which use the dry method. The majority of the factories are equipped with machinery from the 1950s, except for Hoangthach, Bimson, and Hatien II, which were recently built. In general, most of them have no equipment for waste treatment. The primary pollution sources are dust and smoke caused by burning and heating material. Due to the widespread availability of raw materials and the prospective market for cement, this industry is expanding.

Foodstuffs industry

This industry is very diverse. The majority of the enterprises engaged in food processing are small scale. Wastes from these industries contain large amounts of sugar, amidol, and protite. Waste from food factories located near chemical factories can be expected to increase, creating new compounds which are toxic in high concentrations.

Incentives to Improve Environmental Performance

Up to now, there has been no official incentive policy in Vietnam for the industrial, agricultural, or service sector to improve environmental performance. However, Articles 3, 11, and 46 of the Law on Environmental Protection provide the basis for establishing incentives:

> *Article 3*
>
> The state shall exercise unified management of environmental protection throughout the country, draw up plans for environmental protection, build up capabilities for environmental protection activities at the central and local levels. The state shall adopt investment policies to encourage organizations and individuals at home and abroad to invest under different forms in, and apply scientific and technological advances to, environmental protection, and protect their lawful interests therein.
>
> *Article 11*
>
> The state encourages and shall create favorable conditions for all organizations and individuals in the rational use and exploitation of components of the environment, including the application of advanced and clean technology, the exhaustive use of waste, the economical use of raw materials and the utilization of renewable energy and biological products in scientific research, production and consumption.
>
> *Article 46*
>
> The government of Vietnam adopts priority policies towards countries, international organizations, foreign organizations and individuals with respect to environmental manpower training, environmental scientific research, clean technology application, development and implementation of projects for environmental improvement, control of environmental incidents, environmental pollution, environmental degradation, and projects for waste treatment in Vietnam.

The concepts outlined in the above articles have not yet been implemented into specific policies or regulations. There is still no agreement between MOSTE and the

Ministry of Finance (MOF) on how to develop incentives, particularly financial incentives.

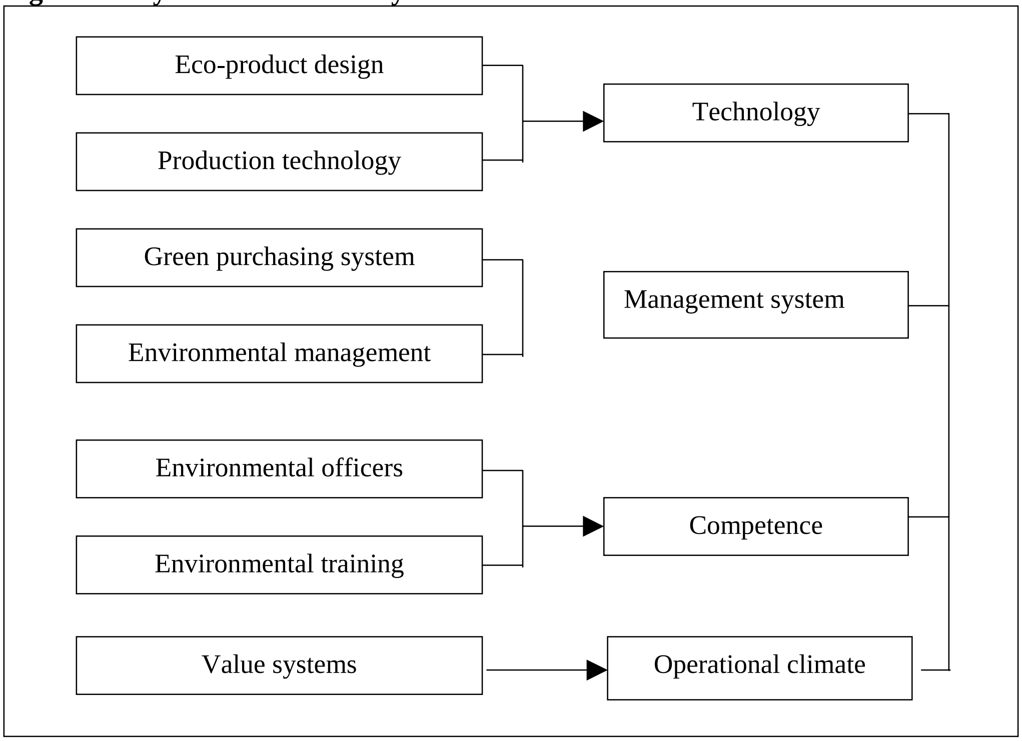
Every year the government has provided MOSTE with a budget for environmental expenditures. However, the financial support from the government has not been enough to cover all environmental research, surveys, workshops, training, monitoring, pilot projects, and other key programs at the national or provincial level. Annual budget allocation for provincial DOSTE is supplied by MOSTE. Certain large or important environmental protection projects have been supported by international organizations (UNDP, UNEP, the Asian Development Bank, and the World Bank) or by foreign countries (Japan International Cooperation Agency - JAICA; Swedish International Development Agency - SIDA; and Canadian International Development Agency - CIDA).

ENVIRONMENTAL PERFORMANCE OF THE TEXTILE INDUSTRY

Methodology for Preparation of This Case Study

- Select plants or enterprise for case study (the enterprise must be typical in terms of size, technology, production, waste treatment, pollution, etc.);
- Conduct walk-through survey of the production process;
- Preliminary analysis of waste generation;
- Identification of waste sources and analysis of waste characteristics;
- Cause analysis for waste generation from identified sources; and
- Identification of waste management options.

Figure 2. Key Green Productivity Factors



Industry Profile

As mentioned in the previous section, the textile industry contributes approximately 65 percent of the gross industrial production value of light industry. The main products:

- Textile fiber: 52,800 tons
- Fabrics for multiple purposes: 226.7 million square meters
- Knitting wool: 1,000 tons

The textile industry produced goods worth VND 1,633.9 billion in 1995 and more than VND 1,800 billion in 1996.[32]

Products of the Textile Industry in Hanoi

In Hanoi, there are now 12 state-owned weaving companies and many other small private or cooperative workshops formed within villages. The private and cooperative workshops in Hanoi were mostly established after 1994 using handicraft technology, and their main products are colored polyethylene fabrics.

Total annual production of the 12 state-owned weaving enterprises in Hanoi is shown below:[33]

- Textile fibers (cotton and PE): 16,300 tons
- Cotton and cotton/PE fabrics: 76 million m^2
- Canvas: 450 tons
- Mosquito netting: 8 million m^2
- Cotton towels: 20 million units
- Socks: 4.5 million pairs
- Woolen jackets and T-shirts: 600,000 units

The weavers in Hanoi are typical of the textile industry in Vietnam, and conditions in other regions such as Ho Chi Minh are similar. The authors therefore chose to survey the Hanoi textile industry as representative of the industry as a whole in Vietnam.

Key Manufacturing Processes

There are five main steps in the textile industry in Vietnam:

1. Fiber production;
2. Spinning;
3. Weaving and knitting;
4. Dyeing, printing and finishing; and
5. Garment production.

Almost all solid waste, wastewater, noise, dust and other pollution caused by textile production in Vietnam is generated by dyeing plants, printing mills, and synthetic fiber production. The textile manufacturing process is outlined in Figure 4.

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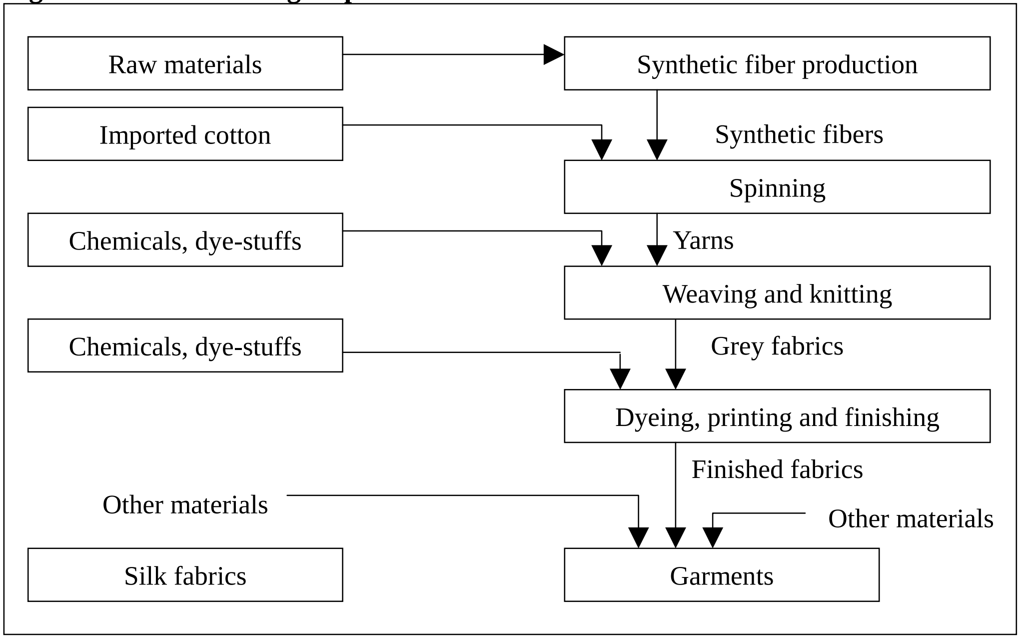
32 CEFINEA/NEA, *Guideline*.

33 Trinh Thi Thanh and other, *Environmental Impact Assessment for Existing Facilities*.

Figure 4. Manufacturing Steps in Textile Production



Environmental Aspects

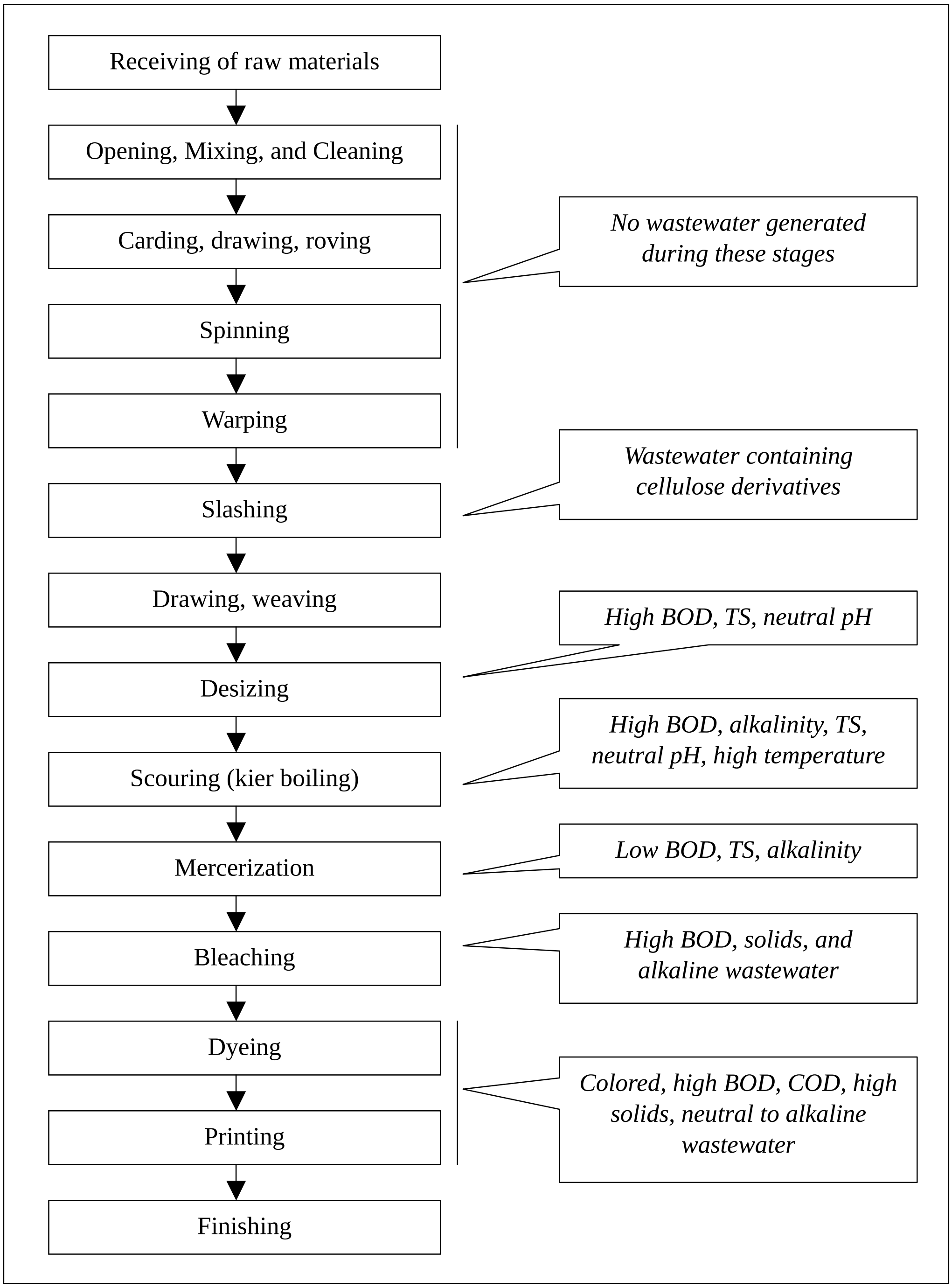
In typical textile operations, both chemical and mechanical treatments are used on the materials to produce the finished product. Unwanted by-products arise from numerous points in the production cycle, the majority of which are discharged to the environment. Chemical companies market a huge range of products to the textile industry such as dye formulations and colorants under trade names rather than by chemical composition. Many chemicals used may be dangerous to handle unless proper safety precautions are used. Ancillary operations such as machine cleaning, boilers, water treatment plants, and effluent treatment facilities may also cause further environmental impacts if they are not properly controlled. The standard textile production process is outlined in Figure 5.

Water pollution sources and characteristics

Textile effluents, generally grey in color, have a high BOD, high total dissolved solids, and a high temperature. Natural impurities extracted from the type of fiber being processed along with the chemicals used for processing are the two main sources of pollution. Other factors which determine effluent quantity and quality include the unit operations used and the degree to which water and chemicals are conserved in a particular manufacturing plant.

Effluent from each individual process varies depending on the variety of fiber blends under production. Cotton finishing effluents are not as strong as those produced by the wool industry, but may have a high color content due to dyeing operations. Effluents from wool processing demonstrate high levels of BOD, solids concentrations, and grease content. Synthetic finishing effluents are generally lower in volume than those generated in cotton finishing, but may contain toxic substances from the dyeing streams where chemical dyes with a metallic ion content are widely used. For most textile

Figure 5. Process Flowchart for Textile Manufacturing



effluents, the ratio between BOD and COD is between 1:2 and 1:3, which is a good proportion for biodegradability. Wool scouring effluents may have a ratio as high as 1:5, which makes biological treatment of these effluents exceptionally difficult.[34]

Typical textile processing operations can include the use of several non-process chemicals such as machine cleaners, shop chemicals, biocides, and boiler treatments. Wastes from textile mills are also high due to the application of dyes with color units ranging between 300 and 1,000 for non-wool operations and as high as 2,000 in the case of effluents from wool scouring. Direct discharge of such effluent can lead to a significant deterioration in the aesthetic value of downstream water quality.[35]

Table 3 shows the approximate concentrations of pollutants generated by various textile-processing operations in Hanoi and Ho Chi Minh City.

Table 3. Characteristics of Textile Effluent in Vietnam

Sub-category	Concentrations in mg/l						
	BOD	**COD**	**TSS**	**O&G**	**Phenol**	**Cr**	**Sulfide**
1. Wool scouring	6,000	30,000	8,000	5,000	1.50	0.050	0.20
2. Wool finishing	300	1,040	130	-	0.50	4.000	0.10
3. Dry processing	350	1,000	200	-	-	0.014	8.00
4. Woven fabric finishing	650	1,200	300	14	0.04	0.040	3.00
5. Knit fabric finishing	350	1,000	300	53	0.24	0.240	0.20
6. Carpet finishing	300	1,000	120	-	0.13	0.130	0.14
7. Stock and yarn finishing	250	800	75	-	0.12	0.120	0.09

Abbreviations: TSS – Total Suspended Solids; O&G – oil and grease; Cr – Chromium.
Source: EIA Guidelines for Textile and Garment Industry, National Environmental Agency, 1997.

– *Priority pollutants in textile effluents:*

- Organic priority pollutants expected to be found in textile effluents (at the ppb level) are substitute phenol (i.e. toluene, ethylbenzene and chlorobenzenes, chlorophenols, methylphenol and nitrophenol), chloroethylenes, chloroethanes, chloroform, and phthalates such as bis (2-ethylhexyl) phtalate and di-n-butylphthalate. These pollutants may appear due to their presence in dyes, dye carriers, and raw materials, as well as from their uses in wet processing.
- Effluents from the mills surveyed all had a loading of total phenols below 0.05 kg per 1000 kg of product. If total phenol is used as a surrogate measure for the control of organic priority pollutants in textile effluents as suggested by the United States Environmental Protection Agency (USEPA),

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[34] Ibid.

[35] CEETIA (University of Construction), *Environment Pollution Caused by Industrial Activities in Hanoi City - Results of Survey and Evaluation (1995 - 1997)*, Department of Science, Technology and Environment (DOSTE) of Hanoi, December 1997, Annex 3. Also, CEFINEA/NEA, *Guideline*. Also, Group of Industrial Area Management, *The Status of Development Industry in Vietnam*, The Asian Environmental Conference, 22-23-1999.

mill effluents are below the limits set by the Vietnamese Temporary Textile Mill Effluent Guidelines.[36]

- Metal priority pollutants commonly found in textile effluents are zinc, copper, chromium, lead, and nickel. Concentrations of these metals tend to be under the discharge limits of 1 mg/l set by the municipal sewer law. Dyes used in processing are the main sources of these metal pollutants.[37]
- Effluents from the mills surveyed had a pollution loading of chromium less than 0.05 kg per 1000 kg of product. If chromium is used as a surrogate measure for the control of all metals in textile effluents as suggested by the USEPA, effluents were below the monthly average limit set by the Textile Mill Effluent Guidelines.[38]

The sources of major metal pollutants (i.e. zinc, copper, chromium, etc.) are likely to be the dyes used in wet processing. The potential sources for organic priority pollutants are related to the varied applications of these dyes as detailed below.

- They may be present in commercial dyes or dye carrier as trace impurities or additives include toluene, ethylbenzene, dichlorobenzene, napthalene, phenol, nitrophenol, 2,4-dimethylphenol, pentachlorophenol, and p-chloro-m-cresol;
- They may be cleaning solvents or scouring agents such as 1,1,1-trichloroethane, tri-chloroethane, tetrachloroethane, chloroform, and 1,2 dichloroethane;
- They may be used as a plasticizer or in formulations are bis 2-ethylhexyl, phthalate, and di-n-butylphthalate; and
- They may be present in raw water supplies or raw materials such as chloroform, 1,2-dichloroethane, phenol, and bis (2-ethylhexyl) phthalate.

– *Wastewater treatment in weaving and textile companies in Hanoi*

Very few weaving enterprises have wastewater treatment plants. A small percentage of companies treat wastewater by coagulation or with biological means, but, systems are frequently not operated. Generally speaking, wastewater treatment plants in the textile industry in Vietnam have low effectiveness, and the result is that most wastewater is still being discharged directly into the municipal sewage system. Eventually, the wastewater ends up in one of four main rivers in Hanoi (Set, Kim Nguu, Lu and To Lich).

Air emissions and occupational safety

Air emissions from the textile processes (excluding boiler emissions) fall into four general categories: oil and acid mists, dust and lint, solvent vapor, and odors.

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[36] CEETIA/NEA, *Guideline*.

[37] Trinh Thi Thanh and other, *Environmental Impact Assessment for Existing Facilities*. Also, Group of Industrial Area Management, *The Status of Development Industry of in Vietnam*.

[38] CEETIA/NEA, *Guideline*. Also, Huynh Trung Hai, Pham Minh Hien, "Study on Dyeing Wastewater Treatment," Hanoi, Seminar on Textile Waste Minimization, August 1996. Also, *Environmental Protection and Sustainable Development,* 1993.

Oil mists are produced when textile materials containing oils, plasticizers and other materials that evaporate or degrade thermally are subjected to heat. The most common source of oil mists is the tender frame, which produces oil mists with a droplet concentration of 0.030-0.045 grains/ACF, corresponding to an emission factor in the range of 25-200 lbs/day of oil.[39]

Acid mists are produced during wool carbonization and during some types of spray dyeing and acetic acid mist dyeing. Solvent vapors generally contain a large number of toxic chemicals in varying concentrations depending on the substances used in dyeing and finishing operations.

Some process chemicals evaporate from materials in the dryers as airborne VOCs. Examples of chemicals which behave this way include methyl naphthalene, chlorotoluene, trichlorobenzene, ortho dichlorobenzene, perchloroethylene, methyl ester of cresotinic acid, butyl benzoate, biphenyl, etc. Table 4 lists typical VOCs and corresponding sources in textile processing operations.

Odors are often associated with oil mists and vapors, and are best overcome by removal of these mists and vapors. The most common problem of this type arises from carrier odors associated with aqueous polyester dyeing and subsequent processes. Resin finishing also produces odors, mainly of formaldehyde. Sulfur dyeing on cotton and cotton blends, dye reduction or stripping with hydrosulphite, bonding, laminating, back coating, and bleaching with chlorine dioxide are other common sources of odor.

Dust and lint are produced in the highest quantities by the processing of natural and synthetic staple fibers prior to and during spinning, napping, and carpet shearing. To a lesser extent, most other textile processes produce lint. While lint is not a pollutant, its presence can interfere with other pollution abatement processes.

Table 4. Partial List of Typical VOCs and Corresponding Sources

Chemicals	Potential sources
Chlorine	Shop, water treatment
Ethylene oxide	Dryer stacks (wetting agents)
Hydrochloric acid	Dryer stacks (catalyst)
Methylene chloride	Shop, paint stripper
Perchloroethylene	Dry cleaner, scour carrier
Toluene	Becks, dryers
Xylene	Becks, dryers
Ammonia	Shop, storage tanks
Tetrachloroethane	Shop, inspection
Trichloroethyllen	Shop, inspection

Source: Environmental Status of Hanoi, Department of Science, Technology and Environment, Hanoi, 1998.

Cotton and fiber dust are also emitted during the production. Dust concentration in several factories surveyed in Hanoi is provided in Table 5.

[39] CEFINEA/NEA, *Guideline*. Also, Thanh and others, *Environmental Impact Assessment for Existing Facilities*.

Table 5. Data on Dust Concentration in Hanoi Textile Factories

No	Enterprises	Cotton dust *(mg/m³)*	Coal dust *(mg/m³)*
1	8-3 Weaving Company	6-10	50
2	Minh Khai Textile Company	2-3	0.4
3	19-5 Weaving Company	4-8	7.6
4	Hanoi Knitting Company	18-25	0.2
5	Winter Wool Company	2-7	0.8

Source: *Environmental Status of Hanoi*, Department of Science, Technology and Environment, Hanoi, 1998.

Most textile and weaving companies in Hanoi and Vietnam use coal and fuel oil (FO) for boilers. The annual quantity of coal used by the textile companies is about 30,700 tons of coal and 3,120 tons of FO.[40]

– *Exhaust gases*

Gases emitted during production can have a very significant impact on air quality and health. An integrated assessment of the emission of key exhaust gases in textile companies in Vietnam is given in Tables 6 and 7.

Due to interrupted processes (boiling, bleaching, dyeing, etc.) and equipment leakage, a large amount of vapor and chemicals are emitted into the air in the working environment.

Table 6. Gas Emissions from Coal Burning *(steam boiler)*

Gas	Pollution coefficient *(kg/ton of coal)*	Emission	
		Ton/year	Ton/day
SO_2	19.5	239.3	0.8
NO_x	9.0	276.1	0.9
CO	0.3	9.2	0.03
THC	0.055	1.69	0.06

Source: National Environmental Agency, EIA Guidelines for textile and garment industry, 1997.

Table 7. Gas Emissions from FO Burning *(steam boiler)*

Gas	Pollution coefficient *(kg/ton of coal)*	Emission (Ton/year)	
		Ton/year	Ton/day
SO_2	18.5	162.9	0.543
NO_x	11.8	37.9	0.126
CO	0.005	0.016	0.000052
THC	0.24	0.749	0.0025

Source: National Environmental Agency, EIA Guidelines for textile and garment industry, 1997.

– *On-site air pollution prevention*

Most Hanoi textile and weaving companies have installed dust collectors such as fabric filters, fans, settling chambers, and cyclones as well as gas absorption equipment. A few of the 12 weaving and textile companies in Hanoi surveyed have

[40] Group of Industrial Area Management, *The Status of Development Industry of in Vietnam*.

good treatment facilities. The majority of companies had ineffective facilities due to a lack of financial resources to provide for maintenance of old equipment or the purchase of new technologies and equipment.

Solid waste

Solid waste is unavoidable in the Vietnamese textile industry, but it is not a major pollution problem. Solid waste generated from boilers and production processes is primarily in the form of coarse coal ashes and is estimated at 10,000 tons per year per company.[41] Other solid wastes include packaging materials, chemicals, and paper and fiber residues. A significant amount of solid waste is generated from the sludge from on-site wastewater treatment or from sewage treatment systems.

There are no textile factories in Vietnam with solid waste treatment facilities, and solid wastes are simply dumped in garbage heaps or transported to municipal landfills by waste haulers contracted by the companies. However, many types of solid waste are recycled, especially coarse coal ash, for construction of households in suburban areas.

In short, solid waste is not a big problem for the textile industry for the short term. However, in the future, solid waste could become a significant problem at the municipal or national level.

Noise

Noise levels in textile companies in Hanoi in particular and in Vietnam in general are higher than the permitted standard (Vietnam Standard: 90 dBA). Machinery within production lines and vehicles cause the majority of industrial noise pollution. The results of a survey of noise levels made by a research team are provided below:[42]

- 8-3 Weaving Company: 95 dBA
- Minh Khai Weaving Company: 100 dBA
- Hanoi Knitting Company: 90 dBA
- Hanoi Industrial Weaving Company: 90–100 dBA
- Winter Wool Company: 94 dBA
- 19-5 Weaving Company: 96 dBA

CASE STUDY ON GREEN PRODUCTIVITY IMPLEMENTATION

Company Overview

The Hanoi Import and Export Textile Company (HANOSIMEX) was chosen for the case study. The Hanoi Import and Export Textile Company is located at No 1, Mai Dong in Vinh Tuy Industrial Zone, Hanoi City (in the south of city). HANOSIMEX was established in 1984 by the Hanoi Spinning and Knitting Union. The company's factory occupies a 24 hectare site. The company is integrated from fiber spinning, weaving,

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[41] National Research Program on Environmental Protection (KT-02), *Environmental Protection and Sustainable Development*, 1995. Also, Tran Yem, *Problems on solid wastes of Vietnam,* Report submitted to ISMES S.P.A Bergamo, December 1994.

[42] - Group of Industrial Area Management, *The Status of Development Industry of in Vietnam*. Also, Thanh and others, *Environmental Impact Assessment for Existing Facilities*.

cleaning, and dyeing up to finishing (no glue). HANOSIMEX employs 6,000 workers whose average income is US$100 per month. Table 8 lists HANOSIMEX's primary products.

Reasons for selection of HANOSIMEX

- HANOSIMEX is a typical enterprise whose pollution discharge has negative impacts on the community and company workers;
- Wastes generated include hazardous materials (heavy metals contained in wastewater, organic vapors, and acid vapors as air pollutants);
- The company generates a large amount of wastewater that requires complex technologies for proper treatment; and
- The textile industry is expected to continue growing strongly in Vietnam.

Production Capacity and Input Usage Patterns

Table 8. HANOSIMEX Products

Mill	Plants/Products	Unit	Annual production
1	Spinning mill 1 - PE/CO fiber - Cotton fiber	 Spindles/year Tons/year	 65,000 4,000
2	Spinning mill 2 - PE/CO fiber - Cotton fiber	 Spindles/year Tons/year	 35,000 4,000
3	Knitwear factory -Tissue - Clothes	 Tons/year Units/year	 2,500 5,000,000

Source: Engineering Department, Hanoi Import and Export Textile Company (HANOSIMEX), 1999.

Table 9. Water Use

Activity/Process	Amount of water *(cu.m. per day)*
Dyeing, cleaning and washing	2,200
Air conditioning for fiber workshop	500
Water for freezing	300
Water for heat creation	250
Water for factory cleaning	70
Domestic water	150
Total	**3,470**

Source: Engineering Department, HANOSIMEX, 1999.

Table 10. Energy Consumption

Items	Unit	Amount
Gasoline A92	Tons/year	25
Fuel oil	Tons/year	2,400
Electricity	kWh/year	50,000,000

Source: Engineering Department, HANOSIMEX, 1999.

Table 11. Chemicals and Dye-Stuff Consumption

	Dye-stuffs and chemicals	Amount *(kg/year)*	Percentage of chemicals and dye-stuffs in wastewater *(%)*	Estimated Waste Volume *(kg)*
1	Dispersed dye-stuff	539.5	15	80.9
2	Activated dye-stuff	1310.8	30	393.2
3	Direct dye-stuff	294.8	20	58.9
	Dye-stuff total	2145.1		533.0
4	Colored substances	1470	30	441
5	Other chemicals	104,055.6	100	104,055.6
	Total of chemicals	**105,525.6**		**104,496.6**

Source: Engineering Department, HANOSIMEX,1999.

Legislation Relevant to GP

Vietnamese standards as a whole do not have requirements for total loading, and some types of pollution such as industrial wastewater are not covered by standards specific to industry sectors. The following Vietnamese environmental standards are relevant to GP practices for textile factories:

- TCVN 5937-1995: Limit of basic parameters in ambient air;
- TCVN 5939-1995: The maximum limit of dust and inorganic compounds in industrial gases;
- TCVN 5942-1995: The permissible limit of parameters and concentration of pollutants in surface water;
- TCVN 5944-1995: The permissible limit of parameters and concentration of pollutants in ground water;
- TCVN 5945-1995: The maximum limits of concentration of pollutants in industrial wastewater; and
- TCVN 5949-1995: The maximum permissible limits of noise level in public area and population area.

Pollution Sources in the Textile Industry

As a typical textile company, HANOSIMEX faced pollution control challenges similar to the rest of the industry. Primary areas of concern for textile companies are air emissions, water pollution, solid waste, and chemical use. Key sources of pollution are described below:

Sources of dust, gases, and noise

- Dust from colored powder and additives in dry form released in the loading and unloading of dyestuffs;
- Dust scattering into the air from material or fibers during the dyeing process;
- Odors from chemicals or dyestuff that are volatile when heated in the dyeing process;
- Air emissions from steam boilers, oil boilers, and electric generators contain soot, SO2, NOx, CO2, and THC;

- Air emissions from transportation units contain dust, SO_2, NO_x, CO_2, THC, and lead; and
- Noise and vibrations from vehicles, electric generators, fans, and air compressors.

Sources of water pollution

- Wastewater from dyeing and finishing lines contains COD, BOD, SS, color, heavy metals, and often has a high pH value;
- Domestic wastewater from factory contains residues including suspended solids (SS), organic matter (BOD/COD), nitrogen, phosphorus, and bacteria; and
- Rainwater run-off brings soil, sand, residues, oil, and grease into the sewers.

Sources of solid wastes

- Waste packaging from materials, chemicals, paper, and fibers;
- Domestic solid waste containing mainly organic matter; and
- Sludge from the industrial wastewater treatment system.

Hazardous materials

- Chemicals (pigments, alkalinity, organic vapors, heavy metals, etc.)

To date, detailed research on the pollution impact of the textile industry in Vietnam has been limited and more investigation of GP options is required.

GP Practices Applied in HANOSIMEX

HANOSIMEX applied GP practices in a number of areas including water reuse, energy recovery, air pollution control, water pollution control, and chemical substitution. In addition, the company also established an environmental management system to help provide an overall framework for their activities. The company's production process is shown in Figure 6.

Water reuse

The company originally used 120–150 m^3 per hour of water drawn from four wells capable of supplying up to 200 m^3 per hour. To improve water reuse, the company undertook the following steps:

- HANOSIMEX counts the current flow of washing water on soaping, mercerizing machines, etc. One simple idea for water conservation is to segregate water used for cooling purposes and set up an independent closed loop system for direct and repeated reuse. The company has been reusing cooling water from the boilers. Figure 5 shows how water circulates through the factory.
- Construction of a water recycling system to save domestic water and reduce the amount of wastewater generated by the factory.

Figure 6. HANOSIMEX's Production Process

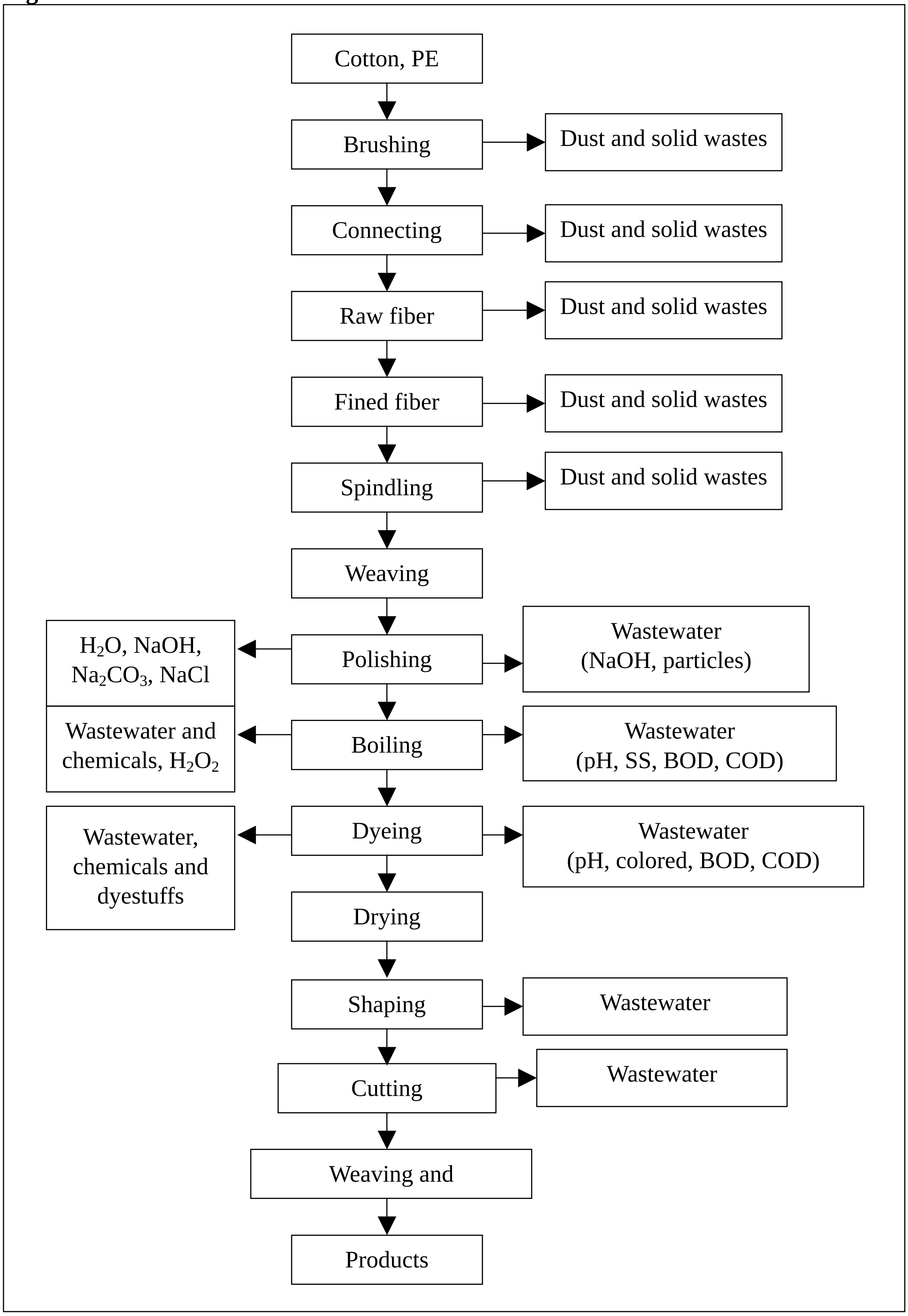
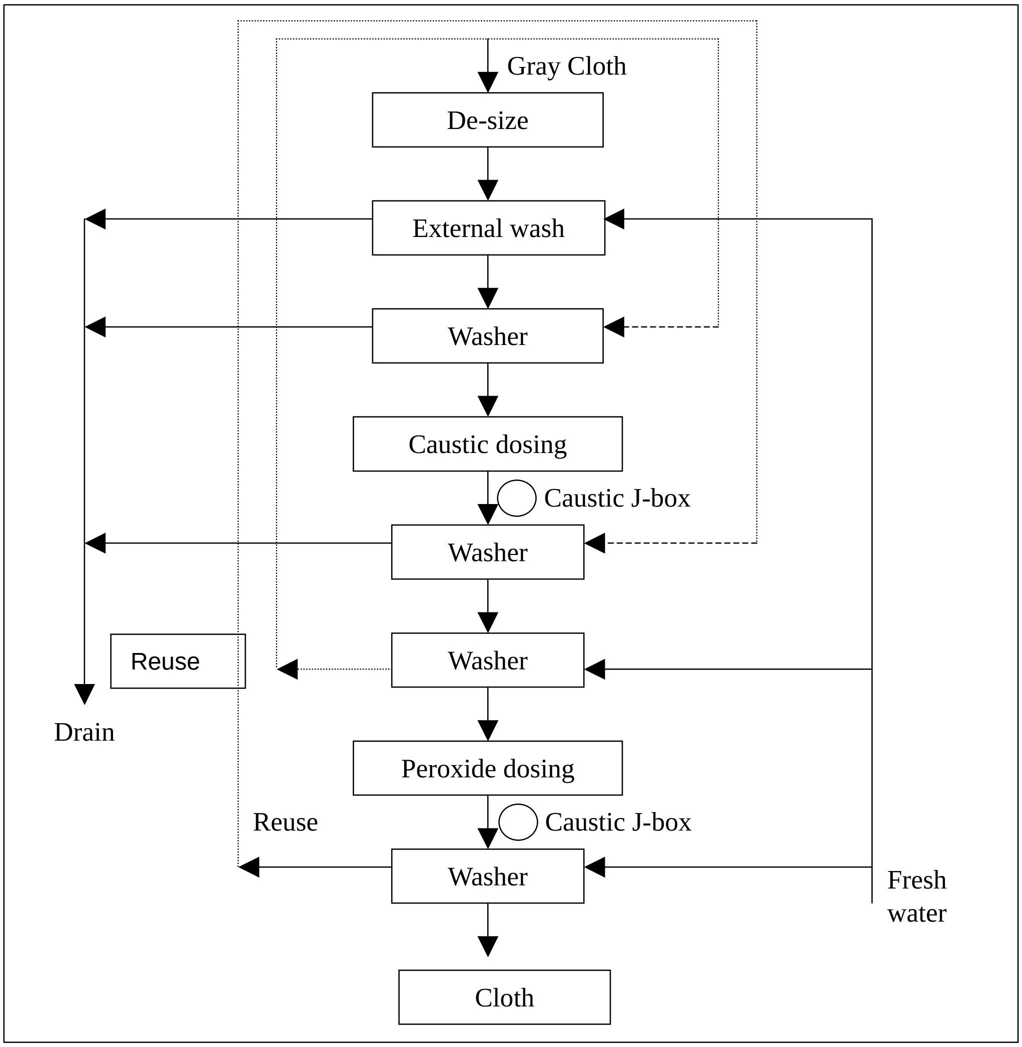


Figure 7. Water Reuse in Continuous Bleaching by J-box method



Source: Engineering Department, HANOSIMEX.

Table 12. Water Recycling in HANOSIMEX

Purpose	Amount *(cubic meters per day)*	Distribution of total water supply as wastewater	Proportion of total wastewater
Water supply	2,800–3,500		
Wastewater	2,500–2,800	84.1	
Uncontrolled wastewater (evaporate and leaching)	300–700	15.9	-
Domestic wastewater	100		3.7
Wastewater from Dyeing, cleaning and washing	1,400–1,600		56.7
Wastewater for air conditioning in fiber workshop	500		18.8
Wastewater for cooling	300		11.4
Wastewater for boilers	250		9.4
Recycled wastewater	600		-
Wastewater passed to treatment plant	1,900–2,200		

Table 13. Volume of Wastewater Recycled

Purpose	Amount *(m^3 per day)*	Recycled Wastewater *(m^3)*	Proportion *(%)*
Wastewater from dyeing, cleaning and washing	1,400–1,600	400	66.7
Wastewater for air conditioning in fiber workshop	500	100	16.7
Wastewater for cooling	300	50	8.3
Wastewater for boilers	250	50	8.3
Total	**2,450-2,650**	**600**	**100**

Energy recovery in textile manufacturing

There is a strong correlation between water and energy use in textile leaching, since a high proportion of the energy is used to heat wastewater. By reducing water consumption, significant energy savings are easily realized.

The temperature of dye bath water when discharged to the municipal sewer was 56^{o}C, causing damage to the terra cotta sewer. In 1997, the company invested a large amount of money in a heat exchange system that had a payback period of two years. To achieve adequate heat recovery, dye water is discharged into a holding vat from which it enters a stainless steel heat exchanger. Heat removed from the water is used to heat incoming feed water from the dye tubes, almost doubling its temperature from 13^{o}C to 40^{o}C. A heat exchanger to recover heat from liquid used in the dyeing process can save companies (especially dyeing companies) significant amounts of energy per year.

Fabric dyeing requires large amounts of hot water –often more than 50 times the weight of the fabric processed. The recovery of heat from used water is difficult because the water usually contains fabric particles that clog conventional heat exchangers. To overcome this problem, a heat exchanger was designed in which there was a turbulent water flow through the machine to prevent fibers from settling on the heat exchange surfaces. Some 23 cubic meters of hot water per hour pass through the heat exchanger and the water's temperature is reduced from 95^{o}C to 38^{o}C. Incoming cold water is heated from about 10^{o}C to 67^{o}C. Energy savings from the new system paid for installation costs in less than two years.

Wastewater disposal and treatment

One of the most pressing issues for the company was improving the wastewater drainage system. Figure 7 shows the redesigned system. After changing the drainage system, the wastewater treatment plant was also redesigned based on a treatment system first used by the Minhphuong Textile Company in northern Vietnam. Under the system, wastewater first flows into a regulated tank before passing into a primary sedimentation tank. Following sedimentation, the wastewater moves to a coagulation tank and then on to secondary sedimentation. By the completion of secondary sedimentation, SS, COD, BOD, and hazardous wastes will have decreased significantly. The next step in the system involves biological treatment. The wastewater enters an aeration tank with activated sludge before eventually being discharged.

Color removal can be accomplished by a number of techniques such as coagulation, carbon absorption, ozonation, and hyperfiltration. Color removal can be improved in biological treatment by adding activated powdered carbon as a catalyst to aeration basins in activated sludge systems. In Vietnam, however, the common solution is coagulation using alum ferric sulfate applied at a dose of 300–600 mg/l with lime, removing 75–90 percent of color. However, chemical coagulation does not achieve satisfactory removal of soluble dyes.

One useful technique applied by HANOSIMEX was to separate wastewater flows for treatment based on the nature of each flow. Wastewater from steps such as cleaning, dyeing, and polishing often contains hazardous pollutants such as chrome and should be treated separately from non-hazardous wastewater. In addition, HANOSIMEX also tried to reduce their wastewater treatment burden by decreasing the amount of water used in production.

Air pollution control

Air pollution posed a very complex problem for HANOSIMEX, so the company sought assistance from universities and environmental centers. The company has built two dust and organic gas treatment plants in order to minimize the impact caused by air pollutants on the surrounding community.

In order to mitigate air pollution, the company took the steps listed below.

- All heat setting equipment must be vented to a chimney;
- All machinery must be enclosed to prevent fugitive emissions;
- Products containing more than 15 percent of methyl naphthanlene, biphenyl, or orthophenyl phenol are prohibited;
- HANOSIMEX established a minimum height for stacks;
- On-line monitoring equipment must be fitted to all stacks including an alarm if smoke levels exceed the permitted standard;

- Records of the amount of dye carrier used in the plant must be kept; and
- No offensive odors or excessive smoke may be discharged from the plant.

Chemical substitution

In addition to technology/process treatments, the company also tried to improve performance through chemical substitutions and implementation of an environmental management system (discussed in the following section). Some of the substitutions implemented by the company are listed below:

- Use of synthetic detergents in place of soaps;
- Use of sodium acetate in place of soda ash for neutralizing scoured goods so as to convert mineral acidity into volatile organic acidity;
- Use of ammonium sulfate in place of acetic acid for pH adjustment in dyeing and pigment printing. Although the salt concentration of the effluent increased in this substitution, ammonium serves as a nutrient in the biological treatment process;
- Substitute emulsion thickening (fully or partially) for gum thickening in textile printing;
- Reuse of NaOH; and
- Use of NaOH in place of CH_3COOH in oxidization in dyeing and then reuse of $NaCO_3$.

At the moment, some other substitutions have been proposed such as the use of sodium bicarbonate in place of acetic acid in conjunction with peroxide or perorate for the oxidation of vat dyestuffs.

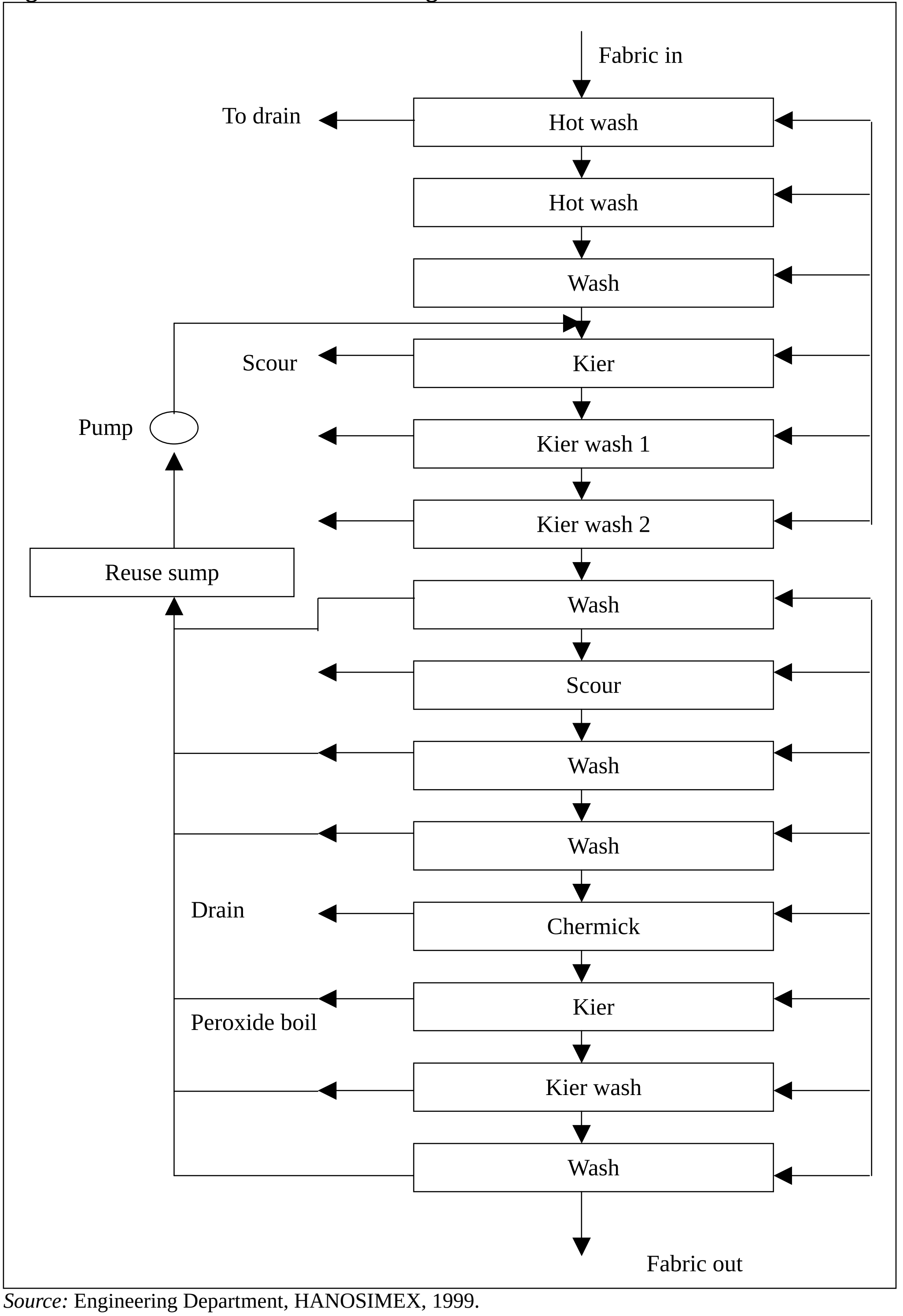
Environmental management systems

The company has established an Environmental Department with responsibility for controlling and managing overall environmental performance and minimizing impacts on the surrounding community. The Environmental Department is also responsible for ensuring the safety and health of the workers, general staff, and people living in nearby residential areas.

HANOSIMEX has proposed an environmental plan consisting of measures to mitigate, offset, or reduce adverse environmental impacts from company operations. The plan includes implementation details for the specific mitigation actions proposed. The company's Environmental Mitigation and Management Plan includes:

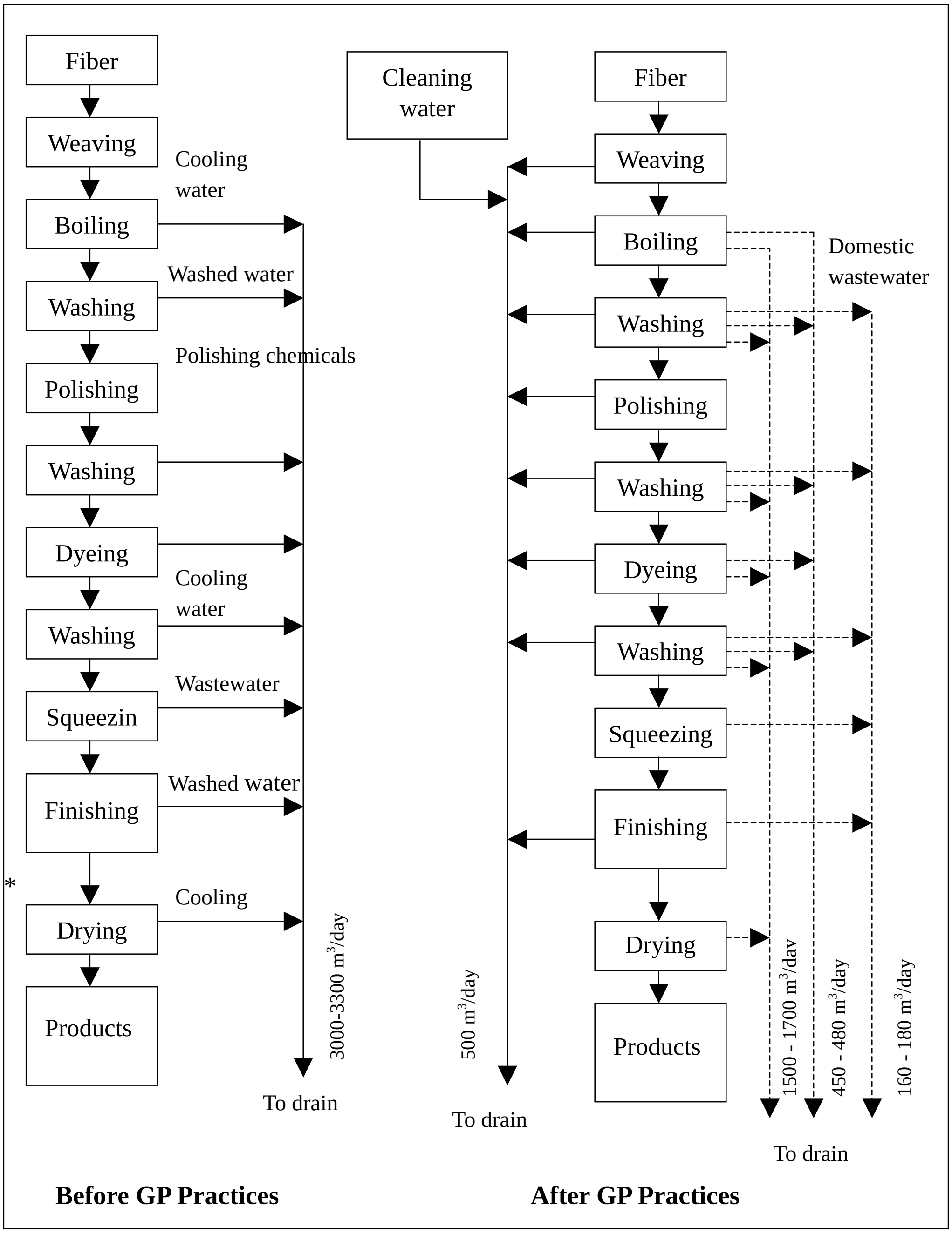
- Identification and summary of all potentially significant adverse environmental impacts from the company's manufacturing activities;
- List of specific measures to be undertaken to mitigate environmental impacts;
- Description and technical details for each mitigation measure, including the type of impact to which it relates and the conditions under which the measure is required, as well as equipment descriptions and operating procedures;
- Institutional arrangements, including assignment of responsibilities for implementing mitigation measures (i.e. supervision, enforcement, monitoring of implementation, remedial action, reporting, and staff training);

Figure 8. Water Reuse in Kier Processing



Source: Engineering Department, HANOSIMEX, 1999.

Figure 9 Wastewater Disposal Systems Before and After Implementation of GP Practices



Source: Engineering Department, HANOSIMEX, 1999.

- Implementation schedule for measures that must be carried out, including implementation phases and coordination with overall company plans;
- Monitoring and reporting procedures;
- System to ensure early detection of conditions that necessitate particular mitigation measures and to provide information on the progress and results of mitigation; and
- Integration into the total company cost tables of the cost estimates and sources of funds for both the initial investment and the recurring expenses for implementing the mitigation plan.

To strengthen environmental management capability in the departments responsible for implementation, most mitigation plans of the company cover one or more of the additional topics identified below:

- Technical assistance programs;
- Staff development;
- Procurement of equipment and supplies; and
- Organizational changes.

The plan also assigns specific responsibilities within the company regarding funding, management and training (strengthening staff capabilities), and monitoring. The company must ensure that all actions are adequately financed. Second, training, technical assistance, staffing, and other institutional improvements necessary to implement the mitigatory measures must be integrated into the overall management plan. Lastly, it is necessary to enable the sponsors and the authorities who supply funding for the plan to evaluate its success routinely as a means of improving future plans.

Results of GP Practices

Air pollution

Prior to the implementation of GP practices, HANOSIMEX's emissions were in compliance with Vietnam's environmental standards. However, pollutant loading was a considerable issue, although not directly addressed in environmental regulations.

Following implementation, total emissions (as estimated from the concentration of pollutant per cubic meter) and pollutant loading (estimated from the concentration per day or night) decreased significantly. Results are summarized in Tables 14 and 15.

Table 14. Air Quality Survey Results

Location	Dust *(mg/m³)*		CO *(mg/m³)*		SO_2 *(mg/m³)*		NO_2 *(mg/m³)*	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Dyeing workshops	0.09	0.03	0.4	0.02	-	-	0.010	Trace
Weaving workshop	0.83	0.30	0.5	0.015	0.020	Trace	0.014	Trace
Fiber workshop I	0.93	0.30	0.4	0.018	0.012	Trace	0.008	Trace
Outside (100m away)	0.46	0.32	0.2	0.010	0.015	Trace	0.012	Trace
Boiler	0.42	0.30	0.1	0.010	0.021	Trace	0.010	Trace
The road near the factory	0.38	0.22	0.6	0.028	0.430	Trace	0.020	Trace
Knitting workshop	0.28	0.20	0.2	0.020	0.020	Trace	0.010	Trace
Fiber workshop II	0.22	0.28	0.3	0.017	0.125	Trace	0.040	Trace
TCVN 5937-1995: Residential areas	0.3 0.4	0.3 0.4	40	40	0.4	0.4	0.3	0.3

Table 15. Air Pollutant Loading

Pollutants	Flow current before GP practices *(kg/day)*	Flow current after GP practices *(kg/day)*
Dust	19.25	8.00
SO_2	2.91	1.20

Water pollution

Generally speaking, the company's effluent did not meet regulatory standards in areas such as BOD, COD, grease and oil, phenol, and chrome prior to implementation of the environmental improvement plan. Following implementation, the company was able to meet the national standard. Results are summarized in Table 16.

Although the company met the Vietnam Environmental Standard based on concentration, the total amount of pollutants discharged into the environment is still an issue. An assessment of pollutant loading following program implementation is given below:[43]

- BOD = 93.5 kg
- COD = 165 kg
- Cr (III) = 2.6 kg
- Cr (VI) = 0.22 kg

[43] Calculations based on 2,200 cubic meters entering wastewater treatment plant.

Table 16. Wastewater Discharge Before and After

Items	Unit	Results		TCVN 5945/95 class B
		Before	After	
Temperature	^oC	39	39	40
pH	-	9.83	7.6–7.2	5.5–9
Color	PtCo	150	10	-
Turbidity	NTU	70	10	-
BOD	mg/l	340	35–50	50
COD	mg/l	553	65–85	100
Total PO_4^{3-}	mg/l	0.47	Trace	6
NH_4^+-N	mg/l	0.5	Trace	1
NO_2^-N	mg/l	0.2	Trace	-
NO_3^-N	mg/l	2.3	Trace	-
Total N	mg/l	8.3	-	60
Grease and oil	mg/l	2.5	0.3	1.0
Phenol	mg/l	0.06	Trace	.05
Cr (III)	mg/l	3.2	1.2	1
Cr (VI)	mg/l	0.75	0.1	0.1

Solid waste

HANOSIMEX generates approximately 88 tons of solid waste per year. Typically, 30 tons are disposed of in the municipal rubbish dump and the remaining 58 tons are reused. The company has built an on-site storage dump and vehicles from the Urban Environment Company (URENCO) collect the waste twice per week. The solid waste is then disposed of in the city's concentrated treatment plant under contract between URENCO and the company.

Noise

The environmental improvement program resulted in significant reduction in noise levels throughout the factory. Results are summarized in Table 17.

Table 17. Noise Levels in Facility

Location	Noise level *(dBA)*	
	Before	After
Dyeing workshops	80.2-82.4	60-65
Weaving workshop	72.1-75.4	60-70
Fiber workshop I	90.1-93.4	85-90
Outside (100m away)	74.9-76.6	50-60
Boiler	69.1-70.6	50-60
The road near the factory	60.3-65.5	60-65
Knitting workshop	65.1-68.5	60-65
Fiber workshop II	78.5-90	82-88
TCVN 5937-1995: Residential areas	75	75
Industrial zone	90	90

Cost–Benefit Analysis

Rental cost (C_1)

The total area used by the company is 240,000 m^2 located in a residential area in the south of Hanoi. Rent is approximately US$2 per square meter per year.

$$C_1 = 240{,}000\ (m^2) * 2\ (US\$/m^2) = US\$480{,}000$$

Healthcare costs (C_2)

- About 4,000 workers are exposed to a polluted working environment. It is estimated that approximately 20 percent of the total number of workers suffer from severe occupational diseases and other problems due to the high noise levels;
- HANOSIMEX organizes medical examinations twice per year at a cost of US$2 per worker (paid to the municipal health office). Examination fees total US$8,000 per year; and
- The cost of hospital treatment for workers with severe diseases averages US$60 each (with the medical insurance). It is estimated that approximately 800 workers per year require hospital treatment.

$$C_2 = (US\$\ 60 \times 800\ workers) + (US\$\ 2 \times 4{,}000\ workers) = US\$56{,}000$$

Environmental monitoring and control costs (C_3)

The cost of environmental control and monitoring twice per year is estimated at US$5,000. ($C_3$)

Costs of pollution impact on the community (C_4)

The company's emissions are believed to have an impact on the ambient air and water quality that in turn affects community health. Residents living near the company have complained about wastewater discharged into Kim Nguu River as well as dust, organic vapors, dye-stuff vapors, etc. The company spends approximately US$1,000 per year on community compensation. (C_4)

Energy savings (S_1)

Pre-heating operations save around 200,000 liters of fuel oil per year, equivalent to US$43,000. ($S_1$)

Water savings (S_2)

After installation of the new wastewater disposal system, HANOSIMEX's water consumption decreased by 2,650 cubic meters per day. Decreased consumption has led to savings of US$23,000 per year (based on 1998 prices). (S_2)

Total annual environmental costs

$$C = C_1 + C_2 + C_3 + C_4 - (S_1 + S_2) = US\$542{,}000 - US\$66{,}000 = US\$468{,}000$$

The company has annual revenues of approximately US$30,000,000. The National Environmental Management Board requires that companies devote 1–3 percent of their income to environmental costs. HANOSIMEX's costs are below the expected minimum. With stricter implementation of regulations, the difference between HANOSIMEX's expenditures and regulatory expectations (3 percent) could be distributed to environmental agencies or communities in the form compensation. The government is now preparing to take more serious action on the issue.

It should be noted, however, that cost-benefit analysis supplied only takes into account costs that can be counted in monetary terms. Many significant environmental problems such as the long-term impact of pollution on ecosystems and certain aspects of health impacts cannot be accounted for accurately.

GREEN PRODUCTIVITY PROMOTION IN VIETNAM

Green Productivity Programs in Vietnam

Vietnam's Green Productivity efforts began with an invitation to a group of Asian Productivity Organization experts to hold a workshop on GP practices in Hanoi and Ho Chi Minh City from April 19 to April 30, 1998. The workshops were attended by over 108 delegates from around the country. The goal of the visit was to lay the groundwork for establishment of "ecological villages" that minimized the environmental impact of human habitation.

The expert group visited three sites chosen to become model ecological-villages:

1. *Tinh Loc hamlet* - *Viet Yen District, Bac Giang Province*
   Population: 1,453 people – 278 households
2. *Kha Ly Ha hamlet* - *Cu Chi District, Ho Chi Minh City*
   Population: 1,500 people – 330 households
3. *My Chanh hamlet* - *Thai My Commune*- *Cu Chi District, Ho Chi Minh City*
   Population: 1,432 people – 270 households

All three villages relied on a mixture of farming (rice, corn) and raising livestock (pigs, chickens, cows and buffaloes) for their livelihoods.

Objectives of GP program

GP practices were developed through community education and participation. Objectives were:

- Guaranteeing clean water;
- Safe disposal of wastes (solid wastes and wastewater);

- Application of integrated pest management; and
- Development of environmental management systems.

To support efforts towards the targets, GP groups were established in each village. The GP groups used the GP methodology provided by APO to identify the optimal feasible solutions for minimizing the environmental problems and impact associated with village life.

GP options implemented

Through the methodology, the villages were able to choose a number of measures that were economical, technologically feasible and appropriate, and environmentally suitable. Options chosen for the different objectives included:

- Clean water: use water filtration technology supplied by the Scientific Institute of Materials;
- Wastes: construction of water drainage systems as well as collection and classification of solid waste for landfilling and composting;
- Development of integrated pest management to resolve issues of pesticide and herbicide use; and
- Use of environmental management system principles to establish environmental protection procedures for the province.

Benefits of GP implementation

- Resolved environmental issues and saved money;
- Increased community awareness; and
- Provided a program model that was easy to replicate in the future.

Barriers to Expansion of GP in Vietnam

GP promotion in Vietnam is still at an early stage and activities develop at a relatively slow pace. Significant barriers to future expansion include:

- Weak and unclear environmental regulations;
- Lack of a detailed policy and regulations specific to GP;
- Unwillingness of SMEs to implement GP and invest in improving environmental performance since it is a new concept with limited information available;
- Insufficient financial support available for SMEs interested in implementing GP;
- Shortage of information on environmental management methodologies and technologies; and
- Low government priority given to protection of the rural environment and application of GP to agriculture.

Recommendations for Improving GP Promotion in Vietnam

A three phase plan for improving GP promotion in Vietnam is outlined below:

Phase one

- Improve NPO understanding of GP concepts and principles;
- Identify appropriate participants for future activities;

- Develop clear information resources on the requirements and approaches for implementing GP and Cleaner Production; and
- Introduce the concept of GP throughout the country and to the SME community.

Phase two

- Identify enterprises that are in priority industries in Vietnam;
- Place priority on promoting GP to state-owned enterprises; and
- Develop a base of SMEs interested in Green Productivity through both central and provincial government agencies.

Phase three

- Establish specific, detailed policies requiring industry to implement environmental protection;
- Increase the number of SMEs engaged in GP promotional activities;
- Encourage the introduction of advanced GP technologies;
- Relocate medium-sized industries capable of causing serious pollution from urban residential areas to industrial zones;
- Reduce the number of SMEs with low production efficiency or high levels of pollution generation;
- Improve enforcement against illegal waste disposal;
- Establish specific, detailed regulations on:
    - Siting of industrial facilities;
    - EIA, environmental auditing, and post-project evaluation;
    - Upgrading environmental standards;
    - Awareness-raising activities;
    - Levying of pollution taxes; and
    - Waste disposal, discharges, and emissions;
- Implement:
    - Seminars and workshops led by international experts on GP; and
    - Training sessions for Vietnamese experts (both in-country and abroad);
- Increase the amount of information available on GP through:
    - Publications; and
    - Guidelines on monitoring and other technical issues.

Appendix 1. Basic Facts about the Socialist Republic of Vietnam

Land Area	331,100 km^2
Population *(1998 est.)*	78.5 million
Population density	237 persons/km^2
Population annual growth rate	2.2%
Population distribution	
Urban	20%
Rural	80%
Proportion of females in population	51.5%
GNP per Capita *(1996)*	US$ 311 (est.)
Land Use *(thousand hectares, 1993)*	
Agricultural land	7,350
Annual crops	5,463
Perennial crops	1,358
Grazing	232
Aquaculture	331
Forest and woodland	9,933
Health	
Infant mortality rate (1995)	34/1,000
Access to safe water (est. 1990-95)	43%
Urban	47%
Rural	42%
Access to health services (1990-95)	90%
Urban	100%
Rural	85%
Access to sanitation (1990-95)	22%
Urban	47%
Rural	16%
Education	
Primary school enrollment ratio (gross, 1990-94)	
Female	100%
Male	106%
Secondary school enrollment ratio (gross, 1990-94)	
Female	41%
Male	44%
Adult literacy rate (1994)	
Total	93%
Female	90%
Male	96%
General	
Currency	Dong
Fiscal year	1 January to 31 December

Economy

Real growth of GDP (1996)	9.3%
Annual average growth rate (1990-1995)	7.7%
GDP by main activity (1996)	
Agriculture	27%
Industry and construction	31%
Service	42%
Exchange rate (average 1996)	US$ 1 = Dong 11,020
Inflation (end-1996)	4.5%
Monetary Growth (M2, 1995)	22.6%
Public Finance (% of GDP at current market prices, 1995 est.)	
Revenue	23.9
Current expenditure	17.3
Capital expenditure	5.7
Balance of payments in convertible currency (1996 est.)	
Exports (f.o.b.)	US$ 7.3 billion
Imports (c.i.f.)	US$ 11.1 billion
Trade Deficit	US$ 3.8 billion
Current Account Deficit	US$ 2.9 billion
Convertible Currency Foreign Debt (end 1995)	US$ 6.3 billion
Convertible Currency Foreign Debt as percent of GDP (end 1995)	31%

Principal exports:	Petroleum, rice, marine products, coffee, rubber, coal, and clothing
Principal imports:	Refined petroleum, capital equipment, vehicles, fertilizers, steel, and consumer goods
Principal markets:	Japan 30%, Singapore 15%, and China 8%, Other Asia 22%

Infrastructure	
Roads	105,500 km
Of which rural roads	47,500 km
Railways	3,260 km
Total Electricity Production Capacity (1995)	14,500 bn kWh

Source: UNDP, the World Bank and IMF.

LIST OF NATIONAL EXPERTS

Republic of China

Mr. Ching Tsung Cheng
Director
Eco-Technology Development Center
CTCI Foundation
11F. No.310, Sec.4
Chung Hsiao East Road
Taipei, Taiwan 106

Malaysia

Dr. Phang Siew Nooi
Professor
Department of Administrative Studies and Politics
Faculty of Economics and Administration
University of Malaya
50603 Kuala Lumpur

Mr. Lee Kiyau Loo
Head
Green Productivity & Project Management Unit
Centre for Economic Development and Policy Management
National Institute of Public Administration
Jalan Bukit Kiara
50480 Kuala Lumpur

Mr. Foo Hee Boon
Researcher
Faculty of Economics and Administration
University of Malaya
50603 Kuala Lumpur

Philippines

Mr. Arnel D. Abanto
Director
Productivity & Development Center
Development Academy of the Philippines
P.O. Box 12788
Ortigas Center
Pasig, Metro Manila

Singapore	**Dr. Peck Thian Guan** Director Environmental Technology Centre Singapore Productivity and Standards Board (PSB) PSB Bldg. 2 Bukit Merah Central, Singapore 159835
	Mr. T. Raghavan Environmental Technology Centre Singapore Productivity and Standards Board (PSB) PSB Bldg. 2 Bukit Merah Central, Singapore 159835
Thailand	**Dr. Prasert Tapaneeyangkul** Head / Advisor Hazardous Substance Control Bureau Industrial Works Department Ministry of Industry Rama 6 Road, Bangkok 10400
Vietnam	**Dr. Trinh Thi Thanh** Doctor Faculty of Environmental Science Hanoi National University 144, Xuan Thuy Road Cau Giay District, Hanoi
	Mr. Tran Yem Master Faculty of Environmental Science Hanoi National University 144, Xuan Thuy Road Cau Giay District, Hanoi
	Ms. Nguyen Thi Bich Hang Director Directorate for Standards & Quality Vietnam Productivity Center Hoang Quoc Viet Street Nghia Do-Cau Giay, Hanoi
	Mr. Luong Quang Huy Assistant Faculty of Environmental Science Hanoi National University 144, Xuan Thuy Road Cau Giay District, Hanoi