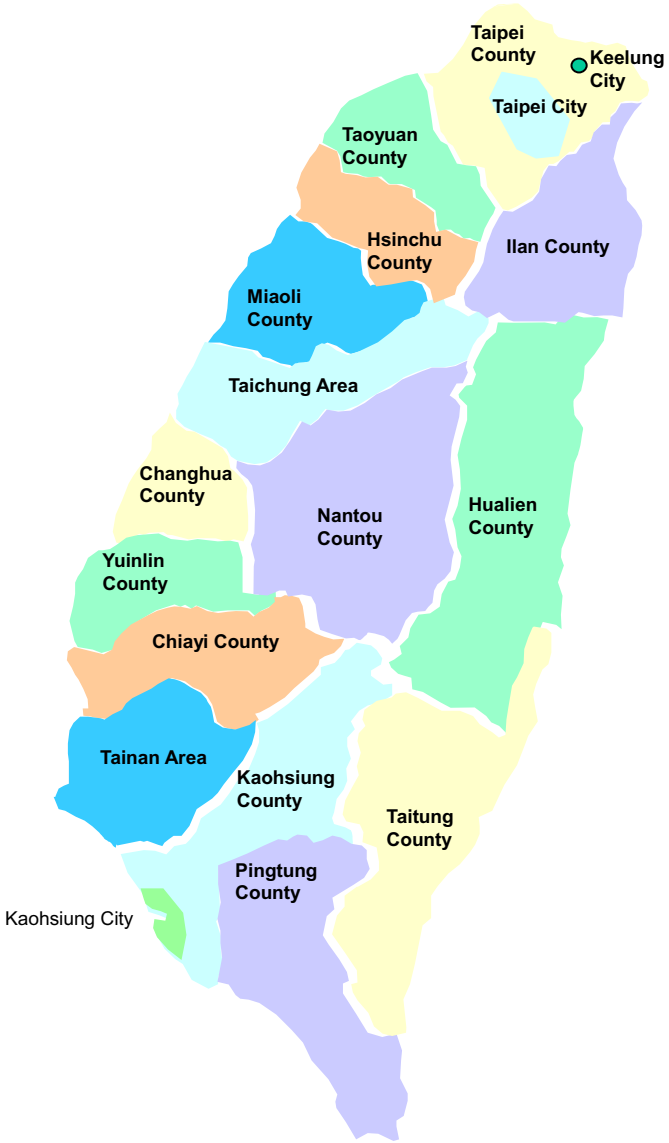
Chinese Taipei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Kaohsiung City

Towards Zero Waste Society. New Management Policies for Solid Waste Disposal in Chinese Taipei

Dr. Harvey Houng, *Advisor, Department of Solid Waste Management, Environmental Protection Administration*
Policies and Measures of Waste Disposal and Treatment in Taiwan.

Dr. Stephen S.H. Shen, *Commissioner, Department of Environmental Protection, Taipei City Government*
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Policies and Measures of Waste Disposal and Treatment in Taiwan

Dr. Harvey Houng

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Foreword

Taiwan is an island with dense population but limited available space. During the 1950s, light industries started to take off in Taiwan. During the 1960s, the industrial focuses shifted to the expansion of export trades. Despite these industrial developments, Taiwan remained an agricultural society with simple styles of living and consumption. There were no large-scale factories and the wastes produced by industries and household were few and of a simple nature. Wastes back in that time were mostly disposed of in open space. Yet, such treatments did not result in serious environmental concerns.

During the 1980s, the industries of science and technology began to develop. The quality of life was significantly improved and the number and types of consumer products increased greatly. The average GNP (gross national product) rose to USD3993, up from USD443 in 1970. For the general public, their habits and attitude about life and living changed greatly from a simple one to a lifestyle of easy spending and high consumption of resources. Until the 1990s, the GNP already exceeded USD8000 and the living standard was further elevated. But as Taiwan was gradually entering the age of industrialization, both the industries and economic developments became more diversified. Thus, the composition of wastes was of a more complex nature, with the quantity (weight) increasing year by year. Problems caused by wastes started to emerge.

Although industries in Taiwan were booming, the weight of industrial wastes (including hazardous waste) was far greater than that of garbage. Furthermore, the Qi-Shan River Incident that took place in 2000 had a huge and negative impact on the source of drinking water. This incident victimized 2 million people and attracted wide attention from all over the nation.

Compared to other countries around the world, Taiwan, with its dense population and limited land space, bears a greater environmental burden. Wastes have resulted in heavy environmental burden for the people in Taiwan and will profoundly affect their life styles and the right of living for the generations to come. Therefore, how to use resources wisely and achieve sustainable developments had become an issue plaguing both the government and people.

The Output of Waste

After years of efforts, which include the establishment of rules and regulations, the promotion of resource recycling, environmental education and campaigns, and the monitoring of the flow of waste, waste management in Taiwan has seen tremendous progresses and is continually improving.

Table I shows the collected data of the amount of waste for the past two decades. The amount

of garbage in Taiwan increased yearly from 1981 to 1997, due to improved living standards. The amount of garbage was 3,560,000 tons, 50,900,000 tons, and 52,400,000 tons in 1981, 1986 and 1991, respectively. It reached its peak of 88,800,000 tons in 1998. Since then, the amount of garbage had been decreasing, and the figure dropped to 72,600,000 tons in 2001. With regard to the amount produced per capita per day, the number increased yearly from 0.630kg in 1981 to 1.143kg in 1997 and started to decline afterwards. In 2001, the amount of garbage produced per capita per day decreased to 0.895kg, indicating that government campaigns on garbage minimization and recycling were significantly effective.

Table 1: Garbage Collection

Year	Amount of garbage cleaned and transported		Amount of garbage cleaned and transported per capita per day	
	(per 10,000 tons)	Change (%)	(Kilograms)	Change (%)
1981	356	-	0.630	-
1986	509	+42.95	0.770	+22.22
1988	590	+15.81	0.860	+11.69
1989	626	+6.11	0.896	+4.19
1990	684	+9.36	0.963	+7.48
1991	724	+5.76	1.001	+3.86
1992	800	+10.53	1.087	+8.68
1993	822	+2.70	1.101	+1.25
1994	849	+3.35	1.121	+1.84
1995	871	+2.53	1.138	+1.47
1996	874	+0.33	1.135	-0.26
1997	888	+1.65	1.143	+0.77
1998	888	0.00	1.135	-0.75
1999	857	-3.54	1.082	-4.63
2000	788	-8.06	0.976	-9.78
2001	725	-7.88	0.895	-8.40

According to the statistics provided by the Environmental Protection Agency (EPA) in Taiwan, the annual output of industrial waste in 2000 was about 39,900,000 tons, a figure five times the amount of general household waste. Most wastes were generated by industrial, construction and agricultural activities (Ratio: 3:2:1) (Table 2)

Table 2: Enterprise Waste (2001, Unit: per 1,000 tons)

Type	General waste	Hazardous waste
Industrial waste	19,310	1,608
Medical waste	70	13
Agricultural waste	6,540	0.003
Construction waste	13,620	-
National defense waste	50	0.0745
School laboratory waste	50	1.95
Urban sewage treatment plants sludge	250	-
Total weight	39,900	1,624

Before the "Waste Disposal Act" was modified in 1999, industrial wastes were collected and disposed of by companies that produced them. The government was not actively involved during this time in Taiwan. The EPA, however, did participate and aid the establishment and operations of private waste clearance companies. Unfortunately, it did not work out due to the hostility among the competitive companies and the lack of stiff penalties for violators. After the Act had gone through three modifications in 1999, 2000 and 2001, liabilities for polluting the environment were more clearly defined in the Act. Moreover, mandatory on-line reporting was given the basis in law, strengthening the mechanisms of examination and control. Thus, the management of industrial wastes was made sound and comprehensive.

Waste Treatment

General Household Waste

With the improvement of the quality of life, the policies for the disposal of garbage in all stages of the network were concurrently modified. In earlier times, garbage in Taiwan was mostly disposed of as landfill or dumped in open space. In 1985, the disposal rate of garbage was

as low as 2.4%, creating numerous problems of garbage disposal. Stories of stacking garbage on the streets were not unheard of. To effectively solve these problems, the Executive Yuan, in 1984, drafted and promulgated "The Guideline to the Disposal of Urban Garbage". The Guideline set up a 6-year plan for garbage disposal and subsidized the local governments for building garbage disposal facilities. Six years after the Guideline was implemented, 179 garbage landfill sites were built and the disposal rate of garbage increased from 2.4% to 56%. The Guideline was indeed effective and efficient for solving the problems of garbage disposal and the improvement of the living environment. However, the method proved to be yet another problem when the landfills consumed a great amount of the already limited land resources in Taiwan. To address this problem, the Executive Yuan, in November 1999, drafted and promulgated another guideline entitled the "Guideline to Garbage Disposal". The new Guideline set out the direction for garbage disposal, aiming on "incineration first; landfill as the alternative". Based on this Guideline, the government invested in 21 public-owned garbage recycling (incineration) plants, processing 21,900 tons of garbage per day. And again in March 1996, the "Guideline to Encouraging Public and Private Businesses to Build and Operate Incineration Plants" was passed. Based on this Guideline, 15 non-government invested garbage recycling (incineration) plants were proposed to be built (the figure was revised to 11 after evaluations). These 11 plants will be able to process 5,500 tons of garbage per day. In 2002 (6 years after the Guideline was implemented), 19 large-scale incineration plants were completed and the rate of garbage incineration (as a method of disposal) increased to 48% with the percentage of landfill relatively dropping from 92% to 44%. With regard to the disposal rate of garbage, the number had risen from 60% in 1987 to 93% in 2001 (Table 3).

Table 3: Methods of Garbage Treatment (Unit: %)

Year	Total	Recycling	General landfill	Sanitary landfill	Incinera-tion	Compost-ing	Stack-up	Others	Disposal rate of garbage
1981	100.00	-	76.13	2.50	1.30	20.07	-		
1986	100.00	-	87.05	1.37	0.75	10.83	-		
1989	100.00	-	30.38	58.61	1.36	0.20	9.45	60.17	
1990	100.00	-	29.90	58.14	1.14	1.65	9.17	60.93	
1991	100.00	-	33.28	59.72	0.40	0.08	6.52	60.20	
1992	100.00	-	26.86	63.59	3.19	0.10	6.27	66.88	
1993	100.00	-	29.81	61.59	3.03	-	5.21	64.98	
1994	100.00	-	24.24	65.64	4.86	0.02	5.25	70.52	
1995	100.00	-	29.14	50.10	14.94	0.07	5.74	65.11	
1996	100.00	-	23.93	55.22	15.62	0.03	5.20	70.87	
1997	100.00	-	17.30	57.76	19.05	0.16	5.73	76.97	
1998	100.00	1.24	12.11	62.25	19.36	0.00	3.30	1.73	82.86
1999	100.00	1.72	9.84	61.58	23.18	0.22	2.81	0.64	86.71
2000	100.00	5.75	8.34	45.75	38.66	0.03	1.43	0.06	90.17
2001	100.00	7.46	5.53	38.23	47.68	0.01	0.91	0.18	93.35

The 1st phase of "Disposal of Urban Garbage Project" focused on the setting up of standardized garbage landfill sites, the creation of a correct concept about garbage disposal and the improvement of environmental hygiene. The 2nd phase revolved around the policy of "incineration first; landfill as the alternative", aiming on the well management of garbage disposal and the formation of the ideas of garbage minimization and resource recycling. Moving into the 3rd phase, the main focus of the Project shifts to the promotion of garbage minimization and resource recycling, and the main objective is to build a sustainable living environment. Meanwhile, the follow-up projects of garbage disposal put emphasis on garbage minimization at the source and the recycling and reusing of resources.

Recycling

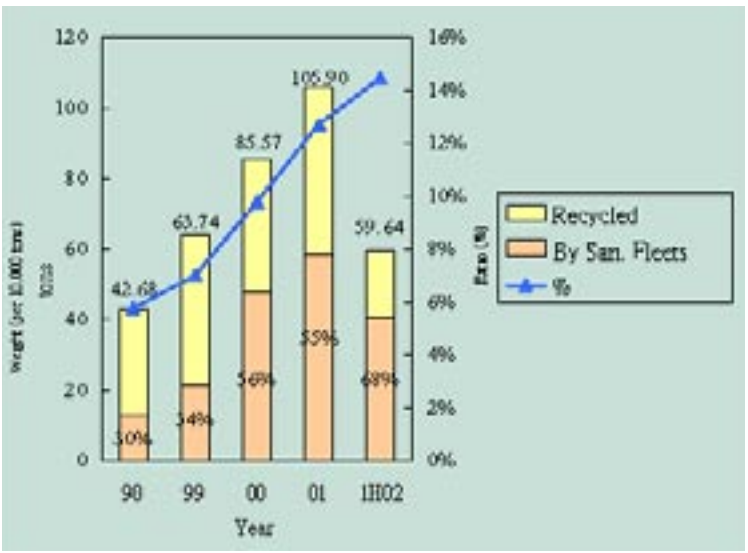
In earlier times, the work of resource recycling was done mainly by street scrap collectors (the used goods recycle system). As the amount of garbage kept increasing every year, the government modified the "Waste Disposal Act" in 1988, requiring all manufacturers and importers to bear the responsibilities of garbage disposal and recycle. The 1997 modification of Article 10-1 of the Act brought about an important change to the recycle operation in Taiwan. Manufacturers and importers are asked to pay fees for garbage disposal and clearance. The fees are collected and managed by the Resource Recycling Foundation Committee from the government.

Currently, 15 categories (of 32 items) are proclaimed as regulated recyclable waste, namely waste iron containers, waste aluminum containers, waste paper containers, waste plastic containers, agriculture waste containers, waste dry batteries, waste cars and motorcycles, waste tires, waste lead-acid batteries, waste lubricants, waste home appliances, waste computers, waste plastic bubble sheets (for packaging) and waste fluorescent light tubes (straight tubes only).

Relevant recycle channels have been put in place for the entire afore-mentioned general regulated recyclable waste items. These channels include the recycle vans of the responsible government agencies (the sanitation fleets), recycle spots set up by retailers, and private recyclers. The regulated recyclable waste is subsidized by the recycling management fund. Waste paper, used clothing and other metals, though not proclaimed as regulated recyclable waste, can still be recycled by the sanitation fleets or private recyclers for their values of recycling and reuses.

According to relevant statistics, the amount of garbage produced in Taiwan increases in tandem with the economic growth. However, negative growth (of the amount of garbage) was beginning to be seen from 1988. On the contrary, the amount of resource recycle has been increasing yearly from 427,000 tons in 1998 to 1,059,000 tons in 2001. The rate of recycling also rose from 5.78% to 12.72%. For details of the yearly growth of the recycling rate, please refer to Figure 1.

Figure 1: Year-on-Year Growth of Recycling



Enterprise Waste

In 1998, the EPA drafted the "Plan for the Control of Enterprise Waste". According to this plan, the Industrial Waste Control Center (IWCC) was set up in order to fully control and track the flow of industrial waste and the medical waste. According to the statistics gathered in 2000, the total amount of enterprise waste for the whole year was about 39,900,000 tons, of which 69.7% was recycled and reused, 30.3% remained to be disposed of, 12.2% was waiting for intermediary processing prior to being disposed of and the remaining 18.1% (72,200,000 tons/year) was dumped in the final disposal sites (Table 4).

The amount of enterprise wastes generated in Taiwan every year falls near 39,900,000 tons. The amount of general household waste generated annually is roughly 8,310,000 tons (including non-recycled garbage of 7,250,000 tons and recycled garbage of 1,060,000 tons). As a result,

Table 4: Amount of Enterprise Waste Nation-wide and the Relevant Statistical Chart on the Treatment Weight

	Total Amount (ton/year)	Reused/ Recycled (ton/year)	Remaining (to be treated) (ton/year)	Existing intermediary treatment facilities (ton/year)
1.Industrial waste	19,312,072 (48.40%)	11,369,091 (58.9%)	7,942,981 (41.1%)	2,564,061 (13.3%) Incinerated: 2,518,352
2.Science- based Park (Hsin-Chu)	57,950 (0.15%)	—	57,950 (100%)	Out contracted to waste treatment companies
3. Medical waste	74,664 (0.19%)	22,392 (30%)	52,272 (70%)	48,072 (64.4%) Incinerated: 48,072
4. Agricultural waste	6,538,676 (16.39%)	4,831,404 (73.9%)	1,707,272 (26.1%)	1,627,363 (24.9%) Incinerated: 33,805
5.Construction waste	13,618,921 (34.13%)	11,590,830 (85.1%)	2,028,091 (14.9%)	382,065 (2.8%) Incinerated: 382,065
6. National defense waste	52,700 (0.13%)	7,506 (14.2%)	45,194 (85.8%)	44,193 (83.9%) Incinerated: 44,193
7. School laboratories waste	950 (0.002%)	—	950 (100%)	Mostly out contracted to waste treatment companies; only few are treated by the generators.
8. Urban sewage treatment plants sludge	247,359 (0.62%)	247,359 —	210,424 (100%)	(85.1%) Incinerated: 210,424
Total	39,903,292 (69.7%)	27,821,223 (30.3%)	12,082,069 (12.2%)	4,876,178 ncinerated: 3,236,911

the total amount of waste generated in Taiwan annually is 48,210,000 tons. In these figures, 12.7% of general household waste and 69.6% of enterprise waste can be recycled and reused, driving the average rate of resource recycling to 59.8%. The remaining amount (72,550,000 tons for general household waste and 12,080,000 tons for enterprise waste) is thus the amount that is to be treated (disposed of). This sums up to a total of 19,335,000 tons a year. The capacity of existing incineration facilities is 77,200,000 tons per year. Once new incineration plans are completed, general waste can be fully incinerated and then disposed of. However, the currently handling capacity for industrial waste is 48,760,000 tons per year only, which means that more facilities must be built to handle the remaining 72,200,000 tons per year.

Currently, relevant government agencies are campaigning on various projects regarding the management of waste. The EPA is also actively involved in managing the storing, treating and disposing of enterprise waste in the country, strengthening the work of baseline establishment of waste generators, management of waste sources and the monitoring and tracking of waste. To solve the problems of enterprise waste, it needs a closer monitoring of public and private businesses from the environmental agencies and a tighter control of the flow of industrial waste. Moreover, the planning and management of treatment of disposal facilities should be improved to ensure a better handling of all types of hazardous waste.

Waste Treatment Policies and Management

The following policies have been drafted in consideration of the purpose of a comprehensive management of waste, the sustainable use of resources, and the cooperation with the international community on "zero waste":

General Garbage and Resource Recycling

1. Recycling:
(1) To include more items as "regulated recyclable waste".
(2) With the mechanism of a market economy, garbage generators and resource recycling facilities should collaborate. This means that the community, local government garbage collection teams, recycling businesses and recycling funds should work together for resource recycling.
(3) According to the newly promulgated "Resource Recycling and Reuse Act", businesses are required to recycle and reuse renewable resources.

2. Food Waste Recycling:
(1) To work with COA (Council of Agriculture, Executive Yuan) on relevant food waste regulations in the Fertilizer Law and substitute measures of feeding the pigs with steamed or cooked food waste.
(2) To subsidize local governments for buying food waste trucks in order to facilitate food waste hauling.
(3) To subsidize local governments or encourage the private sectors (such as Kaouhsiung City and Dong-Shi Town in Yun-Lin County) to set up food waste recycle and process facilities.

3. Non-incinerable Garbage: Sorting and selection facilities are built in large-scale incineration plants to recycle and reuse resources and non-incinerable materials.

4. Bulky Items: To subsidize local governments to build bulky resources recycle plants and to establish the system of the recycle and clearance of bulky garbage. Privatization of such facilities will be introduced and implemented gradually.

5. Policy Instruments
(1) Mandatory garbage sorting: to help all local environmental protection bureaus to draft the "procedures of sorting, recycle and clearance of general household waste". To gradually educate the people, schools, institutions and groups on

ways of sorting, storing, releasing and recycling of recyclable garbage according to the channels of recycling.
(2) Per-Bag Trash Collection Fee Policy: To assist all local governments in mapping out the relevant operation procedures and fee-collecting methods. This will help to achieve fair treatment of fee collection and the objectives of resource recycling and waste minimization.

Enterprise Waste

1. To strengthen the mechanisms of the "Industrial Waste Control Center"
The "Industrial Waster Control Center (IWCC) " was established in 1998 and expanded in 2000. The IWCC is responsible for coordinating issues related to industrial waste (including reusable industrial waste) and medical waste. Examples of the issues include data entry, monitoring and reporting of irregularities, statistical work and planning on-site surveillance and enforcement activities. During the earlier days of its establishment, the IWCC closely monitored the amount and flow of raw materials, products and waste generated by the top 1000 businesses in Taiwan. The figure increased to more than 10,000 businesses in 2002. In addition, transporting vehicles hauling liquid hazardous waste are equipped with Global Positioning Systems (GPS) to keep track of illegal or improper behaviors. Trial runs of bar code of waste are also being carried out, aiming on the electronification of the management of industrial waste.

2. To assist waste minimization, life cycle analysis, and green design
To continue with the campaign of industrial waste minimization that includes: to draft the plan for the promotion of industrial waste minimization; to incubate skilled labors in the field; to set up the guidance system; to campaign on waste minimization and encourage industries to follow suit; to introduce new technologies and boost international cooperation; to assist businesses in waste minimization, life cycle analysis and green design; to reduce the cost of waste treatment; to strengthen the products' competitiveness in the international markets.

3. To promote the Cooperate Synergy System for of industrial waste minimization
To build Cooperate Synergy System that boosts the cooperation between central plants and satellite plants. Based on the feature that central plants (giant businesses) and satellite plants (small-to-medium-sized businesses) co-exist and co-develop, the system's production chains will be utilized to improve the management, minimize waste, save water and replace raw materials with less toxic ones. This will create benefits for environmental protection, industrial safety and the economy.

4. To promote the ISO14000 environment management system
ISO14000 is presently the most authoritative recognition system in the international community. We aim to follow with the overall development of the international standards, to establish a recognition and verification system that is compliant with the systems used in the international community, to obtain international recognitions and to develop a comprehensive domestic environmental management system. Currently, more than 800 businesses and manufacturers have gained the ISO 14000 recognition, attracting positive feedbacks and suggestions from the international community.

5. To upgrade the function of the Industrial Waste Information Exchange Center (IWIEC)
The IWIEC has been established for more than a decade. This IWIEC not only helps to multiply the opportunities of matching and re-using waste, but also expands the resource recycle and reuse market. The exchangeable waste can be divided into 18 categories, namely as organic chemicals, inorganic chemicals, organic solvent, oil and wax, metal, plastic, leather, wood, paper, lime-ash, mineral waste residue, sludge, etc. The amount that was successfully exchanged increased from 5,539 tons (per year) in 1997 to 33,511 tons (per year) in 2001, and further increased to 37,720 tons (per year) in 2002.

Conclusion

As the natural resources on the Earth are waning and the cost of garbage disposal keeps rising over time, waste disposal policies at the current stage no longer emphasize on traditional disposal methods such as mixed incineration or mixed landfill. The focuses have shifted to measures such as minimization at the source, sorting, separation of dry and wet garbage, pre-treatment, and transferring of garbage from remote areas. Moreover, with the policies of front-end prevention (restricting the use of plastic shopping bags and plastic disposable dishes) and the back-end per-bag trash collection fee, households are rewarded to reduce the amount of garbage. In addition, communities are encouraged to set up garbage self-disposal (by the community) systems or other flexible or diversified methods, aiming to ease the pressure on back-end treatment and induce the recycling and reuse of materials. In 2001, Taiwan drafted and promulgated the "Resource Recycle And Reuse Act", speeding up the formation of "recycle society". With the principle of "extended producer responsibility", businesses and institutions are required to work on the "green design" and "life cycle analysis", and to set up the "environment management system" to meet the future needs of environmental protection from the international markets. The attitudes toward waste disposal should also be changed. Those being said, the government will also assist the Center for the Exchange of Industrial Waste Information and the establishment of the Cooperate Synergy Systems, and subsidize the R&D of new environmental technologies. All of these measures help businesses establish corporate images and increase the competition in the international markets.

In consideration of the solutions to the ever-serious problems of waste disposal and the sustainability of resources, countries around the world have been campaigning on the concept of "zero waste". The theory of it is that the ecology was originally of a "zero waste" model. Human beings should imitate this model and build a recyclable ecosystem that contains no waste. This concept is now booming in Taiwan. Although certain difficulties will be met with regard to the adoption and implementation of the strategies and policies of "zero waste", with people's perception, cooperation from the private sectors and the conservatism of the public sectors being the main obstacles, we should still actively strive to establish concrete policies and objectives for campaigns, strict law enforcement and the encouragement of innovation and trials. The human activities have become the biggest cause for damages and crises brought about by the "throw-away society". The problems of waste are also endangering the sustainability of the global environment and creating a heavy burden for the generations to come. Our natural resources are so scarce and precious that we must work in tandem with the global trend to achieve the "zero waste" world. ■

Waste Management Policies and Services in Taipei

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Commissioner
Department of Environmental Protection
Taipei City Government

Taipei City

Geography and Population

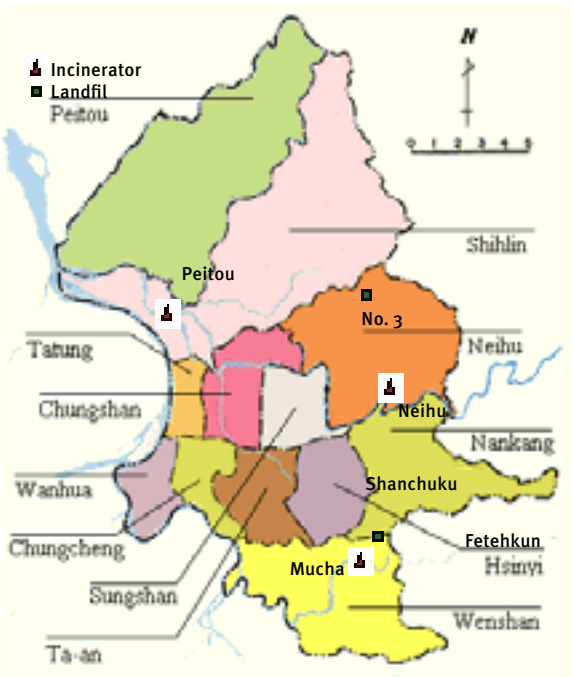


Figure 1: Taipei City

Taipei City is nestled in the Taipei Basin of northern Taiwan, surrounded by Taipei County at its borders. Situated in the subtropical zone, summers of Taipei are characterized by scorching heat and frequent thundershowers, while winters are cold and accompanied by drizzles. Taipei is surrounded by foothills and mountains in the northern, eastern and southern sides. Besides, the city enjoys a rich water system consisting of Tanshui River, Keelung River, and the Jingmei Creek.

The total area of Taipei is 272.14 km2, and is divided into twelve administrative districts (Figure 1). 46.56% of the city s total area has been developed. The households in Taipei are getting smaller. Taipei registers a population of 2.63 million, which is roughly 12% of the total population in Taiwan.

Business and Industry Profile

92.3% of businesses based in Taipei belongs to the tertiary industry; namely, commerce, transportation, finance, and service industries. Adding up the population working and living in Taipei, there are more than 3 million people in and out of Taipei everyday, thus a huge amount of trash is generated each day (Table 1).

Table 1: Annual Waste Volume and Average Waste Volume Per Capita Per Day

	Waste Volume Collected by TDEP Team		Waste Volume Collected by Private Operators		Total	
Yr	Annual total (tons)	Average (kg per capita per day)	Annual total (tons)	Average (kg per capita per day)	Annual total (tons)	Average (kg per capita per day)
82	1,298,026	1.34	90,695	0.09	1,388,722	1.43
83	1,302,850	1.35	101,730	0.11	1,404,581	1.45
84	1,234,141	1.28	133,610	0.14	1,367,752	1.42
85	1,260,147	1.32	156,615	0.16	1,416,764	1.49
86	1,193,511	1.26	169,553	0.18	1,363,065	1.44
87	1,030,682	1.07	443,606	0.46	1,474,289	1.53
88	1,069,201	1.11	293,186	0.31	1,362,388	1.42
89	870,993	0.90	333,026	0.34	1,204,020	1.25
90	687,363*	0.71	360,407	0.37	1,047,770	1.08
91	625,487	0.65	285,297	0.30	910,784	0.95

*: Excluding 190,645 tons of trash caused by Typhoon Nari

Due to the dense population and limited spaces in Taipei, the land available for waste disposal is difficult to find. To thoroughly solve the waste problem in Taipei, and at the same time, search for a plan of implementation capable of sustainable development, Taipei City Government (TCG) is undertaking a great deal of improvements in waste management in the past few years.

Current Status of Waste Management in Taipei

Current Status of Waste Disposal and Resource Recycling

Trash in Taipei City is collected through a Off ground curbside pickup system since 1996. Taipei City Government Department of Environmental Protection (TDEP) is currently offering a household waste collection service six days a week. Residents are required to take out the waste to designated locations, at a specific time and dump them in the garbage trucks that arrive on site. In the meantime, we also offer a recyclable collection program three times a week. Recyclables will be collected by pickups that follow garbage trucks and taken down to the private sorting facility for further sorting and recycling. TDEP has outsourced two private companies for sorting and recycling. Effective manual sorting is capable of handling approximately 120 tons of recyclables per day.

Brief Introduction to Waste Management Facility

Limited by the City's high population and lack of available land space, the City Government initially adopted a waste disposal strategy favoring incineration as the primary treatment method and landfill as secondary. The city currently has three large-scale waste incinerators, the Neihu Plant with installed daily capacity of 900 tons, the Mucha Plant with installed daily capacity of 1,500 tons and the Peitou Plant with installed daily capacity of 1,800 tons. The City's current Shanchuku Sanitary Landfill, opened in June 1994 with an installed capacity of more than 6 million cubic meters, is estimated to reach capacity in 2007. Non-combustible waste, incinerator bottom ashes and fly ashes after solidification

are using landfill as final waste disposal method. Planning and environmental impact assessments are currently underway at the selected site for Taipei City's third sanitary landfill.

Implementation and Progress of Waste Minimization Policy

Per Bag Trash Collection Fee Policy

To achieve waste reduction, Taipei City started with implementing the Per Bag Trash Collection Fee policy. Trash collection fee is used for the disposal of trash. Based on the polluters pay philosophy, all residents should pay to have their trash collected by city crew, and the TDEP certified trash bag is used to measure their trash volume. Residents are required to load the trash in the TDEP certified trash bags before handing over to the collection crews. To encourage recycling, recyclables are collected for free, no need of certified trash bags. In this case, throw less pay less, recycle and save more.

Recent Progress on Waste Reduction

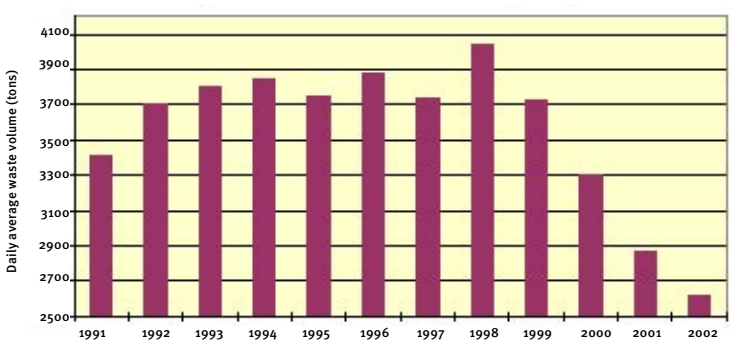
Up to the end of 2002 PBTCH policy has been implemented for 30 months since July 1st 2000. Excluding Typhoon Nari s effect, the average daily waste volume is 2,649 tons (includes household waste volume, waste volume collected by private contractors, yet excludes treated sludge and construction waste), an average of 0.95 kg per capita per day. Compare with 1999 data before implementing PBTCF, the average daily waste volume is 3,695 tons, an average of 1.41 kg per capita per day. Daily waste volume dropped 1,046 tons, and waste reduction rate reaches 28.3%.

If we specifically look at the household waste volume collected by TDEP collection crews, the average daily waste volume is 1,805 tons, an average of 0.65 kg per capita per day. Compare with 1999 data again, the average daily waste volume is 2,970 tons, an average of 1.13 kg per capita per day. Daily waste volume dropped 1,165 tons, thus the waste reduction reaches an even higher at 39.2%.

Recent Progress on Resources Recycling

After implementing PBTCF policy, the volume of recyclables increases dramatically up to an average of 153 tons per day, more than 80 tons of recyclables per day, i.e. a 100% increase, were collected comparing with 1999 data. This progress greatly encourages the recycling business. Most apartment buildings, schools and governmental offices tend to sale their recyclables to the private contractors. In order to fully understand the actual situation for the volume of the recyclables, TDEP started to keep track of the volume collected from the private contractors. Statistic shows that the total volume of recyclables collected in 2002 from both TDEP collection crews and private contractors is 19,079 tons, and the total recycling rate is 20.4%. It is obvious that PBTCF strategy successfully reached the goals for waste reduction and resources recycling.

Figure 2: Waste Reduction in Taipei City



Reduction from the Source Program

Currently, there is a portion of trash generated that can be eliminated simply through consumer choices. The Per Bag policy provides an economic

incentive for consumers to select products, which generate less trash. At the same time, another portion of trash generated can only be eliminated by requests from manufacturers or retailers. TCG is actively working with central government EPA in promoting Restricted use of plastics bags and disposable products program to reduce waste from the source. It is estimated to cut down the usage of plastic bags by 31% and plastic (Styrofoam) utensils by 37%. The usage of plastic raw material is estimated to reduce approximately 36,000 tons in Taiwan, in which 15% is consumed by Taipei.

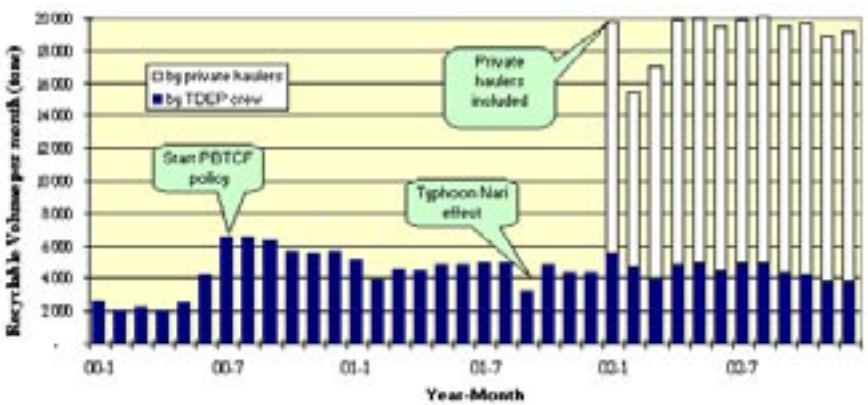
Beginning last July, plastic bags (i.e. thickness less than 0.06mm) and disposable products were no longer provided at governmental offices, schools, publicly owned businesses and military organizations. And starting this year, department stores, wholesales, supermarkets, convenient stores, fast food chain stores, and restaurants joined in. Just before the date of start to crack down the violators, a poll results shows that except for restaurants with compliance rate of roughly 50%, all others reached remarkably over 90%.Such terrific outcome is testimony to the power of environmental awareness.

Green Procurement Program

Green Procurement aims at helping governments achieve their environmental policy goals while meeting their budget lines. By investing in environmentally and economically sound products and services, thus avoiding unnecessary follow-up costs, public institutions can save significant amounts of money. At the same time, they contribute to a healthy and sustainable environment by reducing their direct environmental impact significantly, and by exerting a model function towards other consumers. Our country is one of the few that passed the law necessary to implement green procurement. In addition, we have achieved with great success in promoting eco-label system.

TCG Green Procurement Program was developed in accordance with national policy to purchase equipments and office supplies with eco-label. Seminars were frequently organized to enhance the knowledge on green procurement. In 2001, the outcomes of TCG in purchasing green products reached a satisfactory 55%. We set a target to reach 80% by year 2006.

Figure 3: Chronological Data of Recyclables in Taipei



Zero Waste To Landfill Event Campaign

Recent attempt from the Office of Resources New South Wales demonstrated a Waste Wise Festival with absolutely no waste from the festival going to landfill was achievable. City Government then applied this brilliant idea to 2003 Taipei Lantern Festival to show our citizens that you can enjoyable yourselves, while at the same time, without leaving a great deal of trash behind. A Three s company recyclable bin was specially designed for the occasion to collect recyclables, non-recyclables and food waste for composting, respectively. To prepare the brand new challenge,

TDEP organized 1,143 volunteers and workers for this event. The festival lasted for ten days, and estimated attendance is over four million. Roughly 36 tons of waste was collected on site, and 23 tons of which were either recyclables or food waste suitable for composting. Remarkably, the recycling rate reached up to 63%, and 70% of the waste were placed correctly into the designated bin by participants of the festival. For those who dump the trash on the ground, 16 citations and 54 notice of improvement were issued. TDEP is planning to apply this encouraging experience to future activities, and modify the plan of implementation considering the actual situation to achieve the goal of waste reduction and resources recycling.

Vision for 2010 Total Recycling and Zero Landfill

To transform Taipei into an eco-city capable of sustainable development, TCG proposed the 2020 Vision of Total Recycling and Zero Landfill three years ago. After three years of hard work and promotion, and the advancement of recycling technology, TDEP reevaluated and declared that the vision could be reached by 2010, ten years earlier.

Definition

"Zero Landfill" by definition means that all municipal waste will be either recycled or reused, including energy recovery from combustible waste, composting or animal feed from organic waste, and reuse of waste materials such as metal, glass, paper, construction waste and incinerator ashes, and kitchen leftovers etc, and landfill will no longer be needed for final waste disposal. Through zero landfill, valleys or low lands need not be developed for waste disposal, thus natural environment can be preserved.
Furthermore, resources may re-enter our lives through detail sorting and total recycling to stop depletion. The concept of zero landfill can also promote the development of green industry. In order to achieve the 2010 vision, we should seriously examine the waste we produce everyday, actively develop the reuse technologies that are more economically competitive, and eagerly create green products that are low budget, low energy consumption and low pollution. Therefore, recycled materials and raw materials are both available on the market.

Ten Strategies

TDEP is implementing the following strategies to achieve the goal of Zero Landfill and Total Recycling :

Strategy (1) Crack down the illegal use of counterfeit trash bags and improve the implementation of PBTCF: Organize a anti-counterfeit squad team to work closely with the division crew to perform a double check on the routes that counterfeit problems are most serious. Anti-counterfeit label is required to attach to each trash bag, and crewmembers are trained to identify the real label.

Strategy (2) Mandatory sorting and recycling for private businesses and haulers: TDEP has applied the strategy of mandatory sorting and recycling to private businesses and waste haulers. TDEP offers assistance to all businesses and apartment buildings in installing recyclable collection bins, and demands resources recycling. The examination mechanism will be set up for waste entering either incinerators or landfill site.

Strategy (3) Recycled and reuse of organic waste (including food waste and treated sludge): TDEP is at the same time promoting sorting and reuse of organic wastes. The program includes retrofitting collection truck for both general waste and kitchen leftover, building composting facility and bag breaker and storage facility. The reuse channel of kitchen leftover has been developed at the same time. Parks and schools are required to practice composting on site. Sludge from water

treatment facility will be either handled through incinerator or anaerobic digester. And private companies are invited to invest on composting facility.

Strategy (4) Shredding, sorting and recycling of bulky waste and construction waste: All waste mattresses reaching landfill site will be first disassembled, and the metal parts will be taken out for recycling. All waste reaching incinerators will be shredded first before combustion. Over-sized waste will be sent to the landfill site for shredding, the remaining combustible portion will then be returned to the incinerators for combustion. Construction waste will be required for crushing and grading in the next four years, and TDEP is still searching for the reuse channel of construction waste.

Strategy (5) Introducing total waste sorting facility: Waste reduction and recycling has been successfully carried out through the implementation of PBTCF and mandatory sorting required by law. To further minimize the waste volume into the incinerator, total sorting facility will be built at each incinerator to mechanically and effectively perform detailed sorting.

Strategy (6) Caloric recovery of non-recyclable waste (including gutter and treated sludge): All combustible waste excluding recyclables and food waste shall be incinerated for energy recovery to minimize waste volume into landfill.

Strategy (7) Establishing annual maintenance alliance, raw waste should be stored in the bunkers rather than transported to landfill site: TDEP will contact adjacent cities, such as Taipei County, Keelung City and Taoyuan County, in the near future to organize an annual maintenance alliance to expand the storage capacity. Before the annual maintenance of each incinerator, bunkers need to be emptied to accommodate waste volume collected during that period. Waste will be transported and incinerated in full capacity immediately after the maintenance is over.

Strategy (8) Sorting and reuse of waste from disaster: Transport stations will be set up at the disastrous area, and waste will be grouped according the odor intensity of the waste. For those tends to smell easily will be incinerated as soon as possible, and the others will be taken down to the landfill site for temporary storage, shredding and sorting at the same time. Combustible waste will be transported back for incineration later on. Soil and rocks will search alternative channel for reuse.

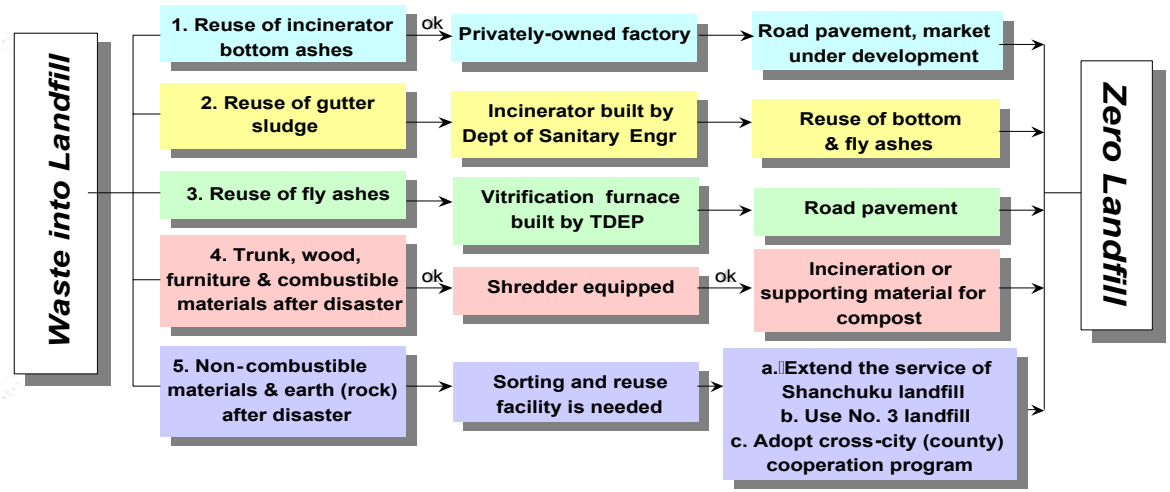
Strategy (9) Grading, solidification or vitrification of incinerator ashes: To establish the standard for the quality of the product, the pilot project for the reuse of incinerator bottom ashes is undertaking. At the same time the market is under development. Through Government Procurement Law, bottom ashes may be processed by private plant for reuse, or city government may build its own reuse plant through BOT. Planning and building a vitrification plant for reusing fly ashes is also under consideration.

Strategy (10) Promoting cross-city (county) cooperation program to expand emergency landfill capacity: To exchange for emergency landfill and temporary storage capacity during disaster, TDEP will establish cross-city (county) cooperation mechanism with Keelung City, Taipei County and Taoyuan County and sign cooperation agreement to support each other on emergency waste disposal. This program will not only extend the time we need for market development on the reuse of bottom ashes and compost, but also create the opportunity of discarding No. 3 landfill site.

Bottlenecks

The bottlenecks waiting for break through at this moment are the immaturity of reuse technology for some of the waste material, underdeveloped market for such recycled products as compost and aggregate from incinerator bottom ash. In addition, the cooperation program with Keelung City on waste management is yet to be approved by Taipei City Council, etc (Fig 4&5).

Figure 4: Bottlenecks waiting for break through (1)



Time Table and Supporting Projects

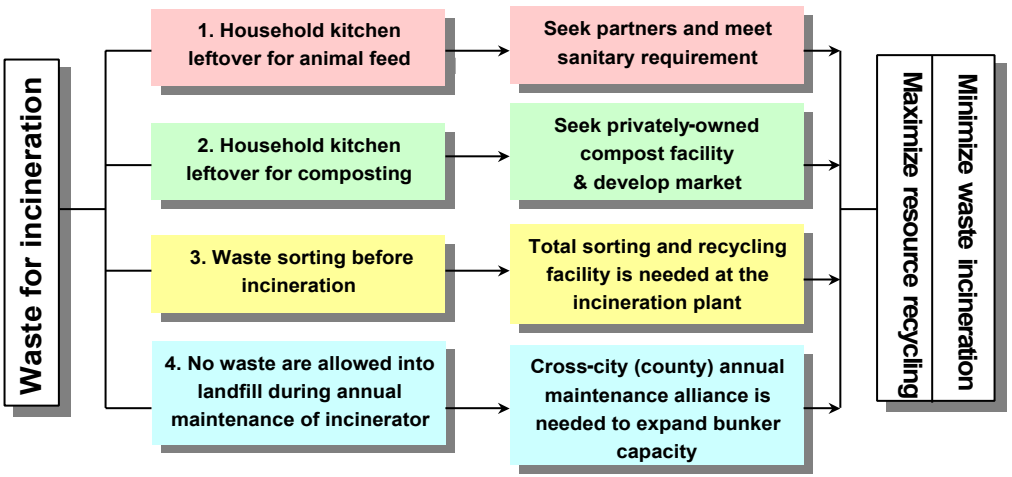
With respect to the reuse of incinerator bottom ashes, TCG will initiate the waste disposal cooperation program between Taipei and Keelung City. During 2003 to 2006 50% of the bottom ashes will be reused through partnership with the privately owned business, and the other 50% will be transported to Keelung City for landfill. After 2007 all bottom ashes will be handed over to the privately owned business for reuse. Incinerator fly ashes will use landfill as final waste disposal method after solidification between 2002 and 2004. Beginning of 2005 vitrification project will be planned and tested for fly ashes. The vitrification plant capable of processing 30 tons/day of fly ashes will be completed before 2008 (Table 2).

Presently, small amount of sewage treatment plant and gutter generated sludge are experimentally incinerated with general waste. Between 2003 and 2006 roughly 30% of the sludge will be incinerated with general waste. Starting 2007 all sludge will be transported to sludge incinerator or dryer built by the Department of Sanitary Engineering for reuse.

Regarding the reuse of food waste, supporting programs such as the design of garbage trucks for food waste and household waste, the establishment of transport facility for pig rearing, and the construction of pilot composting facility at Shanchuku Landfill were quite successful. The privately or publicly owned composting facility will be completed in 2003, which is expected to handle part of agricultural waste. Pig rearing industry is committed to digest all food waste suitable for pig rearing. By 2005 privately owned composting facility is expected to process 100 % of food waste suitable for composting.

Starting 2004 the planning of three privately owned total sorting and recycling facilities, each capable of processing 700 tons/day of waste is expected to complete. The total sorting and recycling rate will reach 15%, 33%, 67% and 100% by 2005, 2007, 2008 and 2009 respectively. Composing facilities for the sorted out organic waste will also be started by 2004, and the processing rate is expected to reach 15%, 33%, 67% and 100% by 2005, 2007, 2008 and 2009.

Figure 5: Bottlenecks waiting for brak through (2)



Waste collection and disposal is one of the basic urban services. To effectively manage waste, rather than dispose of waste, is far more economic in solving waste problem. Taipei city used to adopt downstream management philosophy for waste collection and disposal policy, which was challenged by the non-stop growing waste volume. If we do not practice recycling at this instant, the limited resources of the earth will be depleted and the development of human race will be directly affected. Taipei City is proud of its success in waste reduction and resource recycling in recent years, yet there is a long way to go before reaching the final goals of zero landfill and total recycling. To face the challenge, we need perfect planning, promote supporting projects and most important, the cooperation and support from Taipei citizens to ultimately transform Taipei into an eco-city. ■

An Overview of Chinese Taipei's Cleaner Production Promotion Activities

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Abstract

The Cleaner Production promotion programs have successfully raised the awareness in cleaner technologies in Taiwan. Instead of solely depending on End-of-Pipe treatment technologies, thousands of firms in Taiwan now would consider source reduction and pollution prevention as a viable option for solving their environmental problems. The success of Taiwan's Cleaner Production programs could be attributed to many factors, including: (1)High government commitment, (2)Prominent organization in charge of promotion activities, (3)Well planned master plan, and(4)Stimulating promotion programs under a continuous government funding.

Foreword

The growth of industry has always been a major indicator of national economic development and competitiveness. It is also a major factor of improving quality of life. However, with sharp changes in society and the rapid development of industry, the economic activities of industry and commerce have created everyday environmental problems that now receive much attention from the general public. A variety of scientific evidence continually proves that there are significant environmental problems that affect the human race and the ecological balance of the world. They have become problems that will never again be just local issues and will eventually develop into a worldwide focus.

From the 1970's, European nations and the United States began to implement a continuous series of environmental regulations to compel industries into protecting the environment. Beginning in the 1980's, to encourage industries to voluntarily participate in environmental protection programs, the international community evolved various environmental concepts, methodologies, activities and management systems. These included "Pollution Prevention", "Industrial Waste Minimization", "Cleaner Production", and "Environmental Management System".

Because the environment is considered to be in the public realm, it falls under the jurisdiction of the government. If the government takes proper action and creates comprehensive plans and initiatives, then it can bring together truly effective management and applications. Accordingly, the government's role is paramount as it is responsible for environmental regulations, research, promotion and application.

Taiwan is an island with a dearth of natural resources, but in terms of industrial strength, Taiwanese industries have always developed vigorously. However, efforts to prevent environmental impacts and destruction were not common. For the past thirty years, the government has strived to promote environmental production strategies and cleaner production. All of its efforts were not only directed to-

wards economic development, but also towards the sustainable development of the human species.

Government's Role in Promotion of Cleaner Production

Government plays the role of a very powerful catalyst in encouraging Cleaner Production(CP). Since the mid-1970s, Taiwan government agencies has been active in designing and implementing programs to promote CP concepts. Governments consists of two different groups of people: those who develop and enforce regulations and those who provide assistance. Both of these groups have distinct roles in promoting CP. Their specific roles are briefly described below.

(1) Laws and Regulations. The role of government in passing and enforcing laws on product manufacturing and waste management is to require industries to provide environmentally safe products and use low environmental impact methods to manufacture products. Toward this end, lawmakers and enforcement government agencies can contribute to promoting CP by:

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

(2) Assistance and Incentives. The second component or role of government in promoting CP is to provide technical and economic incentives. Government can contribute to the success of CP by:

- Funding and performing research not covered by the private sector;

Funding and supporting industries willing to perform demonstration projects and go public with results;

- Encouraging utilization of the results of CP research;
- Serving as a technical link between industry and the regulators;
- Serving as a focal point for comprehensive, multimedia pollution reduction strategies; and
- Compiling and distributing cost-effective CP techniques that do not negatively affect process/product performance.

Additionally, government can set standards itself by promoting CP within its own agencies and thus serving as a role model for other institutions. With its significant purchasing power, a government is capable of creating and developing new markets by its purchase decisions.

With a diversity of options available, government can institute many types of efforts to promote CP. In this paper, examples and results of CP promotion programs in Chinese Taipei are presented.

CP Promotion Programs in Chinese Taipei

To prevent environmental impacts from production processes and to highlight environmental performance, various Taiwanese governmental agencies in the 1970's established together a series of environmental regulations and promoted a variety of environmental protection measures and actions. These activities included are described below.

The Environmental Protection Administration (EPA) was established to formulate pertinent policies and oversee environmental regulatory programs. The Ministry of Economic Affairs (MOEA), on the other hand, was given the responsibility of developing appropriate technologies and providing technical assistance and financial incentives to encourage industries to practice proper environmental management. Table 1 shows four general phases of the past thirty years of Taiwanese environmental protection and cleaner production efforts.

Table 1. Timeline of Taiwanese Environmental Protection and Cleaner Production

Phase/ decade	Management Objective	Environmental Regulations and Guidance Measures	Industrial and Environmental Issues
1970's	Pollution control guidance to lead into pollution prevention. Assist industries to comply with the requirements of environmental regulations.	Laws/Regulations: Establish basic laws, such as Water Pollution Control Act, Air Pollution Control Act, Waste Disposal Act, etc.	Control pollution discharges
		Incentives: pollution prevention investment compensation, low interest loans, etc.	Encourage environmental protection by industry
		Assistance: Establish Service Group for Industrial Pollution Prevention and Control Technology.	Provide guidance for treatment technologies
1980's	Emphasis on pollution prevention, energy and resource conservation. Assist industry in source reduction, pollution prevention, and resource recovery through recycling and reuse, while considering both environmental protection and economic development.	Laws/Regulations: Noise Control Act, Toxic Chemical Substances Control Act, etc.	Management of risks and environmental quality
		Incentives: pollution prevention investment compensation, low-interest loans, etc. Assistance: Push forward industrial waste minimization and cleaner production assistance, etc.	Encourage environmental protection by industry Promote concepts and methods of industrial resource reduction and reuse and recycling
1990's	Using pollution prevention as a basis, respond to international trends in environmental protection and management	Laws/Regulations: Environmental Dispute Settlement Act, Environmental Impact Assessment Act, etc.	Pollution prevention and environmental responsibility management
		Incentives: pollution prevention investment compensation, low-interest loans, environmental labeling, etc.	Encourage environmental protection by industry, encourage consumer s to choose environmental products
		Assistance: Guidance for industrial waste minimization, cleaner production, occupational safety and health, and environmental management. etc.	Promote concepts and methods of industriaL resource reduction and reuse and recycling.
2000's	Based on goals for environmental needs and productivity upgrades, emphasis is placed on effective resource use and corporate cleaner production for sustainable development.	Laws/Regulations: Soil and Groundwater Remediation Act, Resource Recycling and Reuse Act, Fundamental Environmental Protection Act, etc.	Encourage cleaner production and extend environmental responsibilities.
		Incentives: Encourage industry to upgrade regulations, environmental labeling and promote green government preferential acquisitions, etc.	Encourage consumers to purchase environmental products, require government agencies to purchase environmental products.
		Assistance: Encourage cleaner production, risk management, environmental performance, environmental reports, and green productivity, etc.	Encourage industry to respond to international environmental trends and increase competition.

In the initial phase of the industrial environmental improvement program, End-of-Pipe (EOP) technologies were generally viewed by government agencies and industry as the sole solutions to environmental problems. The EOP technologies focus on treating effluents and emissions after they are generated. Although they are, to certain degree, proven effective methods of protecting the environment, they have some disadvantages. Mainly, the cost of controlling pollutants after they are generated with EOP solutions is prohibitive. Moreover, some EOP technologies only transfer pollutants from one medium to another, don't solve pollutant problem completely, thereby resulting in no net environmental benefit.

In the late 1980s, the limitations of EOP treatment caused environmental decision makers in the country to consider alternate methods in pollution prevention. Industrial waste minimization (IWM), or cleaner production (CP), is a method of multimedia pollution management that focuses on reducing the generation of pollutants at their sources to avoid subsequent handling, treatment, and disposal. IWM encourages industry to reduce its pollutants at the source, rather than to treat and dispose of pollutants in the environment. This preferred strategy for dealing with pollutants is often referred to as the "environmental management option hierarchy." Under this hierarchy, pollutant avoidance and source reduction are ranked as the most preferred approach; recycling and reuse are next, followed by treatment of effluents and emissions to reduce volume and/or toxicity. Finally, legally permitted disposal is the least desirable waste management technique.

Since the mid-1990's, the International Organization for Standardization(ISO), issued the ISO 14001 Environmental Management System(EMS), which can be certified by the third parties. The Industrial Development Bureau(IDB) in 1995 used the foundations of IWM and CP to advance EMS in industry. The IDB pulled industry in line with international trends to establish ISO 14001 environmental management systems. In the same year, the IDB responded to the United Nations Environmental Program (UNEP) plans for national cleaner production and established the National Center for Cleaner Production(NCCP), in the efforts to strengthen international exchange and cooperation.

Since the year 2000, legislation has been structured to capture the essence of effective resource use and effective cleaner production in order to pursue sustainable development. These laws include the Resource Recycling and Reuse Act and the Fundamental Environmental Protection Act. The methods of Taiwanese environmental protection have developed from the government giving strict orders to that of practical management. Eventually, the next step can be taken towards a new milestone of cleaner production and sustainable development. Similarly, environmental labeling and green purchasing measures in environmental products and industries not only promote environmental protection within industry but also expand the responsibilities of producers.

Policy Commitment and Plan Formulation

In the following sections, the initiation, organization, accomplishments and recent developments of Taiwan's EOP, IWM and CP promotion activities are briefly reviewed.

EOP Guidance

The beginning of this initial phase was in 1974, when the government put forth one of its first environmental protection laws – the Water Pollution Control Act – and initiated an associated industrial wastewater guidance improvement plan. The Industrial Development Bureau of the MOEA compared comprehensive and systematic environmental protection guidance efforts and, in 1983, created the Industrial Pollution Prevention Technical Service Group. Afterwards, it guided industrial plants towards pollution prevention as an effective way to deal with pollution and comply with environmental regulations.

The service group in its initial phase helped plan or examine industrial pollution prevention plans, without looking at specific draft industrial guidance and improvement plans. It especially focused on internal factory housekeeping and strengthening process improvements. Afterwards, in accordance with international environmental trends, the group took into account practical industrial needs and initiated a multi-phase guidance that included the promotion of industrial waste minimization, cleaner production and environmental management systems. From 1983 to 2001, the group attained the following results:

- Technical assistance: More than 10,000 factories and 12,000 sites were provided assistance.
- Improvement case studies: Over 8,300 cases, included waste water, solid waste, air pollution improvement, etc.
- Technical consultation: 2,500 times.
- Knowledge management: Published 75 technical guidebooks.
- Training and promotion: Held over 500 EOP related training course, seminar, workshop, and attracted near 50,000 participants.
- Improvement benefits: Average COD reduced by 85%, average SS reduced 95%, average particulate matter reduced by 95%. Regulations non-compliance rate reduced from 51% to 9%

An Explicit Government Policy Declared to Promote IWM

In 1988, an executive order was declared by the executive branch of the government that IWM should be adopted as a key approach to the solution of the environmental problems in the country. This executive order represents the government's commitment that: (1) the priority is being given to IWM and, (2) high-level attention should be paid to promote IWM. Following this executive order, MOEA and EPA together in 1989 established the Joint Waste Reduction Task Force (JWRTF) to take the overall responsibility of promoting IWM in the country. The Industrial Development Bureau (IDB) of MOEA was chosen to implement the programs of the JWRTF as the agency is closely associated with environmental protection and industrial development programs in the government.

IWM Program Elements and Accomplishments. The IWM program has been implemented for over ten years. The first 5-year plan was complete in 1995, and then followed up with a second 5-year plan. In the following paragraphs, numerous program elements that have been or are being implemented to promote IWM concepts throughout the country are described.

A. Public Awareness Promotion. Awareness promotion is the first and also least expensive step among many different programs to encourage adoption of IWM measures in any country. In Taiwan, JWRTF employs a variety of tools such as booklets, posters, newsletters, technical manuals and videos to educate industries and the general public about IWM. These tools disseminate the meaning of IWM, its importance and advantage, and sources of pertinent information. Another form of awareness promotion involves the presentation of awards to organizations with outstanding achievements in IWM. Beginning in 1990, firms, individuals and organizations were invited to participate in annual competitions for awards based on their IWM management and technical achievements. As of 2002 a total of 115 firms, 101 individuals and 37 organizations have received such awards.

B. Training and Education. The IWM concept was relatively new to many in Taiwan when the program was first introduced. To help industry implement IWM, sector-based training courses were provided for technical staff and decision makers in industry. Training programs were also provided for regulatory agency personnel to inform them about the advantages and applicability of IWM to the environmental regulatory program. With this knowledge, regulatory personnel can become advocates of IWM while carrying out their regular responsibilities, such as inspection and permit reviews. Between 1990 and 2002 more than 300 IWM training courses were offered in Taiwan, benefiting more than 30,000 participants.

C. Information Exchange. General information on the nature and benefits of IWM technologies, and case studies that illustrate technical feasibility are necessary for user communities. In addition, IWM opportunity assessment procedures are needed by firms to identify and implement IWM options. These types of information, commonly presented in form of guidance manuals, fact sheets, and case study reports, have been made available in Taiwan. Furthermore, two computer data systems are being established. One of these systems contains technical information and case studies of IWM techniques. As of December 2002, more than 2,000 entries have been stored in this system. The other data system is designed for use by industries to locate individuals capable of providing specific expertise; it collects human resource information pertinent to individual expertise, capabilities, and experience. This data system contains 850 entries as of 2002. Aside from these two data systems, an industrial waste exchange information has been in operation since 1987. This system has facilitated nearly 348 cases of waste exchange between the waste generators and users, resulting in reuse and recycle of over 311,000 tons of industrial waste and an estimated benefit of over US$100 million.

D. Technical Assistance. Guidance efforts on industrial waste minimization can be separated into two major phases. In the first phase (1990-1995), guidance was based on each individual industrial type. In the second phase (1995-2001), the corporate synergy systems between central and satellite factories were used to promote industrial waste minimization. The results from the main efforts of each phase are illustrated in Table 2.

In light of concepts and methods of industrial waste minimization, resource reduction, and recycling and reuse, the IDB helps industries solve environmental problems upstream. The bureau can upgrade the efficiency of a factory's energy and resource use to concurrently address both environmental and economic issues. However, statistics show that in the first phase of the IDB's efforts, the overwhelming majority of participating organizations were large business enterprises. Seeing as 97% of the nation's companies are small-to-medium sized businesses, assistance for these groups was largely disproportionate and subsequently did not reap the benefits of industrial waste minimization. As a result, the IDB turned towards corporate synergy systems. By requiring large central companies to pass on IWM requirements to their associated satellite firms, smaller businesses will also be included in the process, as shown in Figure 1.

Table 2. Results from the first phase of industrial waste minimization guidance

Factory Receiving Guidance	Improvement Investment	Guidance Results
Provided assistance to 45 industries, 245 factories (50 small-to-medium sized businesses)	With a total investment of US$30 million, of which 12% supported by the government, and 88% paid for by the industry, the firms were estimated to generate a benefit of US$85 millions per year.	Cumulative economic benefits US$85 million, investment-reward ratio: 1:3 Other environmental performance achievements included a reduction in energy and material consumption, industrial waste, and CO_2 discharges.

Because of the success of corporate synergy systems and the associated IDB guidance methodology, the IDB took one step closer to expanding application to industrial safety. By 2002, the IDB had already established 36 corporate synergy systems, among which 9 had industrial waste minimization CSS systems, 16 had industrial safety CSS systems and 11 had both industrial waste minimization and safety CSS systems. Industrial waste minimization CSS results over the past few years are illustrated in Table 3.

Figure 1: Relationship Among Organizations Involved in the IWMCSS Program

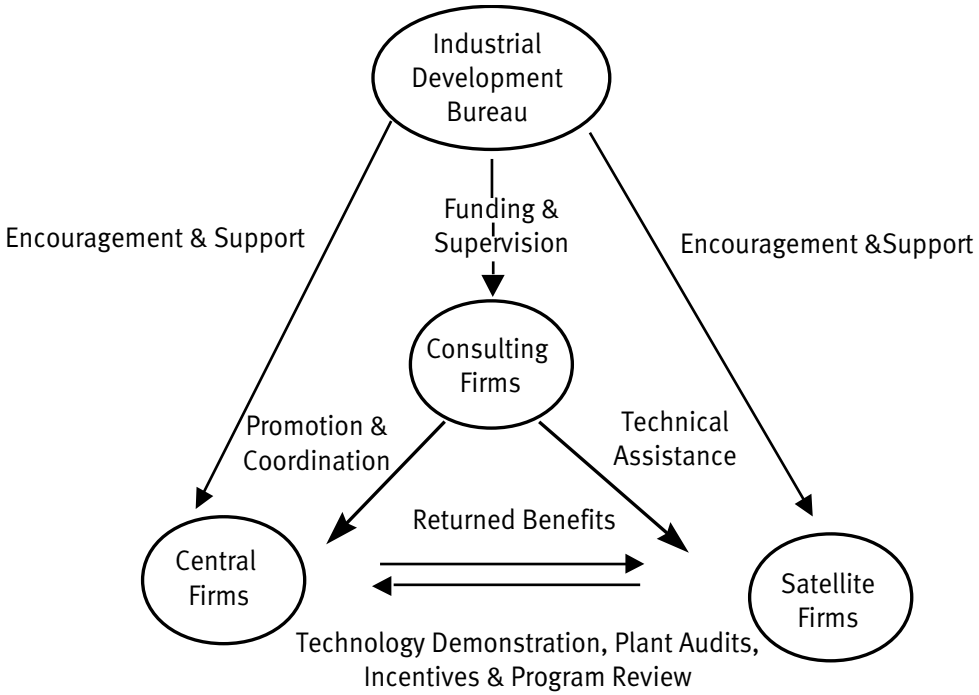


Table 3: Results from industrial waste minimization corporate synergy system guidance

Guidance System	Improvement Cost	Guidance Results
Industries included: automotive, electrical appliances, electronics, food products, machinery, and rubber, totaling 20 different systems and 275 individual factories (inc. 200 small-to-medium sized businesses)	Highest cost: benefit ratio among all systems was 1:10. Lowest cost: benefit ratio was 1:2.5 Government investment to factory investment ratio averaged 1:5.	**Cumulative economic benefit:** US$ 72.6 million **Environmental performance:** CO_2 reduction: 64,140 tons/yr Solid waste reduction: 29,380 tons/yr Wastewater reduction: 1,427,120 tons/yr **Energy/resource performance** Conserved water: 227,600 tons/yr Conserved electricity: 487 million kWh/yr Conserved materials: 48,740 tons/yr

Technology Research, Development and Demonstration. Under this program element, special attention has been given to developing specific technologies and detailed case studies demonstrating which IWM technologies suit domestic conditions. Many of these projects emphasize testing imported IWM technologies at domestic firms. In some cases, research and development of special equipment and/or processes are performed to meet the specific needs of the local industries. These RD&D projects can be classified into several categories: low or non-polluting manufacturing process development, material substitution, process modification, process automation, resource reuse and recycling, and water conservation. From 1989 to 2001, the MOEA and National Research Council co-sponsored nearly 80 RD&D projects geared toward IWM technologies.

Financial Incentives. IWM projects often require substantial investment by firms. Under the sponsorship of IDB, low-interest loans are being provided by banks to help firms implement IWM projects. Additional financial incentives that are being provided by government include investment tax credit, import tariff exemption, and accelerated depreciation of IWM equipment. In years 1994 and 1995, more than 1,200 applications were approved of tariff exemption for imported IWM and pollution control equipment. The approved low-interest loans for the same period totaled approximately US$ 150 millions.

International Cooperation. In last few years, increasing number of activities are implemented in Taiwan to promote international cooperation of IWM in the Asia-Pacific Region. Large-scale international conferences are held in Taipei every other year since 1993. The conference in December 1995 attracted more than 300 participants from 23 countries. Under the sponsorship of IDB and regional or international organizations such as US-Asia Environmental Partnership (US-AEP), Asian Productivity Organization, and US Environmental Training Institute, several CP training workshops were organized in Taiwan for participants from Southeast Asian countries.

Establishing the National Center for Cleaner Production (NCCP)

To answer calls from the UNEP, cleaner production was actively pursued. Also, to expand the scope of IWM promotion program, the National Center for Cleaner Production (NCCP) was established in Taiwan in December 1995 under the funding support of IDB. NCCP is endowed with unique and rich resources to upgrade IWM in the country. The Center will accomplish this mission through performing technical and policy related studies, and provide training and information dissemination. Since its inception, NCCP has engaged in life-circle analysis of consumer products, and benchmark comparison of selected manufacturing processes. These studies will contribute to formulation of national cleaner production policies. The Center is also providing training and education programs at numerous technology R&D institutes. It is expected that, through these courses, the R&D organizations in the country would be alerted of the international trends in IWM, and new technologies developed in the country would be cleaner -- they will use fewer resources, less toxic material, and at same time, produce more environmentally friendly (or, greener) products. The responsibilities and results of the NCCP are listed in Table 4.

Promotion and guidance of ISO 14000

In the past few years, the international community urged businesses to make an even greater effort to effectively use resources and protect the global environment. The eventual result was the development of an environmental management method that integrated business management systems. Currently, the development of environmental management faces a systemization of management concepts. All environmental

Table 4: NCCP Responsibilities and Accomplishments

Type	Item	Result
International cooperation	1. Link international cleaner production with the construction of an information network	Created global contact network for NPPC to relate to 40-70 nations and organizations
	2. Participate in international activities and promote international cooperation	
Coordination	1. Create cleaner production methods and expertise information clearinghouse	Estimated 2,500 submissions
	2. Integrate cleaner production resources	
	3. Promote cleaner production cooperation	Participation in international conference
Technical guidance	1. Cleaner production technology research and development with factory guidance	Encouraged eight industries including mineral, leather, dye, and food towards cleaner production guidance
	2. Create a cleaner production technology guide	Creation of a cleaner production manual for the semiconductor industry
	3. Develop cleaner production indicators and evaluation techniques	Developed cleaner production indicators for solid waste generation, hazardous materials and energy consumption
Data and consultation	1. Consultation on regulations, policy and technical tools	Created and maintained ROC NCCP website
	2. Provide technical support and data to policymakers	
Training dissemination	1. Hold a series of cleaner production conferences/ lectures	Held or participated in 80 worldwide conferences

affairs will be based on systemized methods for management, measurement, improvement and communication. Taiwan industries will use exports to follow growing international use of ISO 14001, created by the International Organization of Standardization (ISO) in 1996, and can be certified by third parties - and influence global trade of environmental products.

During the past few years, the government of Chinese Taipei has been working seriously to face the challenge. An ISO 14000 Working Group was established involving several agencies such as the Ministry of Economical Affairs (MOEA), the Environmental Protection Administration (EPA), the National Science Council (NSC), and the Council of Agriculture. The major program activities toward promoting ISO 14000 standards, shown in Figure 2, includes:

- Setting up national standards in conformity with the international standards (responsibility of the National Bureau of Standards, MOEA);
- Establishing national accreditation and certification systems (by the Bureau of Commodity Inspection and Quarantine (BCIQ), MOEA);
- Reviewing and amending pertinent environmental policies and regulations (by NSC and EPA);
- Developing tools and procedures for use by firms to implement standards (by the Department of Industry Technology, MOEA);
- Conducting international information exchange (by NSC and the Board of Foreign Trade, MOEA); and
- Providing technical and information assistance to domestic industries (by Industrial Development Bureau (IDB), MOEA).

Under the collaborative efforts of the government and enterprises, ISO 14000 has gained substantial ground in Taiwan. For example, the national standards of CNS 14001, CNS14004, CNS 14010, CNS 14011 were finalized in 1996 by NBS following a series of discussions and public hearings. BCIQ in March 1997 published the national accreditation and certification systems. The national environmental labeling system developed by EPA is now in operation—over 1,600 products have received environmental

labels and discussion is under way with a Canadian environmental labeling agency for mutual recognition.

Furthermore, under the effort of IDB, a technical assistance and training program was implemented in 1995. The training courses focused on environmental management systems (EMS) under ISO 14001, environmental auditing, and life-cycle assessment have trained more than 10,000 participants. Besides, IDB has also raised the standard of domestic environmental management guidance and encouraged the sound development of an environmental management system consultant market. The IDB has also developed a number of guidance tools and training materials to help industries establish effective environmental management systems. The IDB environmental management measures and results are listed in Table 5. By June 2002, a remarkable number of 1,024 factories in Taiwan passed ISO 14001 certification, making Taiwan 11th in the world in terms of certifications.

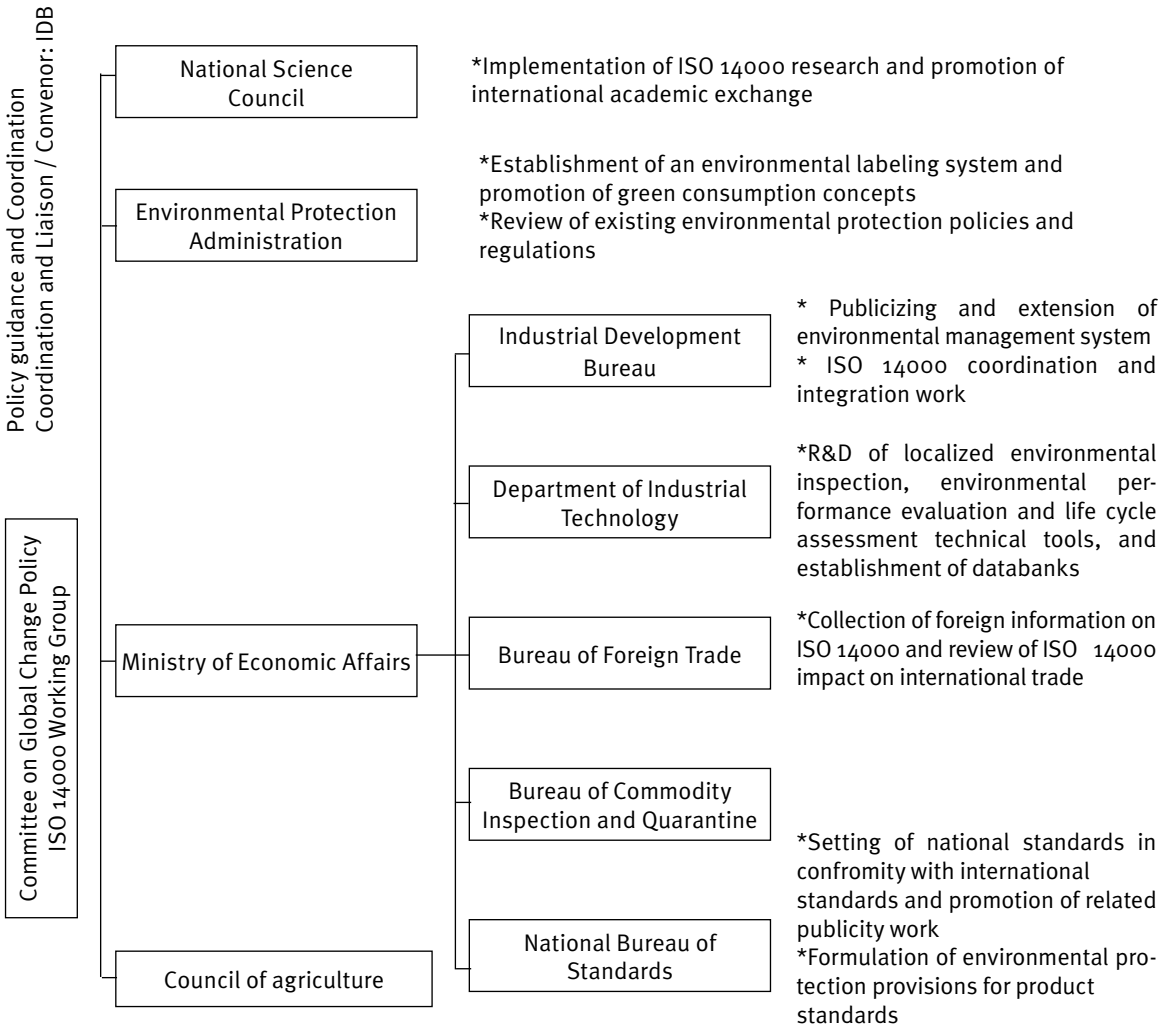
Table 5. Implementing Contents and Results of IDB on EMS

Type	Related Measure	Results
Establish environmental management registration mechanism	Announce the Registration and Management guideline for The EMS Consultant Companies, January 1997	Registered and managed 37 EMS consultant companies
	Announce The Registration and Management guideline for for The EMS Consultants, July 1998	
	Announce The Registration and Management guideline for The EMS Training Organizations, December 1998	Registered and managed 287 EMS consultants
Establish environmental management registration mechanism	Promotional EMS demonstration team program	Over 220 teams participated in demonstration teams, and passed the ISO 14001 certified
Environmental management system	Held ISO 14000 related conference and lectures	Over 100 conferences Over 50,000 participants
	Publish bimonthly Environmental Management Reports, Since 1997	Total of 21 issues Over 10,000copies/issue
	Publish bimonthly Safety, Health and Environmental Today, Since 2001	Total of 43 courses Over 1,100 trained
	Conduct environmental management system guidance personnel training courses, March 1997	
	Write ISO 14000 series technical manual	Over 10 technical manuals Over 20 books on training materials and case studies

Recently Added Program Elements: Green Design Campaign

In 1994, IDB launched a five-year program to promote green design of consumer products. Executed by the China External Trade Development Council (CETDC), the first five-year plan emphasizes persuading local firms to adopt the green design methodology. CETDC's strategy to promote green design comprises the following six elements. (1) Workshop - local and foreign experts are invited to provide seminars on green designs; 8 seminars have been held with more than 2,000 participants attended thus far. (2) Publications - CETDC has published green design guidance manuals related to telecommunications, sanitary wares, electrical household appliances, furniture and light fixtures. (3) Expert Consultancy - Under this element, green design experts are dispatched to spend four to five work days with manufacturers to provide advice on how new products can be designed with consideration of environmental factors. (4) Technical assistance - Assistance has been provided to firms making two

Figure 2. ISO 14000 Division of Responsibilities Among Government Agencies



kinds of electronic consumer products on how to implement green design concept. (5) Information Exchange - Information pertinent to green design practices is being collected and supplied for use by local manufacturers. (6) Competition for National Awards - The first national green design competition was held in January 1997, with 480 entries participating in contest.

Summary and Vision

Summary

Through many years of hard work, the CP program's focus has switched from public awareness promotion, training and technology demonstration from the early stages, to providing assistance to industries in the implementation of IWM options. Furthermore, since 1995, new program elements have been added to promote ISO 14000 and cleaner technologies and cleaner production, and green design of consumer products. Although no information is available indicating the numerical extent of IWM and CP practices in the country, it is clear, however, that government's programs have successfully raised the awareness in cleaner technologies and green productivity in the country. Instead of solely depending on EOP treatment, thousands of firms in the country would now consider IWM and CP as a viable option for solving their environmental problems.

The success of Taiwan's CP program can be attributed to many factors. The most important of all, of course, lies in the inherent cost-saving benefits of IWM and CP practices. Additional reasons for program's success include:

- High-Level Government Policy Commitment--A policy was established early on that high priority is being accorded to IWM and CP.
- Prominent Organization in Charge--A prominent high-level organization, JWRTF, takes charge of planning, developing and coordinating the overall IWM promotion activities.
- Well-Thought Promotion Plan--The first 5-year plan set the tone of the promotion program early on. The program as a whole has been under constant review and adjustments to meet new situations and additional needs.
- Stimulating Programs–With a continuous government funding, numerous programs have been and are being implemented to stimulate industries to practice IWM, such as offering of technical assistance, financial incentives, information services, training, and international cooperation.

Vision

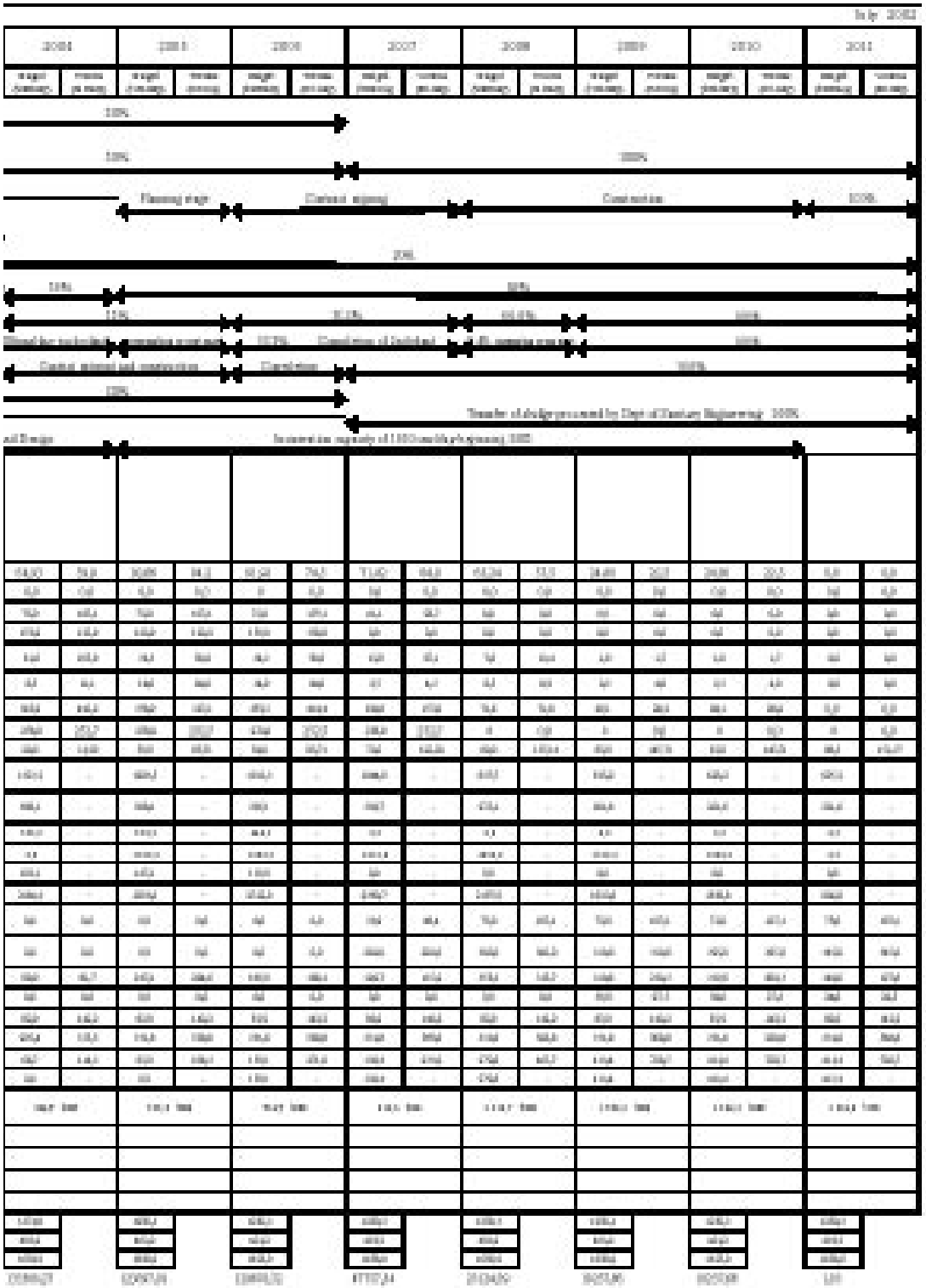
Small-to-medium sized businesses are numerous in Taiwan. They face problems that grow day-by-day, which are related to global resources, energy and the environment. Government assistance, whether for comprehending data or refining technologies, is a necessity. Government agencies have also issued proactive and preventative environmental regulations and guidance measures to increase industrial participation in CP. Through these actions, it is expected that environmental problems can be resolved, the health of businesses can be improved, and overall competition can be raised.

The Industrial Development Bureau of the Ministry of Economic Affairs in the past several years has especially aligned itself with environmental world-wide trends and has taken several measures to address international CP issues. These measures include providing guidance, tools, training, data and incentives. In the future, the increasingly active development of local industries will still lead to more significant environmental issues that include: industrial water conservation, operational waste resource recycling, hazardous waste discharge risks, etc. Measures taken to accelerate the engagement of global environmental problems, such as global warming and the exhaustion of precious resources, will bring about the turning point to sustainable development. Accordingly, the most important directions that need to be taken now include:

- Continued collection of domestic and international data on industrial energy, resources and

environmental issues. Identify and define guiding principles and concrete methods to help industry.

- Establishment of a combination of industrial sustainable development regulations and the specific measures and systems needed to address them. At the same time, integrate governmental guidance and incentive measures such that industry can carry out comprehensive voluntary measures of its own.
- Continued development of industrial sustainable development technical tools (e.g., cleaner production indicators, life cycle assessment, design for the environment, environmental performance evaluations, etc.). Through the channels of industrial associations and corporate synergy systems, many tools such as websites, journals, manuals, training courses and guidance, can be used to bring about a transformation of the industrial sector.
- Active participation in global environmental protection efforts. Cooperatively carry out environmental protection measures to strengthen international exchange and collaboration. ■



Management and Performance of Chinese Taipei's Waste Recycling Fund

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Abstract

A resource recycling program was established in Taiwan in 1989 starting with PET bottles. The mandatory regulated materials were extended to 8 categories with 26 items. Recycling went from being run by an experienced private enterprise system to a state run corporation. Currently, the structure is built on six main bodies: RRFMC, consumers, industries responsible, collection and treatment agents, a Collection, Disposal, And Treatment Fee Reviewing Committee (CDTFRC), and auditing agents. The industries that are responsible submit the fee (CDTF), which is set by the CDTFRC, to the waste recycling fund (WRF), which is operated by RRFMC. The auditing agents routinely check the responsible industries by documentation review as well as on-site counting to ensure that the CDTF is corrected submitted. The WRF provides the initiative for abandoned waste to become recyclable materials and finally secondary raw materials. The fund is split into a trust fund and a non-business fund. The trust fund is set up to subsidize projects that deal with collection, disposal, and treatment of the listed materials. Incentives for consumers to return recyclable items are included in the trust fund portion. The non-business portion of the fund deals with the support work and makes the system run effectively. Any expenditures other than direct subsidies are under this category. The ratio is 80% trust fund to 20% non-business fund.

The current practices established a win-win recycling framework, and the results are paying off. Household waste is substantially reduced by 22%. The yearly rate of recycling is steadily increasing. And, most importantly, the benefit-to-cost ratio of implementing the recycling program was calculated as high as 1.24. This indicates that resource recycling is a viable business from an economical point of view. The environmental point speaks for itself. The recycling system should be privatized as the recycle market and the operating procedures are well establish and fully mature, and the consumers and the responsible industries are well educated. By doing this, a sustainable free enterprise recycling industry can be realized.

Introduction

Demands for improvements in environmental quality have been raised for the past 20 years. The public demands higher effluent standards, less discharge of pollutants, and more efficient and environment friendly production of goods. The

pursuit of a zero waste environment has become the recent goal of non-government organizations. This presents a challenging task for the environmental department of the Taiwanese government, and puts them under pressure to perform. Actually, the implementation of household waste recycling is a good model to demonstrate the zero waste policy. It involved policy making, industrial involvement and most importantly citizen participation. The concept of household waste recycling was first included in the Waste Disposal Act in 1987. Since then, the articles were revised 9 times. The last two revisions in 1998 and 2002 made a clear switch moving the system from privatization toward nationalization through government endeavors of establishing the waste recycling fund (WRF), and the Resource Recycling Fund Management Committee (RRFMC). Responsible industries, as determined by law, must pay the collection, disposal, and treatment fee to the fund. RRMC is the managing body to implement this policy. I will discuss Taiwan's experience into waste recycling in the following chapters: system evolution, current framework, operation and performance of the WRF, and issues for sustainable management.

System evolution

As in many other societies in the world, resource recovery in Taiwan was undertaken by individuals and small size enterprises long before the government intervened with rules and regulations. However, since recycling of PET bottles became law in 1987 by administrative order, the market entered a new era. It has been a long and difficult road these past 15 years. The recycling policy in Taiwan faced many pressures, many of them from parliament. Recycling changed from an entirely privatized enterprise to the current state corporation. The role of government changed from setting the rules, to supervising the work performed under these rules, to taking full responsibility for the work. On the other hand, except for paying a fee, the responsible industries are almost exempt from any obligation or responsibility to collect, dispose of, and treat these products, by they manufactured or imported. There are four stages in this evolution.

Stage I (1, 1987 – 3, 1994)

In this stage, the responsible industries collaboratively formed common organizations to implement the rules on recycling of their products. For example, the tire industry, manufactures as well as importers formed the Taiwan Waste Tire Recycling Foundation. This foundation, by contract, was responsible to manage all collection, disposition and treatment of waste tires, and it had to satisfy all regulation requirements. On the other hand, the role of government was a) promulgation of the regulations, b) announcement of the annual recycling rate for each regulated item, and c) supervision of the entire project. At that period in time, a total of 17 items had been mandated to be collected, they consisted mainly of beverage containers, tire, lead- acid batteries, and lubricant oil. At the same time an equivalent number of organizations were established by the industries to take care of these items.

Stage II (4, 1994 – 12, 1996)

This stage is characterized by the attempts of government to become involved in the recycling business. First a non-profit, government supported organization, the Reduction, Recycling, and Re-use Foundation (3R Foundation) was established. All board members of the foundation were government nominated. To break into the recycling business was one of the major functions of the 3R Foundation. The foundation was successful in obtaining a contract by the vehicle industry to handle the recycling of abandoned vehicles. Then other responsible industries were approached by the foundation to discuss the possibility of handling their regulated items. However, efforts by other interest groups as well as by parliament made the effort unsuccessful.

Stage III (1, 1997 – 6, 1998)

This was the transition stage from private enterprise to nationalization. Although this

stage only lasted one and a half years, it was the turning point in the evolution of recycling. Because the entire private industry of recycling was riddled with fraud and scandals, the entire structure, including the private organizations was dismissed by the amended Waste Disposal Act. Items to be recycled were regrouped into eight categories, namely containers, tires, pesticide containers, lubricant oil, lead-acid batteries, vehicles, home appliances, and communication products. Meanwhile, 8 committees were set up by the government, one for each category, as management groups. The board members were picked from the responsible industries, consumer groups, and experts in the field, and they were appointed by the EPA. Although these committees were under the supervision of the EPA, they were independent as far as control of their budget, personnel as well as the operation of the business. Four major independent segments supported the recycling system: material recycling operation, fund management, auditing, and fee setting. The obligations of the government and the responsible industries were redefined as follows,

Government:

1. Evaluating and promulgating the lists of regulated items and setting the related administrative regulations.
2. Reviewing the qualitative and quantitative amounts reported by the responsible industries as well as the treatment agents.
3. Selecting capable auditing agents to monitor the responsible industries and material treatment facilities, and
4. Supervising the operation of the 8 committees financially as well as materially.

Responsible industries:

1. Reporting the amount of production or import of the regulated items every other month,
2. Paying the collection, disposal, and treatment fee set by the government.

Based on the regulation, the responsible industries could be warned, fined or even shut down, if they do not comply with the regulations.

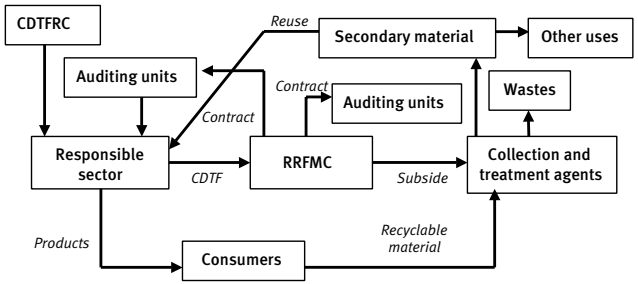
Stage IV (7,1998-present)

The nationalization of the system is completed. The EPA now includes the eight units that were established in stage III, and they established the Resource Recycling Fund Management Committee (RRFMC). A special fund, the waste recycling fund (WRF), was set up under the government account, to collect the fee paid by the responsible industries. So, now the staffing, the budget, and the WRF all are within government control and is supervised by parliament. Up to this point in time there are 26 items in 8 categories under the mandatory recycling program.

Current Framework

The implementation of the resource recovery program has been part of the government's responsibility since the nationalization of the system in 1998. The current structure is built on six main bodies: RRFMC, consumers, responsible industries, collection and treatment agents, Collection, Disposal, And Treatment Fee Reviewing Committee (CDTFRC), and auditing agents. In this framework the CDTFRC is an ad hoc unit that sets reasonable fees for the responsible industries. The auditing agents are judicial third parties contracted by the RRFMC to scrutinize the submitting of the fees and subsidiary applications. Figure 1 summaries the relationship of these six bodies. It can be illustrated in the flow of material and cash. In the material flow, the regulated products are manufactured by the responsible industries. After losing values, the product is thrown away by consumers including individuals, organizations, or communities, then, they become recyclable objects. The recyclable objects are then collected and transported to recyclers via salvage operators, retailers, or municipal garbage collection teams, and finally sent to treatment facilities for disposal and remanufacturing.

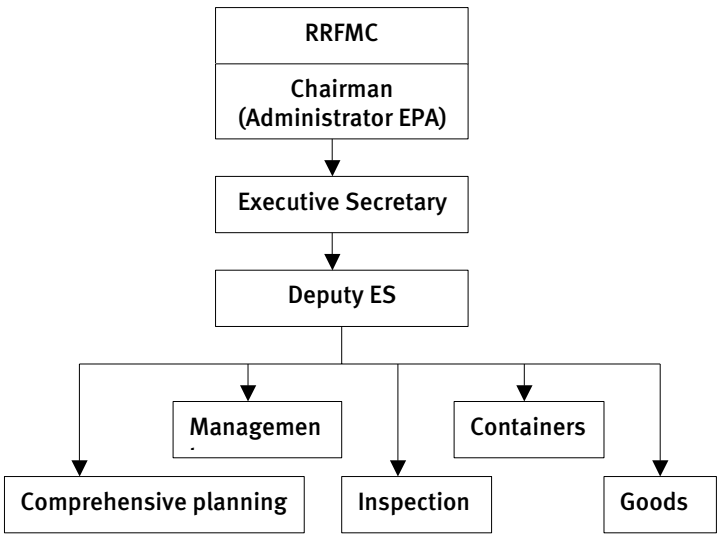
Figure 1: Framework of resource recycling



In the cash flow, the responsible industries submit the CDTF set by the CDTFRC to the waste recycling fund operated by RRFMC. The auditing agents routinely check the responsible industries by documentation review as well as by on site counting to ensure that the CDTF is correctly submitted. The industry will be warned, fined, or even be tried in court, if fraud is detected. The major expenditure of the WRF is to subsidize the collection and treatment system. Similar to the auditing of the CDTF, the RRFMC contracts other judicial third parties to check the work and practices of the collection and treatment agents. Individual counting, mass balance, 24hr-CVR monitoring, and other techniques are adopted to verify the claims. The subsidy is calculated based on the actual amount approved by the auditing agent and the per unit subsidy. In order to make sure the auditing is functioning properly, all auditing schedules are announced via the Internet in advance. NGOs or individuals are welcome to supervise and examine the auditing procedure. Meanwhile, the auditors are evaluated by a supervising committee appointed by the RRFMC. The auditing system is designed with strict reporting, auditing, and reconfirmation via documentation and administration control to minimize incorrect subsidizing.

Figure 2 illustrates the organization chart of the RRFMC. The board consists of 22 members drawn from government departments, NGOs, responsible industries, and experts. The administrator of the EPA is the chairman of the board. This design is an indication of the importance of resource recycling, as well as the close relationship between the RRFMC and the EPA. Comprehensive planning, management, inspection, container and goods are the major five divisions in RRFMC. The comprehensive planning div. is concerned with administrative work, educational programs, and plant certification. The responsibilities of the inspection and management divisions are to work closely with the contracted auditing agents to ensure that the correct CDTF is paid and that the subsidy applications are correct. The container and goods divisions are responsible for the effective management of the cash flow as well as the material flow. The controller and the accounting offices are merged with the main body of the EPA, instead of an independent div. In total, there is 79 staff in the organization.

Figure 2: Organization Chart



WRF Operation

In the free market, products are produced to last. They have to have a benefit for the seller in addition to the consumers wanting it. Otherwise, products will not be on the shelves for long. For the same reason a waste product can be recovered if the resale price is higher than the cost of collecting and processing. If not, the waste product will be discarded on the street or buried in the landfill. Unfortunately, most recyclable waste products fall into that category. Therefore it is necessary to subsidize and lower the collection, disposal, and treatment costs of these waste products. Although there are other methods, subsidy is one of the most effective tools to keep the recycling system moving smoothly. Of course, the higher the subsidy, the higher the recycling rate that can be achieved.

So, where is the financial support coming from? It is not easy to collect extra taxes or levies via legislative procedures. However, the concept of a front-end disposal charge was adopted. The Waste Disposal Act clearly states that the responsible industries of the regulated products must pay the mandatory collection, disposal, and treatment fee. The responsible industries are defined as the producers, importers, and retailers of the products. Actually, it is the producers and the importers that pay the fee. The obligation of the retailers is only to report purchasing and selling information and to provides a location for consumers to deposit the designated items. In Taiwan recycling is a mandatory program. However, it is based on incentives. The front-end industry provides the CDTF to the (WRF), and then the Administration of the EPA takes care of the rest of the work.

The WRF operation will be discussed in two parts as follows:

Income resources

As mentioned above, the major income of the WRF comes from the CDTF paid by the responsible industries. Also, a small portion of the fund comes from the interest earned by the fund deposit, such as from the approx. 4 billion NTD surplus in the vehicle fund. The Collection, Dispose, and Treatment Fee Reviewing Committee (CDTFRC) was established to take responsibility for the fee setting. The committee consists of 15 members including government (5), responsible industries (2), consumers (3), and experts (5). The administrator of the EPA appoints these members, and the term of appointment is 2 years. The CDTF is basically reviewed and amended annually. However, adjustment can be made anytime as new items or emergency cases are raised. Since the operation of the committee in 1998, a consensus for the calculation of the CDTF was reached after extensive debates and public participation.

CDTFA = (cost of CDTB + cost for amount not collected but disposed in landfills or incineratorsC + cost of abandonmentD + management expenditureE + amortization allowance of fund balanceF)/estimated amount to be sold

In which,
A: based on total actual and equivalent cost to recycle the estimated 'to be sold' amount (NTD/ unit or kg)
B: average purchasing cost + average collection cost + average treatment cost – average selling price of the new raw material produced + collection incentives + extra weight for complex material.
C: CRT cost of domestic solid waste.
D: environmental cost for amount neither collected nor disposed.
E: expenditures for auditing, personnel, administration, research, development, training, and others.
F: (WRF deficit/ surplus)/ (years to balance)

It is clear that this equation is based on the principle of "pay as you go". In normal conditions, for items with a short life cycle, the CDTF is balanced on an annual basis. Such is the case for containers, dry batteries, and lubricant oil. However, it also allows a reasonable reserve for items with a long life cycle such as, vehicles,

home appliances, tires, and communication products. After carefully deliberating each factor in the formula, the FY 2002 CDTF was approved as shown in Table 1. It is obvious that the environmental factors play a dominant role in the fee calculation. For products in the same category but with different specifications, those containing environmentally unfriendly ingredients have a higher CDTF than others. In the case of iron and aluminum cans, the CDTF is 30% higher for those cans where the pull-tab can't stay with the can after opening. In addition, for items containing complex material or heavy metals exceeding the limits, an extra weight factor of up to four times is added to the fee calculation.

In the past 3 years, the total CDTFs collected from the responsible industries were 6.21B, 6.34B, and 6.20B NTD, respectively. These numbers indicate that the system is settling down, although fluctuations do exist among items.

Table 1: Collection, disposal and treatment fees in FY2002

Items		Fee
Containers	Steel cans	2.64 3.43 (with non-stay pull-tab)
	Aluminum cans	1.3 1.69 (with non-stay pull-tab)
	Glass bottles	1.56
	Tetra Paks	6.9
	Paper carton	3.94
	PET	11.87 20.28 (complex material)
	PVC	19.55 25.24 (complex material)
	PP/PE	9.39 12.21 (complex material)
	PS (unfoamed)	9.39 12.21 (complex material)
	PS (foamed)	37.29
	Dry-cell batteries	12-56
Containers for pesticides and sanitation		0.35 (imported raw material) 0.83-1.55 (imported products)
Vehicles		643 (cars) 96 (motocycles)
Lead-acid Batteries		1.90
Tires		7 (10") 33-270 (<10")
Lubricant oil		0.3 NT/l
Home Appliances	Television sets	441 (>25") 284 (<25")
	Washing machines	378
	Refrigerators	714 (>250kg) 462 (<250kg)
	Air conditioners	305
Communication products	Notebook computers	52
	Motherboards	40.5
	Monitors	147
	Printers	58-108
	Peripherals	6.5-40.5
	Fluorescent tubes	23.98

Fee is expressed as NTD/kg for containers and light tubes and NTD/unit for others

Expenditures

CDTFs collected from responsible industries go to the WRF. The fund is split into eight independent accounts: containers, vehicles, tires, lead-acid batteries, lubricants, pesticide containers, home appliances, and communication products. These accounts are operated independently, although some common expenditures are shared, such as administration, education, training... etc. According to the Waste Disposal Act, the WRF is managed in two parts, trust fund and non-business fund.

Trust fund

The main function of the trust fund is to subsidize those items that deal directly with collection, disposal, and treatment of the mandated materials. The incentives provided to consumers for taking back recycled items are included in the trust fund also. All organizations or agents applying for a subsidy are regulated by the RRMC. All applicants must meet both the facilities requirements and the environmental standards as set by the RRMC. In addition they must report the amounts collected and treated, and they are subject to audits as part of their obligations. Subsidies will not be issued unless the applicant has received a plant certificate and audit approval. For collection and treatment, there is a list of standard subsidy rates for different items. This rate is reviewed annually by the RRMC. Offences are punishable by substantial fines or a jail sentence. The majority of the WRF is in the trust fund. The ratio used to be 70% when the system started, and increased to 80% at present. The ratio for the non-business fund decreased accordingly to 20%. This indicates that more and more of the total budget goes towards direct incentives, subsidies for material collection and treatment, and less for management and administration. This development ensures the system keeps moving toward a healthy structure. No one expects the non-business fund to be reduced to zero. It is generally accepted that 10-15% is a reasonable overhead figure for a mature system.

Non-business fund

The non-business fund unlike the trust fund, deals with supporting the system and to make it run effectively. Expenditures other than direct subsidies are under this category. Their main involvement includes:

1. Educational programs,
2. Auditing of the CDTFs (as submitted by the responsible industries),
3. Auditing of the subsidies (as applied for by the collection and treatment agents),
4. Promotion and support for collection, disposal, and treatment programs for recyclable materials, and the utilization of secondary materials,
5. Administrative and operational duties of the RRMC, and
6. Research, development, and training programs.

Because of criticism and demands for more efficient management of the WRF, the NBF budget distribution was adjusted in the FY2003, although it remained at 20% of the WRF, the same as in the FY2002. There were two major adjustments. First, management and operation funds for the RRFMC and the R & D were both cut reduced to 13.1%. Second, the funds for auditing responsible industries increased to 10.9%. That makes the total expenditure for auditing 28.3%. The distribution and trend of adjustment, clearly shows that the focus of the activities is toward strengthening local government capacity to implement resource recovery and auditing CDTF collection and subsidies. A substantial amount of studies, research and other activities have been carried out within the budget of research, development, and training. They include:

1. Technical assistance and evaluation of collection and treatment agents,
2. Baseline investigation into resource recovery markets,
3. Improvement of recycling system for various items,
4. Emission standards and specifications for collection and treatment operations,
5. Research and promotion of renewable technologies, and

6. System computerization for auditing work as well as reporting activities on both cash and material flows.

The achievement of these projects was outstanding and directly benefits the environment as well as the entire market. The reduction of this budget will damage the integrity of the entire system, and will set us back in international competition regarding any future developments. It is urgent to increase this budget and set a minimum percentage for R & D to ensure motivation and the ability to compete.

History has shown us many times that trying to save pennies on R&D is like reducing the oxygen supply to the brain because the lungs could use some more.

Performance of the Waste Recycling Fund (Wrf)

The RRFMC works closely with the responsible industries, the CDTFRC, authorized auditing parties, collection and treatment agents, and the general public. Producers pay the CDTF, which is reviewed and adjusted regularly by the CDTFRC. The fund collects the fees from industry, and in turn provides financial incentives for consumers and recycling industries to turn recyclable waste into secondary raw materials. In the meantime, auditors, selected and accredited by the RRFMC are authorized to monitor the collection and treatment processes and assure that the amounts of collected and processed items are as claimed. Subsidies are not paid out by the RRFMC until all collected items are properly handled and processed and verified by the auditors. Under the current WRF operation, performance is assessed from two perspectives: Initiative and prevention

From the perspective of taking the Initiative

From this perspective the WRF has improved the living environment, reduced the production of waste, re-used resources, established a complete recycling system and created high economical benefits.

1. Reducing waste production and improving the environment

In 2002 alone, almost 1.27 million metric tones of recyclable materials were collected on the island of Taiwan. Of that, 716,000 metric tones were regulated items and 555,000 metric tones were non-designated items such as newspapers and cloth, which account for 1.3% and 59% of growth respectively over 2001. Because of the continuous rise in the recycling rate each year, the net waste produced per capita per day in Taiwan has been reduced from 1.143 kg in 1997 to 0.895 kg in 2001, or a 22% reduction.

Recycling procedures are subject to environmental standards so as to prevent the production of other pollution. For example, the Freon in older refrigerators and air conditioners and insulation foam, is separated, collected and purified for other uses so as to reduce the destruction of the ozone layer. Certain recyclable materials containing hazardous substances such as fluorescent materials in cathode ray tubes (CRT) or in lamps, mercury or cadmium in dry-cell batteries, and polychlorinated biphenyls (PCBs) in capacitors, are regarded as environment-destructive items. Thus, it is important to carefully regulate and monitor the treatment and storage of these materials to ensure they are properly processed when being disposed of.

Another significant contribution to environmental protection from the fund is the substantial support to the removal of waste scattered in remote areas and isolated islands. Although the quantity collected is not significant, the improvement to the environment is in many cases dramatic.

2. Increasing the re-use of resources

As shown in Table 2 below, since the recycling system was implemented, the amounts of items designated for recycling have gradually increased over the past three years. However,

several problems still exist. For example, as far as the recycling rate is concerned, the recycling rate of PET bottles was sometimes as high as 110%. These erratic recycling rates are due to the incorrect claims from both recyclers and PET industries. Also, the recycling rates for unfoamed PS, Tetra Paks and paper containers are still at low levels, and need to be raised drastically.

Table 2: Amounts of regulated materials processed in Taiwan

Category	Year		
	2002	2001	2000
Containers (Metric Tons)	281,891	245,885	226,579
Containers for pesticides (Metric Tons)	961	886	738
Vehicles (Units)	542,594	530,351	503,702
Lead-acid Batteries (Metric Tons)	32,856	36,257	31,688
Tires (Metric Tons)	103,747	119,034	100,283
Lubricant oil (Metric Tons)	9,411	12,328	11,996
Appliances (Units)	1,300,035	1,848,757	985,548
Communication products (Units)	1,701,338	1,247,946	946,518

After being recycled, recyclable materials become secondary raw materials for new products. It reduces the use of virgin resources. Generally speaking the material regenerated from plastic containers is sorted, shredded and is then ready for sale on the market. Glass manufacturers usually utilize waste glass as supplementary materials in glass products. Colored glass is smashed and ground into powder that is currently being investigated for use as an additive in bricks. End-of-life vehicles are dismantled for conditioner-usable parts and then shredded to become ferrous as well as non-ferrous scrap. Both types of scrap are high-ranked raw materials for smelters. Most of the waste tires are disposed of by grinders. Some of them are also processed through pyrolysis. After the process, tires are converted into small pieces as fuel, solvent, gas, and carbon black. Besides, Portland cement plants are authorized to use recycled waste tires as a heat source in their kilns. Waste electric appliances and waste communication products are collected, dismantled, shredded, and reclassified into metal and non-metal scrap, plastics and waste residues.

3. Establishing a win-win recycling framework

After being generated by consumers, waste is collected and delivered to treatment plants through various pathways. The current framework is a win-win system that was established after countless efforts and with the integration of the WRF. It is an open system that welcomes any individuals and firms to join in. Via the Internet or telephone, the recycling program provides easy access to the general public as well as the recycling industry regarding any related information. The services provided include the following:

a. A toll-free telephone hot line for recycling information

It provides recycling-related information and solutions.

b. The inquiry system for vehicle recycling rewards

With providing an ID number, vehicle plate number as well as the serial number on the recycling document, an owner who gave away their end-of-life vehicle can check on-line the status of the recycling reward application.

c. An on-line declaration system for responsible industries

Producers and importers can report their business volume via the Internet to the EPA for the submission of recycling fees.

d. The recycling management system

Provides schedules of auditing routes, municipal resource recycling statistics, solid waste

treatment status, recycling rates and properly processed proportion of waste.

e. Education and promotion system

So far, there are 620 recycling industries including 523 collectors and 97 treatment plants which are certified to join the system and entitled to apply for subsidies. Among the collectors, 220 of them are collecting end-of-life automobiles and motorcycles. Among the treatment plants, the majority, 58 of them, process waste containers. The distribution of these organizations, based on their characteristics is shown in Table 3.

From the perspective of job opportunity creation, it is estimated that more than ten thousand jobs were created directly by the WRF operation. In addition more than two-hundred thousand jobs are indirectly associated with the existing recycling system.

Table 3: Number of certified recyclers and treatment facilities

Items	Collectors	Treatment plants
Containers	58	58
Vehicles	220	3
Computers and accessories	38	3
Electrical appliances	51	6
Tires	11	17
Lubricants	43	9
Lead-acid batteries	19	1
Total	523	97

4. Creating a high level of economic profits

In 2001, the WRF spent 6.375 billion NTD for subsidies, administration and related activities. The direct economic benefits from waste reduction and resource re-use amounted to NTD 7.835 billion. This figure is based on the estimated collection and disposal cost that was saved on municipal domestic waste, at NTD 3.96 per kg, plus the net profit of about NTD 1.5 billion, from selling the regenerated materials. Roughly, the overall benefit-to-cost ratio was as high as 1.24. If the benefit from reducing environmental pollution impact is further taken into account, the ratio should increase even higher. It is no doubt that resource recycling is a more than worthy business from both economical and environmental point of view.

The side of Prevention

The other achievement of this recycling system under the current WRF operation is prevention of fraud. Manufacturers and importers of regulated items are obligated to report the volumes of their business and must accordingly pay recycling fees for the number of these items sold. At the same time, recyclers have to report the amounts of recyclables collected and processed in order to receive the subsidy from the EPA. To ensure the amounts are as claimed, authorized auditing and certification teams are dispatched to on-site examine manufacturers and recyclers. The function of these auditing teams is as follows.

1. For the responsible industries:

In 2002, a budget of NTD 78.5 million was spent on 13 projects for CDTF auditing, including the prosecution of offending companies. For the 7,000 plus manufacturers and importers who were registered, sales records were scrutinized and reclassified more than 40,000 times. About 1,500 on-site auditing activities were completed. During those audits about NTD 600 million of unpaid CDTF from 900 manufacturers/importers was detected. In addition, 145 cases of illegal CDTF submission were filed in recent years, accounting for NTD 480 million. Of them, 34 cases were settled with the promise from the parties responsible to clean up their act and back pay the unpaid fees. The other 111 cases were sent to court for prosecution of those manufacturers or importers. Since each auditing project traced the previous 5-year records, it is believed that on average, illegal practices amount to approx. 5% of the WRF, each year, although there are fluctuations among individual items being scrutinized.

2. On the auditing recyclables collectors and treatment plants

To prevent false reporting of recycling volumes,

more than 14 projects were contracted to audit the recyclers and treatment facilities. The total expense was twice as that for responsible industries, which was equivalent to 2.6% of annual WRF budget in 2002. Due to the hard and strict actions taken by auditing parties, most of the applicants are well understood the seriousness of illegal practices and report the handled volume carefully. The rejection rate decreased to 1.05, 2.01, 4.48, and 4.38% for plastic containers, tires, motocycles, and cars, respectively.

Issues for Sustainable Management

It has been a long difficult road from the start of the system 15 years ago. The system was caught in the middle of a tug of war between responsible industries and environmental groups as well as pressures from parliament. However, all of these experiences were transformed into positive assets to create a better recycling system. With all the efforts that have gone into this system it can be said that the resource-recycling venture in Taiwan has finally reached a mature level in terms of scope, volumes of recycled materials, and market. The system is well developed and all the participants, including the industry as a whole, the consumers, as well as the government are well informed. However, as far as the actual WRF management and system operation, there remains still room for improvement. The most critical issue is how to more properly plan and utilize the WRF. Suggestions for further improvements are these:

1. Simplification of the administrative process
In general, the processes of declaration and registration are far too complicated and cumbersome for manufactures, importers and recyclers alike. Besides, the costs for doing an audit as required remains so high, that it is far too expensive to include all of the recyclers into this recycling system. It is therefore strongly urged that the administrative processes of the recycling regulations be simplified.

2. Setting the goals of resource re-use rates
In addition to pursuing higher recycling rates, promotion of material re-use rate for regulated items should be a priority. Short and long term goals for re-use rates should be so set that recyclers can gradually improve their collecting, sorting, and treating processes to meet these goals. Most important is the need for the responsible industries to start with aggressively developing and introducing more environmental friendly products into the market place.

3. Development and exploration of the regenerated product market
Due to a lack of markets and the high cost of resale, stockpiling of some of these secondary raw materials causes bottlenecks in the recycling system. More efforts and incentives are required to develop the market for these materials. Meanwhile, deregulation on the utilization of certain recycled materials is urgently required as well. Providing clear guidelines on the use of secondary material will guarantee a smoother circulation of material flow.

4. More R &D on innovative technologies
Improving existing technology, developing and introducing cutting edge technologies is simply an indispensable measure in order to maintain market competitiveness. Reducing the ostrich burying its head in the sand gesture, it will actually be harmful to the development and growth of the system. Substantial investment and a minimum R &D budget should be declared at once, and should be maintained.

5. Privatization of the recycling system
The contemporary trends in international society, and the original spirit of the Waste Disposal Act all focus on producer's responsibility for the collection, disposal and treatment of end-of-life products. However, the present situation is that producers merely have to pay a CDTF. They are presently exempt from any other obligations in this regard. The responsibility of management and implementation should be returned to the responsible industries instead of being

shouldered by the government. Setting the rules, monitoring the system and resolving conflicts should be the role of government. By doing this, a fair and free market system can be obtained without government interference.

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Overview of Solid Waste Incineration and Management in Taiwan

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Introduction

Within only less than two decades of development, Taiwan has rapidly developed its environmental protection (EP) and waste management industry to considerably more mature than most Asia Pacific countries. Although still not quite to the standard of those fully developed western countries, the authors, based on years of multi-national EP and waste management experience, believe Taiwan's experience can be a good reference for administrative regions strongly influenced by Asian cultures of similar living behavior and costal living environment as Taiwan has.

To help readers appreciate Taiwan's experience, the authors guide readers through this paper in the following sequences:

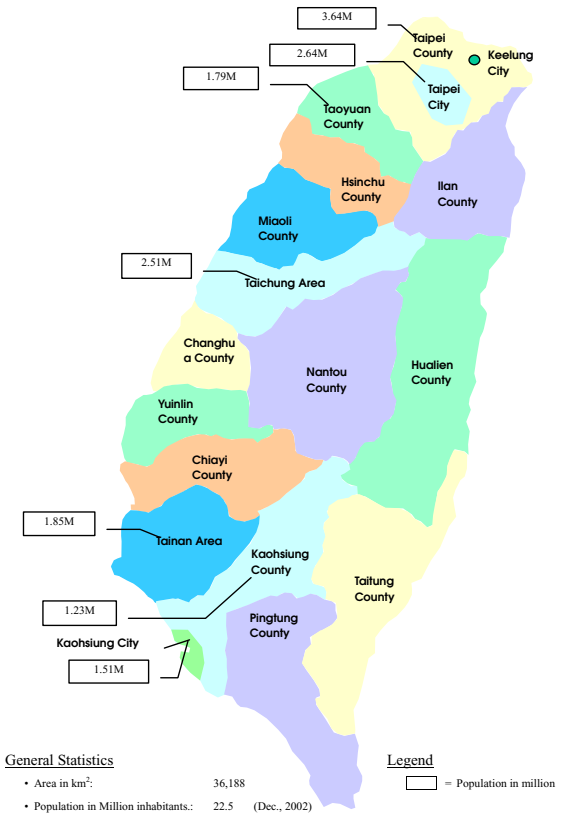
1. Evolvement of Taiwan's environmental protection industry, with brief historical and social-economic background of Taiwan;
2. Legal and regulatory framework of environmental protection industry in Taiwan with an introduction of key policies, rules and regulations promulgated;
3. Waste flow distribution, parties and treatment technology used in Taiwan, with an overview of all waste types, treatment methods and summaries of current status of MSW, NHIW, HW management;
4. MSW, NHIW and HW treatment and disposal facilities in Taiwan;
5. Challenges, problems and the causes of problems that Taiwan's incineration and waste management industries are facing;
6. Future prospect of waste management industry in Taiwan;
7. Suggestions for and future prospects of waste management industry in Asia Pacific Countries.

Evolvement of Taiwan's Environmental Protection Industry

Taiwan is an island state with approximately 22.4 million people living on a land approximately 36,000 square kilometers in size of which 3/5 of the land are steep mountains and are not suitable for living. It is geographically located southeast to Mainland China apart by the 150-kilometers wide Taiwan Straight. With Tropical of Cancer line crossing over southern Taiwan, the weather is mainly sub-tropical. Figure-1 shows the map, administrative regions and basic economic statistic data[1] of Taiwan.

Prior to 1960, Taiwan was essentially an economically under-developed territory with its economy built mainly based on agricultural production that generated an income per capita less than US$ 1,000 per person per year. During this stage, environmental protection (EP) was not an agenda for the government at all.

Figure 1:
Map of Taiwan and basic Economic Statistics



Source: Directorate General of Budget Accounting Statistics

When light industries for manufacturing basic plastic utensils, bicycle, exporting upgraded food products and the similar industries emerged from 1960 to 1975, Taiwan's income per capita reached around US$ 2,000 per person per year. EP however remained an insignificant issue and a division under the National Water Bureau managed EP related affairs without serious consideration for law development and budget appropriation. EP was merely a concept rather than a real affair during this stage.

Within the following 12 years from 1975 to 1987, Taiwan began to embark on developing heavy industries like petroleum refinery, plastic industry, automobile industry, steel production, shipyard building, modern highways, modern airports, etc. The development pace was remarkably rapid and heavily concentrated in southern Taiwan. Unavoidably, large quantity of waste was generated along. Illegal dumping of household garbage and industrial wastes became popular scenes and "Garbage Mountains" started to "grow" along the highways and river banks while spent chemical solvents poured on the ground soils were not uncommon. With the Taiwanese income per capita already reached US$ 6,000 per person per year that made managing environment affordable, the Taiwanese government began to seriously think of controlling the environmental pollutions during this time period.

Many meetings took place in the period with enthusiastic participations of overseas Chinese experts, international experts and Taiwanese government officials. Two major milestones were achieved and materialized during this stage, which are (a) the central point of the waste management policy was formed gearing toward incineration and (b) Taiwan Environmental Protection Administration was established as a government cabinet level agency to manage all EP affairs.

EP law was finally taking its shape, followed by development and promulgation of regulations and rules. Subsequently, incineration plants were built in accordance with the central theme of solid waste management policy; local Environmental Protection Bureaus were established and staffed; more and more modern waste collection trucks were purchased and operated by local sanitary teams and the EP law enforcement task forces were gradually building up. With all of these developments, waste being continuously generated was becoming controllable but waste accumulated from early days was left untouched until recently.

During this time period, water and air pollution control were also monitored, although the actual facilities and systems were almost

all financed, built and operated by private industries within their industrial fence and the government's role and responsibility was only for promulgating laws and regulations and their enforcement.

In terms of the waste category focused for proper management, the Taiwanese government had dedicated its efforts and thus allocated relevant resources largely on managing municipal solid waste (MSW) disposals in the first ten years of the course of EP management implementation campaign, or between 1990 and 2000. When MSW management was stabilized and reached substantial proper treatment rate, the government refocused on proper management of industrial waste (IW) issues from year 2001 with a goal of proper management of all IW by year 2010.

With its high population density of more than 3,000 people per square kilometer of effective useful land and comparatively scarce flat land available for industrial use and relatively comfortable economic strength with an income per capita reaching US$ 13,000 per person per year, Taiwan naturally chose to use incineration as the main disposal method for managing its waste with a goal of achieving maximum volume reduction. Generally speaking, Taiwan uses incineration to treat more than 50% of its wastes.

Nowadays, most MSW, non-hazardous solid and semi-solid industrial waste (NHSSIW) and hazardous solid and semi-solid industrial waste (HSSIW) are disposed off mainly by means of various incineration technologies including conventional mass burn MSW incineration plants installed with air pollution control system (APCS) and steam turbine for power generation and export, rotary kiln incineration plants installed with APC and steam generation unit for burning mixed solid, sludge, liquids while generating steam for export, and fluidized bed combustion plants installed with APC for burning prepared solids and sludge.

Legal and Regulatory Framework of Environmental Protection Industry in Taiwan

The government in Taiwan is mainly divided into three administrative levels. At the central level, the Executive Yuan supervising a dozen of ministries forms the executive branch of the government while the Legislative Yuan consisting of approximately 250 seats of Legislators, similar to the combination of congresspersons and senators in the western world, reviews, passes and promulgates the laws.

The next level is made up of 16 counties and 5 cities. The 16 counties are managed by their respective County Commissioners while their budgets are reviewed and approved by their respective County Councils. The five city mayors manage the cities and their respective budget are reviewed and approved by the City Councils. Among the five cities, Taipei City is the capital city of the island and is directly supervised by the Executive Yuan. As such, Taipei City enjoys a higher political status than other counties and cities on the island.

The organizational chart of the Taiwanese government and relationship among various agencies are manifested in Figure-2.

At the bottom level of the government administration is approximately 400 villages and townships (within the counties) and districts (within the cities) managed by their respective Administrative Leaders.

As a regard to environment management, all environmental relevant laws are initially proposed by the cabinet level agencies of the Taiwan Environmental Protection Administration (TEPA) and the Ministry of Economic Affairs (MOEA), followed by review and approval of the legislative branch. Accordingly, proposals need to pass three readings in the Legislative Yuen in order to become or amended as official law(s). Once legalized, both TEPA and MOEA will develop more detailed

implementation rules for daily administration and enforcement use. The development of the rules and the implementation of rules and regulations are mainly the responsibilities of TEPA.
Key laws and regulations concerning environmental protection industry are manifested in figures 3, 4, 5 and 6.

Waste Flow Distribution and Treatment Technology Used in Taiwan

To help readers quickly grasp an overall insight to the waste flow distribution with ease, the authors of this paper have compiled all data published by various agencies of the Taiwanese government and converted into waste flow distribution diagrams in an innovative graphical fashion as in Figure 7 through 13. These figures start out with the total waste generation quantity, flowing through various treatment methods and end up in various kinds of final disposal destination including informal disposal methods.

The data presented in these figures have been carefully reviewed and verified not only against the government publications but also with industries actually in operations including informal disposal methods that the Taiwanese government is generally reluctant to admit.

These figures are self-explanatory. Figure-7 shows the overall waste flow distribution in Taiwan including the treatment and disposal channels by parties involved and by technology utilized.

Figure-8 shows the overall waste flow quantity distribution in mt/year in Taiwan. The stream numbers used in figure-8 are the same as the stream numbers used in figure-7.

Figure-9 to 12 show respectively the flow and quantity distribution of MSW, commercial and Non-Hazardous Industrial Wastes (NHIW), Hazardous waste (HW), medical and infectious waste in Taiwan, including the treatment and disposal channels by parties involved and technology utilized.

Overview of MSW Quantity, Treatment Methods and Flow Distribution (Figure 9)

Taiwan currently generates approximately 21,500 metric-ton (mt) per day (or 7,839,470 mt/year) of MSW, approximately 64% of the 11,370,000 mt/year of MSW quantity reported by the government two years ago2. Currently, approximately 57% of the MSW is incinerated at WTE plants while about 31% of MSW are disposed off by landfills. The industry of recycling and reuse of MSW is just at the beginning stage in Taiwan. They do not represent a significant outlet of MSW disposal yet.

As the main disposal method of MSW, WTE plants are built with standards and quality comparable to western countries. The mass burn technology is adopted as the standard technology for burning MSW and plants are generally installed with modern air pollution control (APC) system, boilers, steam turbine and electricity generator3. On the contrary, landfills are fairly primitive. Not only most landfills do not have a gas collection system but also they are not built with liners and leachate collection system. Landfills in Taiwan are largely financed and built by counties and cities and operated by local townships and villages.

The MSW quantity generated currently is much lower than the government has originally estimated a few years ago, which projected a daily generation rate at about 31,000 mt/day (or 11,370,000 mt/year) for year 2002. The over estimation of the MSW quantity has resulted in a situation of over supply of incineration capacity by approximately 25% as WTE industry is experiencing today and will climb up to 40% soon after all WTE plant construction are completed unless government is bold enough to shut down all landfills that are taking in combustible solid wastes.

There are a few reasons causing the over estimate of the MSW quantity:

1. Local villages and townships over reported the waste generation quantity initially with a motivation to get more financial subsidy from the central government.
2. Some villages and townships did not distinguish the difference between the volume and weight by taking the volume of MSW collected mistakenly as tonnage collected.
3. A large number of factories and people have moved to China to work and resulted into a population drop in Taiwan by approximately 5% instead of a continuous increase originally estimated by the government and likewise for the waste estimation.
4. Although not significant enough, waste minimization and recycling program promoted by the government is bringing effect on MSW generation.

Although the Taiwanese government is advocating in the program promotion, the real progress may be slower than the government had hoped for mainly due to limited living space of households and cultural behavior. In addition, the economic fundamental of recycling and reuse industry is not as promising for the reasons that it is not only lack of economic scale but the protection of the legal ground for preferential use of recycled materials for making goods and construction is also missing. Unless the government is willing to put in hefty financial subsidy, the ultimate recycling and reuse rate will be lower than that in most western countries.

Overview of Commercial and Non-Hazardous Industrial Waste Quantity, Treatment Methods and Flow Distribution (Figure 10)

The Taiwanese government reported the year-2000 annual generation quantity of commercial and non-hazardous industrial wastes at approximately 18,000,000 my/year4 or 2.3 times of MSW generation rate. The quantity of the non-hazardous industrial waste (NHIW) and the hazardous industrial waste (HIW) generated was based on the field survey of top 1,000 industries conducted from 1996 to 1998, multiplied by the ratio between the entire island's GNP and the GNP of these top 1,000 industries (equivalent to approximately 75% of the island's GNP) and further assumed a growth rate of 3% per year from 1999 onward.

As shown in Table 2, Non-hazardous Industrial Waste Production Estimate in Year 20004, a breakdown of the NHIW by waste types, approximately 59% of the NHIW are inorganic in nature comprising mainly sludge, ashes, construction debris, spent metals and mining slag while approximately 41% are organic in nature mainly comprising of paper, plastic rubber, lumbers, chemical sludge, petroleum sludge and organic solvents, etc.

The waste management industry, however, believes the actual quantity of NHIW in year 2002 is far less than the reported year 2000 data for the following reasons:

1. Taiwan's industry, especially those traditional manufacturing not related to computer industry, is in general moving out to China and has a significant impact to the islands' GNP with an estimate decrease in waste generating quantity amounting to approximately 30%.
2. Economic growth rate has been lower than 3% per year for the past three years approaching zero growth and even negative growth based on actual buying power, implying that the industrial waste production has been much lower than estimated quantity.
3. The effect of waste minimization and waste recycling programs are slowly taking place.

Experts in the waste management industry are more inclined to believe the actual quantity of NHIW is 30% less than the government reported quantity, or close to 12,600,000 mt/year.

Overview of Hazardous Waste Quantity, Treatment Methods and Flow Distribution
(Figure 11)

The Taiwanese government reported the hazardous waste generation rate in Taiwan is approximately 1,600,000 my/year4. The detailed

break down of the HW by generation industries and by waste categories (waste code) are manifested in Table-3 and Table-4 respectively.

The estimation of HW has been difficult as most factories are reluctant to voluntarily report the generation quality and quantity. Once a factory has reported the HW generation data, they have to face the routine inspection of the treatment operation and disposal destination by TEPA. On the other hand, the government also does not want to actually enforce the regulations as there are far less than sufficient of HW treatment facilities available in Taiwan. Strong enforcement of the regulations would only cause the society to be panic while no solution can be offered. In a way, the government is half closing their eyes on tracing and controlling the HW generation and disposal.

Because the treatment and disposal cost of HW is far greater than NHIW, most factories choose not to report and to treat nor to dispose of the HW in formal and regulated ways. The results is that although there are a few treatment and disposal merchant facilities, financed and operated by private operators, available in Taiwan yet these facilities are having problems of receiving the HW, which is not even 10% of the government estimated generation quantity.

MSW, NHIW and HW Treatment Facilities

MSW Facilities

When TEPA promoted and fully funded mass construction of WTE plants to promptly manage increasing need of MSW generated, the program gave municipalities with higher population density the priority. As a result, WTE plants were first built in metropolitan city and regions including Taipei City, Taipei County, Taichung City, Tainan City and Kaohsiung City during the first phase of the Program, followed by constructions of WTE plants in Kaohsiung County, Chung-Hwa County, Ping-Tung County and Chia-Yi County during the second phase. As shown in Figure 13, more plants are built in the southern Taiwan than in northern Taiwan. Upon completion of construction, these central-government-financed plants were transferred to local municipalities for maintaining ownership and proper operation and management.

There are a total of 19 government-financed and one privately financed WTE plants in commercial operation today in Taiwan, amounting to a nominal incineration capacity of 21,150 mt/day based on TEPA data. There will be additional three government-financed and 8 privately financed WTE plants becoming on line in a few years of time, with a total of additional 3,500 mt/day of nominal incineration capacity. These facilities are listed in Table-5 and Table-6 respectively.

When all of these facilities are completed, there will be a total of 24,650 mt/day of nominal incineration capacity available in the market or more than double of all MSW currently incinerated. Even with all landfills restricted for taking in organic wastes, the incineration capacity is still over supplied by 25%, meaning only 75% of the incinerated capacity are needed to burn the entire island generated MSW. In view of over-supply of the MSW WTE plant capacity, TEPA finally decided and announced in March 2003 to cancel all WTE plant BOO/BOT projects that are not yet tendered/awarded.

NHIW Facilities

NHIW in Taiwan are treated either at facilities that are dedicated to treating NHIW only or at MSW WTE plants through co-incineration approach.

There are quite some NHIW treatment facilities; most are small in scale, available in the market. Most of these facilities are non-incineration in nature and are designed for recovering spent solvents, landfill ash, recycling and reuse of ash, paper, plastics, motor vehicle and household

appliances. These facilities are listed in Table-7 for reference. It is worthwhile to note that only a very few plants are taking in NHIW in organic nature for incineration, as the economic scale of most facilities in the market are too small and are not able to compete with large WTE plants that are also allowed to burn large percentage of NHIW directly in the waste mixture collected. The only few exceptional facilities that are in fact treating NHIW are those fluidized bed incineration plants, which are dedicated to burn petroleum and chemical sludge only. As a matter of fact, the prospect is for almost all kinds of solid NHIW in organic nature to be incinerated in WTE plants.

Unlike in western countries that use WTE plants to co-incinerate mainly the commercial wastes (waste collected from restaurants, department stores and shopping areas) only, the practice in Taiwan is to use WTE plant burning true non-hazardous industrial solid wastes such as the chemical industrial wastes, plastic industrial wastes, petroleum refinery industrial wastes, pharmaceutical industrial wastes, machinery industrial wastes, leather tanning industry, etc. These true industrial wastes often contain components that are corrosive and abrasive in nature with high heating value beyond the plant's design envelop and with high percentage in volatile organic matters that stretches the WTE plant's technical application to the limit. These in turn bring the most challenging tasks to the material for constructing boiler tubes and the operational and maintenance management and control beyond the level most western countries have experienced.

This kind of application will continue and dominate the market development in the future mainly as a result of that (a) there are significant excess in incineration capacity available of these WTE plants and (b) only very few incineration plants that are dedicated solely to treating NHIW can survive in Taiwan's market financially.

HW Facilities

There are actually very few hazardous waste management facilities in operation as of date in Taiwan, as shown in Table 7. The most prominent one, also the largest and in scale, is a hazardous ash and sludge landfill developed by Kan-Lien Cleanaway that is current in operation in the southern part of Taiwan. The facility is actually constructed with a standard comparable to western countries' standard. The pitiful thing however is that the facility can not receive enough HW from the market in order to pay back its investment and operation cost, although the actual HW generated by the industry is far more than manifested.

There are two HW solvent recovery facilities in Taiwan. However, the operation is on and off from time to time. They are on for operation because there is always a need for chemical industry to dispose of hazardous solvents. They are off from operation often on a temporarily basis as a result of license suspension due to illegal operation involved and found caught by local authorities.
In addition, there are also a couple of facilities that provide packaging, not ultimate treatment and disposal, of HW such as PCBs and mercury laden sludge for exporting to western countries with advance treatment facilities for final treatment and disposal. Most of these facilities are operated under very low profile fashion to avoid public attention and political complications.

Some medical incinerators are also available in Taiwan but the scales are generally quite small, ranging from 1 to 10 mt/day, owned by private developer or general hospitals. The overall incineration capacity is sufficient to treat all medical and infectious waste generated daily.

Challenges, Problems and the Causes of Problems Faced by Taiwan's Waste Incineration Industry

Analysis of Taiwan's waste incineration industry is presented by waste type, namely, MSW, HISW, and HW, as in the followings:

MSW Industry

1. Geographical Imbalance of Treatment Facility Distribution

As a result of over estimation of MSW generation and over-supply of MSW WTE plant capacity, TEPA cancelled all un-tendered BOO/BOT MSW WTE plant projects in March 2003. However, as most MSW WTE plants already built and in commercial operation locate in the south where industry move-out is most prominent and severe, the highest incineration availability or excess capacity is found in southern Taiwan.

2. Improper Exercise of Waste Flow Control by Local Municipalities

In acknowledge of the fact of excess MSW WTE plant capacity in some municipalities while some municipalities are not installed with any MSW WTE plant, TEPA encourages sharing of incineration capacity among municipalities on the island by formally amending the Waste Management Act to prohibit blockage of cross-municipality-boundary transportation of waste by local governments.

Nonetheless, political blockage of waste flow against the central government's regulation exists as a known fact in Taiwan not just as a single case but a popular phenomenon all over the island. Local governments of counties and cities where MSW WTE plants are available often remain inclined to have the sentiment of not accepting other administrative regions' waste. This kind of waste flow control has resulted in regional imbalance between waste generation quantity and incineration capacity in service.

The most prominent example of refuse to the sharing of incineration facility is Taipei City's refusal to Keelung City's request for treating its MSW at an incineration plant owned by Taipei City. Taipei City's incineration capacity is in excess, to such an extent that most of the time only 50% of the capacity is utilized while the neighboring Keelung City has no incineration plant. Despite Keelung City's request and that the TEPA's regulation is to encourage sharing of incineration capacity among municipalities, Taipei City Council remains firm in rejecting Keelung City's MSW delivery to Taipei City's incineration plant for treatment.

Improper exercise of waste flow control is however even more severe in NHIW management. While the southern Taiwan is experiencing most impact from industry and resident move-out to China and thus having highest vacant incineration capacity, northern Taiwan's population remains relatively stable and industries based on electronics and computers, although affected somewhat, continues to be active, both result in higher demand for incineration capacity and outbound management supplement for treating NHIW.

With the mentality of not favoring waste delivered from other municipalities, local governments hosting WTE plants with capacity remain available often make the cross-boundary NHIW applications by private sectors difficult. This improper exercise of waste flow control by hosting governments in fact further jeopardize the NHIW gate fee revenue stream collected by private operators who subcontract the operation and management responsibility of WTE plants from the hosting governments and are already suffering negative financial impact from significant reduction of waste generation on the island (further detail in the section on NHISW discussed below).

3. Unfair government WTE plant operation and maintenance (O&M) contracts standardized by local governments[5]

Most WTE plants are financed by TEPA and the ownership is transferred to local counties and cities for free of charge after constructions are completed. Most counties and cities then subcontract private companies for long-term operations under either 15 years or 20 years O&M contracts and get concession fees from these private operators. As mentioned above, municipalities hosting WTE plants often cannot deliver sufficient MSW to keep the plant running at full capacity and results in running plants

only at 1/3 to 1/2 of plant maximum incineration capacity in most cases.

Because of their inability to provide sufficient MSW guarantee to operators, hosting governments therefore allow private operators collect and receive Non-Hazardous Industrial Solid Waste (NHISW) from the market to fill up excess plant capacity as an "incentive" to private operators so that the plants' operation and maintenance contracts can be successfully tendered and awarded. The incentive includes entitling subcontracted operators to all gate fee income collected from receiving NHISW secured by the operators from the market and power sales revenue generated by burning MSW and NHISW collected.

By doing so, hosting governments not only were able to lock the operators in for proper operation and management of the incineration facilities that hosting governments inherited from TEPA for free, minimize service fee charges that the municipalities normally have to pay for subcontracting the operators for plant operation and in some cases hosting governments even get reverse concession fees from operators for treating MSW delivered by hosting municipalities, but also receive a hefty fixed income of concession fees for the NHISW tonnage guaranteed by the subcontracted operators, regardless of the NHISW market conditions the operators are exposed to.

Not only hosting governments transfer waste source risk (which is both fuel risk and revenue risk in WTE plant industry) to subcontracted operators, but also they benefited from the commitment of operators for returning the "leased" incineration facilities with a plant performance guarantee that is no less than 96% of is original efficiency, at the end of the 15- or 20-year concession period. This implies that the operators have to replace almost all equipments before handing back the plant to the municipalities in addition to many major overhauls the operators have to accomplish during the concession years.

The commercial nature of this kind of contractual arrangement widely used in Taiwan in a way makes the municipalities able to get two times the value of the plant construction cost plus a guaranteed hefty interest income from the private operators. The total financial benefit gained by the hosting governments over the 20-years concession period is equivalent to or even better than a bank could get from the mortgage payment for lending money to customers for purchasing private property because the governments retain the ownership of the facilities "leased" out to private operators at the end of the contract term while customers of banks will own the mortgaged property at the end of mortgage period.

It is a win-win situation for the municipality and the lose-lose situation for the private operators. It is a rip off deal in this case except the private industry has no other choices because they are dealing with the government authority.

4. Lack of proper incinerator ash disposal sites

Another challenging aspect of the WTE industry in Taiwan is the lack of incinerator ash landfills. With twenty WTE plants already in operation, the supply of fly ash landfills and bottom ash landfills remains lagging behind the demand, with most ash landfills being only temporary by their fairly short service life. Some WTE plants have no choice but to temporarily store ash in bags within the fence and hope that the neighborhood does not become aware of the ash storage fact so that no protest will be launched. When a protest does get launched, the impact would be most severe on the subcontract plant operators but not hosting governments because it is the operators who will suffer from financial loss but not governments.

NHIW Industry

Currently Taiwan generates approximately 15,000 mt/day4 of Non-Hazardous Industrial Solid Waste (NHISW) that is combustible in nature where approximately 3,500 mt/day are incinerated by government operated and privately operated WTE plants, 1,000 mt/day are incinerated in various

small incinerators run by private operators, 4,500 mt/day are directly disposed off in landfills that are far from adequate in design and construction for the purpose and undeniably approximately 6,000 mt/day of the NHISW is left unmentionably disposed of in unrecognizable open areas without proper and prompt monitoring from authority in charge.

The problems of proper management of NHISW that the Taiwanese government is facing include the followings:

1. Unethical competition from landfill

Although the basic policy taken by TEPA is to co-incinerate the NHISW in WTE facilities and a few small-scale independent incineration facilities developed and operated by private entities yet the reality is far from ideal.

Taiwan has more than 200 landfills of which most are operated by local villages and townships. Most landfills do not have a gas collection system yet are taking in raw MSW and NHISW daily. These raw waste in organic nature are either taken in by government owned and operated trucks or collected and delivered by privately operated hauling companies, and are gradually converted to vaporized gases that pollute the ambient air with CO, aromatic hydrocarbons, dioxins, etc. in the scale far more than all WTE plant stacks could emit out together by a factor of several tens to hundreds. These landfills not only pollute ambient air but also pollute the underground water and soils due to lack of proper liners and leachate collection and control systems.

More than 90% of the landfills are developed and operated by local governments mainly by townships and villages with the rest less than 10% of landfills developed and operated by private entities. Most privately operated landfills are owned or partly owned by local politicians such as county council members or legislators. Most of these landfills, be them government operated or privately operated, are lack of proper plastic liners, gas collection systems and leachate collection and treatment systems yet they are receiving MSW and Non-Hazardous Industrial Solid Waste (NHISW) and sludge all the time. These landfills receive NHISW and sludge from waste hauling companies; get paid for the waste disposal fee but not necessarily fully report their income properly and ethically. Because the operations often involve participations of politicians who have more or less influence in the review and approval of the county and city budgets, hosting local governments remain fairly helpless in overcoming the problem of inappropriate operations.

2. Improper exercise of waste flow control by hosting governments

While hosting governments of WTE plants offer the incentive for subcontracted operators to collect NHISW as a revenue generation operation so that the operators would commit to properly operate and manage government property/asset and pay their respective hosting governments with fixed NHISW concession fees, governments do not fully lend their support to operators for collecting NHISW. Improper exercise of waste flow control is in fact more severe in NHIW management than it is in MSW management.

Although southern Taiwan is experiencing most impact from industry and resident move-out to China and thus having highest vacant incineration capacity, northern Taiwan's population remains relatively stable and industries dominated by electronic and computer related business continue to be active with less impact. This situation results in northern Taiwan's having higher demand for incineration capacity and requiring outbound management supplement for treating NHISW.

With the mentality of not favoring waste delivered from other municipalities, local governments hosting WTE plants with capacity remain available often make the cross-boundary NHIW applications by private sectors difficult. This improper exercise of waste flow control by hosting governments in fact further jeopardize the NHIW gate fee revenue stream of private operators who

subcontract the operation and management responsibility of WTE plants from the hosting governments and are already suffering negative financial impact from significant reduction of waste generation on the island.

3. Unfair government WTE plant O&M contracts standardized by local governments[5]

As mentioned, governments hosting MSW WTE plants subcontract operators with the incentive of allowing operators collect NHISW by their own and the associated income including NHISW gate fee and electricity sales revenue. In return, the governments are guaranteed by the operators' commitment of fixed NHISW concession fees and, in some cases, MSW concession fees as well, despite market conditions.

On the surface, the incentive offered to operators allowing for self collecting NHISW from the market seems to be attractive but the reality is that governments are transferring market risks to operators and the government is in fact creating part of the market risks.

As known, the operators get their income from two revenue streams, the gate fee revenue from NHISW that are secured and collected by operators themselves and the electricity sales revenue by selling electricity generated from burning wastes to Taiwan Power Company, a state owned power company that is the sole legal power distribution company in Taiwan. Operators therefore need to take risks that are related to both of these two revenue streams and relevant laws and general market development.

When the facility owner (municipalities) is also the authority in charge, it naturally puts the government in the winning position. The most immediate example has been stated above on improper control of NHISW delivery application.

The next example of risk related to law changes is the central government's promulgation of a new law that bans the use of plastic food containers and shopping bags by restaurants, food stands, super-markets and traditional markets effective January 1, 2003. This new law hence has drastically reduced the valuable NHISW sources and heating value of mixed waste received at the WTE plants, resulting in less gate fee sources and electricity revenue.

As a new law, it did not exist or even being planned by TEPA when most WTE plants' O&M contracts were awarded and committed by operators with guaranteed NHISW concession fees to the hosting governments. Operators hence were never made aware of the law development but are nevertheless locked in by the contract to have to endure with this new market risk created by the central government. Operators can not find a way to exit the contract but to continue perform their contract obligations in paying the same amount of concession fee to the hosting governments because protection for operators against such kind of law change is not properly provided in most government issued contracts.

Another good example is changes in power tariff schedule. By contract, operators are subject to the risk of power tariff schedule changes up to 5% range. When Taipower is the sole power dealer of the nation, it determines power tariff schedule at its discrete decision unless serious objection is raised through a joint effort of all operators and co-generation facilities.

Of course, operators also need to take up the basic industrial development risks. When the macro economic condition becomes unfavorable to private operators like the current time in which manufacturing industry reduces production that in turn reduces waste generation, most operators are losing money for being unable to self collect sufficient quantity NHISW, thus, insufficient waste disposal gate fee income.

In sum, the market risk is greatly increased on the private operator's side while hosting governments get fixed income regardless of the market risk and economic conditions in the market. This development in a way significantly deviated from the basic civil service concept of the government

providing infrastructure systems to its people. Rather, the "lease" concept of WTE plant O&M contract is putting the private industries in a position to "actually" providing infrastructure systems to the public while naturally making governments becoming a bank that just lends its money to its people and collects fixed income for as long as the contract remains valid.

If the situation like this is to continue for long, most private operators will go bankrupt and the waste management service will be interrupted. Whether or not this lease concept of WTE plant O&M contract is a sustainable scheme for waste management is highly skeptical.

4. Informal disposal by hauling companies

Taiwan's private hauling industry remains primitive and undeveloped as compared to most developed western countries. As almost all MSW collection is carried out by government sanitary trucks with only less than 3% of the works subcontracted to private hauling companies as short-term pilot projects, privately owned and operated hauling companies in tradition provide services in collecting and transporting NHISW from factories, buildings, supermarkets, restaurants, etc.

There are approximately 2,000 privately owned and operated hauling companies in Taiwan nowadays collecting and transporting NHIW. Most of these hauling companies are very small with only one to two trucks in service and are owned by the truck driver whose wife helps in getting in new clients, collects the waste and serves as the accountant too. With this large number of small hauling companies that are generally lack of operational quality and people working in the companies are lack of proper education in operation, a lot of informal and unethical operations seem unavoidable. By charging a full fee to the waste generators that covers both transportation cost and gate fee for delivering NHISW to legal proper disposal facilities, unethical hauling companies simply dump NHISW collected at remote sites unmonitored by governments such as valleys that are seldom visited by people and riverbanks. Essentially, unethical haulers make impressive income by saving gate fees and part of transportation charges as their net revenue and at the same time making the government difficult to monitor and control the waste disposal destinations.

Not only that the local authorities can not identify sites illegally dumped with NHISW easily, even if they can they would probably find themselves in a difficult situation of executing pertinent penalty or prosecution. By investigating the responsible hauling truck owners, local authorities often either have to face a company fully or partially owned or backed up by local politicians who are involved in the review and approval process of local government's operational budget, in some cases even relevant government officials, or a company that is registered under a figure head's name and that figure head has no real assets nor money to be penalized for the wrong doings. If it were the former case, local authorities often find them necessary to compromise for safeguarding their jobs or budget; as for the later case, some local authorities would suspend or terminate the company's hauling license. This suspense or termination of license may seem severe in many countries, but the Taiwanese hauling companies are cleaver enough to make themselves always readily available with a number of licenses in their hand, all registered under different figure heads again with no money and assets, so that their business will never be interrupted by any means.

HW Industry

The Taiwanese government assigned the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs (MOEA) to take full responsibility of promoting the development of three Integrated Industrial Waste Treatment Centers namely the North Center, the Middle Center and the South Center for the past 15 years but without success. Initially, the idea was to promote the development of integrated IW treatment centers handling both hazardous

and non-hazardous industrial wastes. After the promotion for the three centers continued for many years without success, TEPA then switched to legalize and promote NHISW co-incinerated at MSW WTE plants in order to help relieve the worsening problem of unmanaged NHISW. NHISW therefore became better controlled by being either incinerated in the existing WTE or disposed of in landfills.

IDB then re-focused the program in late 2001 by promoting the centers dedicated to treating hazardous industrial wastes (HIW) only. Nevertheless, after a number of public tendering have failed, there are still no sign that these facilities are to be developed because private developers still see no substantial support or guarantee from the government that would make the investment risk6 beyond manageable range.

Taiwan finds itself caught in the catch 22 dilemma that on one hand the government does not want to step up its law enforcement due to the concern that there are no qualified treatment facilities available in the market to treat the hazardous waste. Once the waste is driven out by the law enforcement, they will have no place to go to. On the other hand, waste management industries do not want to invest in developing the treatment facilities either, due to the concern they may not receive sufficient quantity of the waste to keep the operation sustaining financially. The dilemma has been dragging on for years and still no sustainable solutions been worked out by the government other than creating the legal status for Temporary Storage Facilities (TSF) to legalize formally illegal storage and dumping piles on a temporary basis.

IDB then took a short cut to promote existing small facilities that sort of partially meet modern design and construction standards as legal treatment facilities by exempting them from the having to satisfy tedious and exhaustive Environmental Impact Assessment (EIA) and rigorous trial burn requirements.

Unfortunately, these facilities can not receive HIW in sufficient quantity and are suffering significant financial losses. As these facilities are the only few legal service providers in Taiwan and their equipment and operation procedure are more expensive, often the cost is more than NT$10,000/ton (while the cost for NHISW is only NT$2,000/ton), they charge a higher gate fee than others in order to recover the pay back installment of development and construction cost and to cover a higher operational cost. The cruel fact then resulted is that hazardous waste generators rather take the chance to dispose off their hazardous waste through informal channels in order to save the cost rather than following the laws and regulations, with some generators just keep storing and piling up HW in their backyards or in borrowed backyards.

The cost-saving informal channels of disposing of HIW often result in illegal dumping, intentional or un-intentional by waste generators through hauling companies, in river, at riverbank and valleys or unattended open areas that in turn caused severe environmental damages such as toxic chemical solvent contamination of river and soil and heavy metal contamination of ground soil. The famous incidents of recent year in Taiwan include illegal dumping of hazardous chemical solvents by Sheng-Li Solvent Recovery Company into rivers and the dumping and burying of mercury laden sludge by a leading manufacturer of its industry that led to international complication and society crisis.

The Taiwanese government could have taken the advantage of learning experiences from its neighboring city government of HK and Singapore who take proactive measures of stepping into a situation that breaks the catch 22 dilemma by either directly invest in the facility with a high equity percentage such as HK's Tsin-Yi Island facility or providing significant annual subsidy to keep the operation going until the facility becomes financially independent like in the case of Singapore's ECO System facility.

However, the Taiwanese government seems to take more passive measures in managing its hazardous waste problem by hoping, or letting, the industry will sort out the problem by itself. This attitude taken by the Taiwanese government in a way is reflecting the true problem the island is facing with that on one hand, the government's budget is drying out in recent years that makes it difficult to help out the industry through either direct investment or financial subsidy while on the other hand the government can not perform like a unified body to sort out its priority and implement the program with executive orders.

As a regard to medical waste management in Taiwan today, the overall incineration capacity is sufficient to treat all infectious waste generated in Taiwan yet the reality is often that medical and infectious waste are not always being properly treated. The reason is not so much technically related but more of political related, which from time to time triggers public protest that leads to license suspension or plant shut-down, society crisis and eventually the infectious waste unmanaged promptly and properly.

Future Prospect of Waste Management in Taiwan

The Taiwanese government authority has already decided to completely ban landfills of raw organic wastes by year 2010. That is, only incinerator ash and inorganic waste can be disposed of directly at landfill, supposedly, by year 2010. It is anticipated that combustible waste disposal by means of landfill will gradually diminish. The authors however anticipate that landfill owners will accelerate waste intake before 2010 in order to fill out the capacity and to recover their investment before year 2010. The high peak of waste intake by landfill is likely to take place from year 2003 to 2005.

In view of the government's performance history and, current industry and trend as summarized so far, industries are not confident in the government's law enforcement. As a result, the investment in new waste treatment facilities will be nominal. It is highly possible that the Taiwanese government would maximize the use of existing WTE plants or to be completed in near future by driving all MSW and all organic or combustible industrial wastes delivered to these WTE plants. Waste types identified may well include the MSW, sludge, pre-sterilized medical wastes and non-hazardous wastes. It is also possible that the Taiwanese government would re-classify the hazardous wastes by delisting some of the wastes with less hazardous nature to allow these wastes to be incinerated in WTE plants. In the long run, WTE industry will remain as the main stream for disposing solid wastes in Taiwan.

With all WTE plants in operation, outlets for fly ashes and bottom slag will remain a challenging aspect for the Taiwanese government and the industry to deal with in the near future. Bottom ash re-utilization as construction raw materials (such as concrete filler, brick filler, etc), geotextile materials for landfill construction and road subsurface paving material would be plausible solutions. Nevertheless the Taiwanese government needs to take the lead in passing promotional regulations and perhaps even providing pilot programs and subsidies in order to help cultivate bottom ash re-utilization becoming a sustainable industry in the long run.

Although fly ash reutilization is another focus under development in many countries, it seems far away from reaching the commercial reality in Taiwan and the long-term prospect is not bright at least viewed from Taiwan's prospective. Technologies including high temperature melting process through combustion, electrification and plasma furnaces have been tried but without success for the reasons that (a) the cost is too high to survive in the market and (b) the outlet of the product is very limited. The authors therefore see fly ash reutilization unlikely to

become an economically sustainable solution in the near future. Most likely, the trend of fly ash management in Taiwan would be to continue using the current in-plant equipment for solidification (by mixing with cement) and stabilization (by mixing with chemical chelate and cement) that most WTE plants in Taiwan are installed with for fly ash treatment, followed by landfill at specially designed and constructed fly ash landfills.

Taiwan's hauling industry is unlikely to be improved to a satisfactory level soon because of politicians' involvement and too many interested groups are involved in the operation. TEPA and local Environmental Protection bureaus although are tightening up the manifest control forms and start using Global Positioning System (GPS) for tracing some large hauling companies' trucks, the results might just look good on paper but not so much in reality.

It is worthwhile noting that a new business branch in Taiwan's waste management industry is emerging, the cleaning up of sites illegally dumped with waste. As mentioned previously, there exist a very large quantity of MSW and NHISW illegally dumped at valleys, riverbank and other unattended open areas alike in Taiwan as by-products of its rather impressive economic development in the past two decades. With further development of the island, more modern highways and railroads need to be constructed, such as the famous Taiwan High Speed Rail (THSR) project that gets the worldwide attention. When these infrastructures are being built, often former illegally dumped or buried waste piles or "mountains" are discovered. Ranging from several thousand to more than 10 million cubic yards in size, the removal and disposal of these waste mountains are in fact a significant burden to the government's budget appropriation.

Proper solutions for cleaning up these waste mountains, or excavation, removal and final disposal of former illegal dumping sites, therefore become a significant new branch of Taiwan's waste management industry. Quite a few projects are already done or in the execution process. Typically the project scope involves waste excavation, segregation, sorting and separation by trommel mills and air classifiers, recycling and reuse of plastics, transporting combustible waste to WTE plants for incineration, refilling the site and reinstating the landscape, etc. Projects for cleaning up waste piles on riverbank are more complex and often require temporary blockage of underground water flow, construction of wet soil retaining wall, temporary water storage pond and simple treatment plant.

There are hundreds of sites illegally dumped and buried with waste, of which a significant number are even contaminated with chemicals. Some of the contaminated soil have been caused by toxic and hazardous chemical solvent spillage, shallow-well injection, leakage of underground storage tanks or heavy metals and require urgent treatment. The budget required is humongous and the technical expertise is broad. The authors forecast that it will take more than 10 years for Taiwan to complete proper management of sites illegally dumped with non-hazardous waste and even much longer for remediation of soil contaminated by hazardous waste, toxic chemicals or heavy metals.

Application of the Taiwanese Experience and Prospect for Other Asian Pacific Nations

As an island state with high population density and medium income per capita (approximately US$ 13,000 per person per year), it is logical for Taiwan to employ incineration as the main method for disposing of all kinds of solid organic wastes. The authors based on many years of experience believe waste incineration will be a logical and affordable solution for managing organic solid wastes for a geographical region where the total GNP reaches US$ 30 millions per square kilometer. A hypothetical case would be for a mega city in Asia with income per capita reaches

US$ 4,000 per year and a population density reaches 7,500 people per square kilometers.

In most western countries, the income per capita is much higher than the US$ 4,000 /person/ year threshold while the population density is much lower than the threshold of 7,500 people per square kilometer. The economic strength measured by the multiplication product of the two factors still reaches the economic threshold of US$ 30 millions per square kilometer. As a result, we see the fact that the WTE industry is quite popular and developed in western countries.

On the contrary, the income per capita may be lower than US$ 4,000 per year in most Asian mega cities while the regional population density can be much higher than 7,500 people per square kilometer, sometimes even reaches 20,000 people per square kilometer. For these cities, it may not be economical to transport MSW and IW to the outskirt of the city for landfill because both the traffic congestion through down town areas (meaning require more time to transport one way and needs more trucks) and the actual transportation distance for getting across these mega cities (meaning to use more fuels) can be a heavy financial burden for the city administration. For these mega cities, having large incineration plants in the city seems a viable solution for waste management and disposal. We have seen this kind of development trend in Taiwan, Singapore, Macau, South Korea and many cities in Japan. It is not unlikely that countries like China, Malaysia, Thailand, Philippines and Indonesia will follow the development trend when their economics are further developed to reach beyond the economic threshold in the future.
One interesting development worthwhile noting is the application of thermal gasification becoming a new focus by some Asian countries. A good example is the Malaysian government is promoting the use of thermal gasification technology to treating their MSW in large scale, which may reach 2,000 mt/day. Although whether or not the technology is commercially matured yet remains to be seen as many western countries have tried it but the industry never took off, the key point is the commercial structure and financial cost involved. Are they sustainable in the long run? After all, WTE industry using mass burn technology is a commercially mature and has been around for almost 100 years.

Having said the above, it is important to learn from Taiwan that the commercial nature of the program and the fairness of the contract are critical to the sustainability of the waste management programs. In addition, as it is always the case that excavating and properly treating illegally dumped waste will cost far more than managing waste when it is freshly generated, Asian governments can learn form Taiwan and properly develop suitable laws and regulations with acceptable enforcement to avoid transplanting Taiwan's problem.

As a regard to waste collection or hauling industry, readers are reminded that maintaining a few large-scale waste collecting and hauling companies can always ensure better hauling industry quality than allowing thousands of small scavenger type of hauling companies loosely or lack of proper feasible regulatory control. The problems and potential damage brought about by thousands of small under-qualified hauling companies upon the society are enormous and the impact can last for years that in turn costs price for correction.

Appendix

Figure 2: Organization of the Taiwanese Government

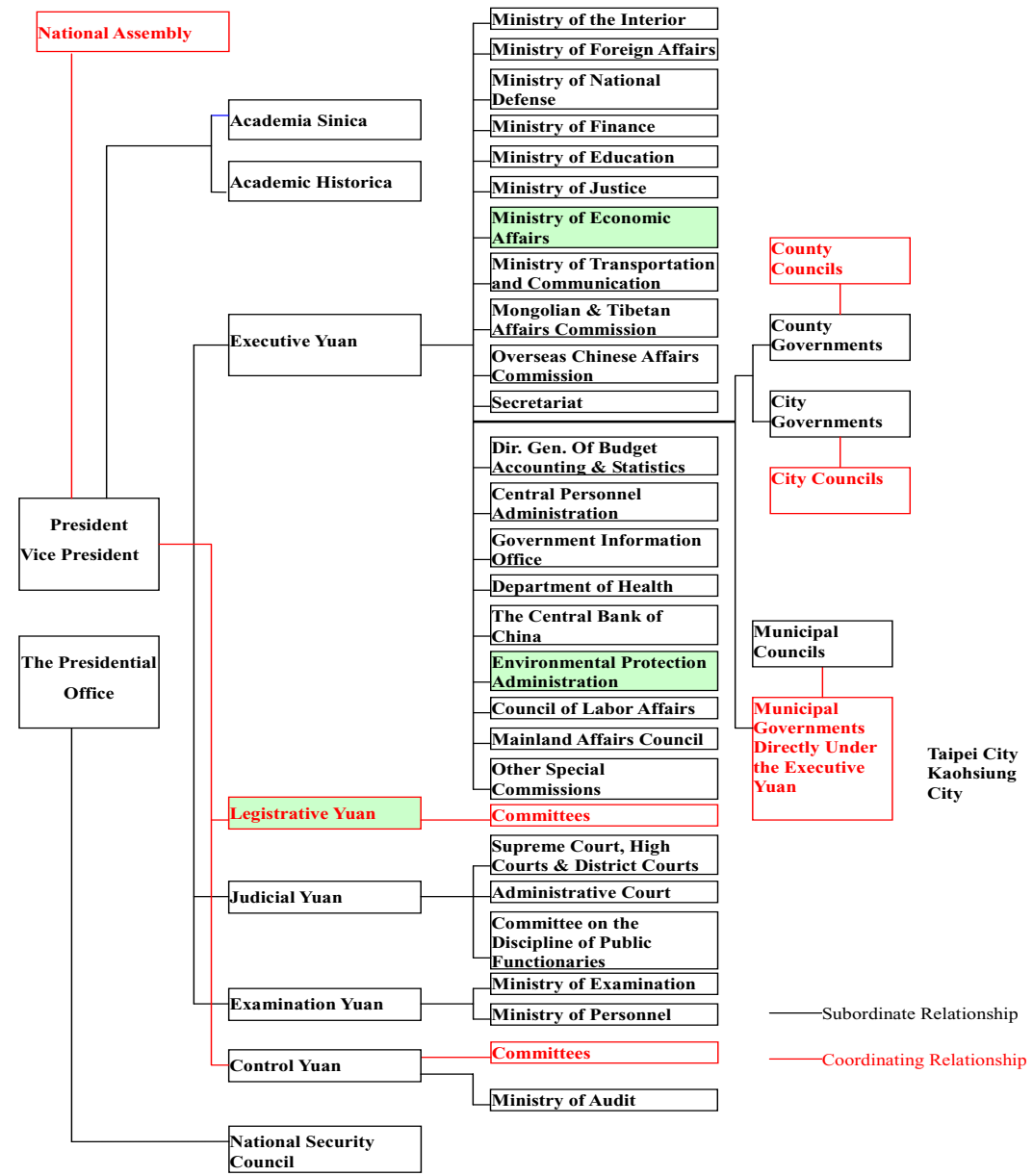


Figure 3: Institutional Framework of Taiwan's Environmental Protection Industry

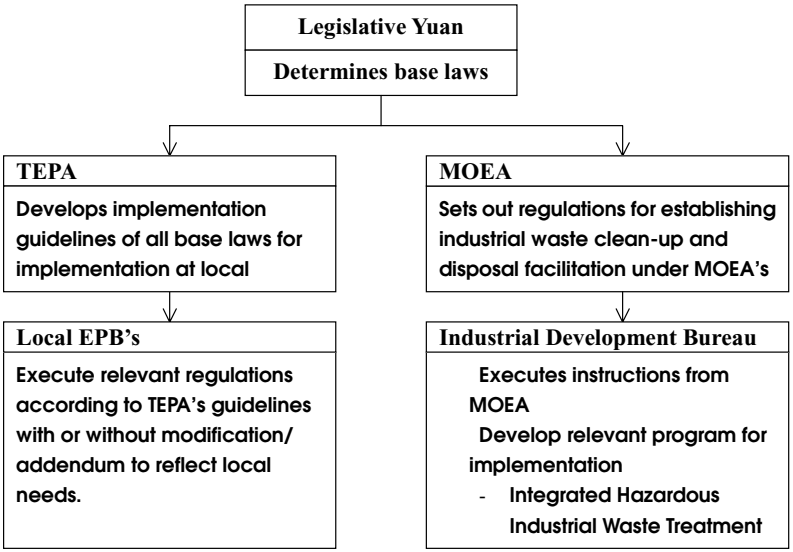


Figure 4: Key Environmental Laws in Taiwan

Waste Disposal Act
Air Pollution Control and Management Act
Water Pollution Control and Management Act
Noise Control and Management Act
Toxic Chemicals Management Act
Soil and Underground Water Contamination Remediation Act
Environmental Impact Assessment Act

Figure 5: Definition of Waste Categories in Taiwan

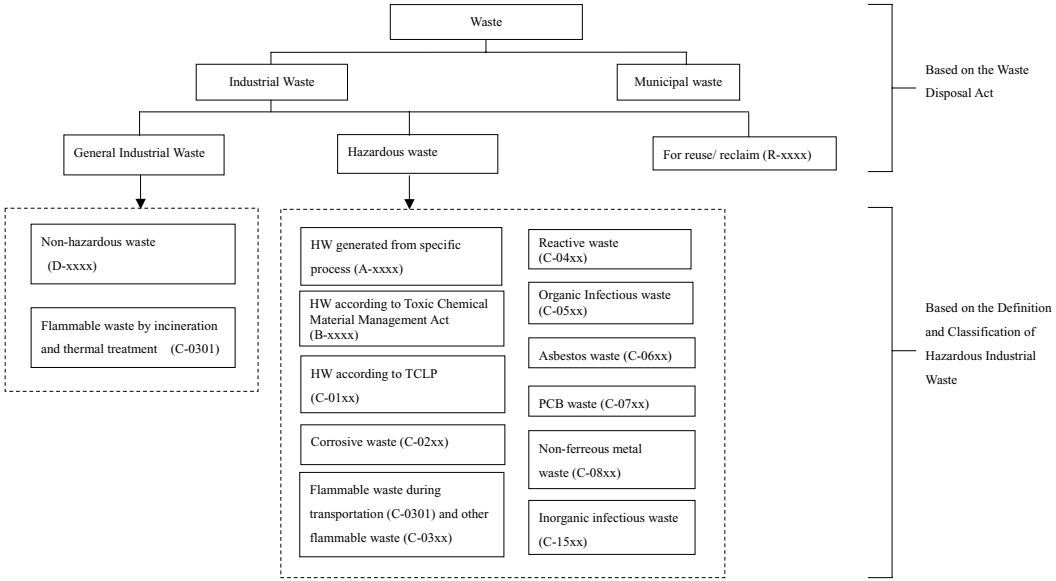


Figure 6: Regulatory Organization of Waste Management in Taiwan

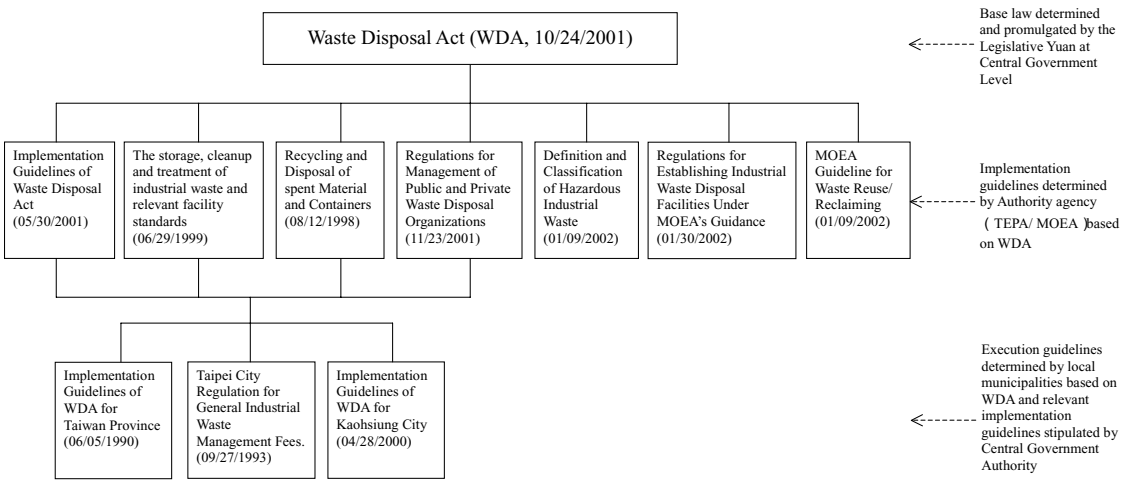


Figure: 7 Overall Waste Flow Distribution and Treatment Technology in Taiwan

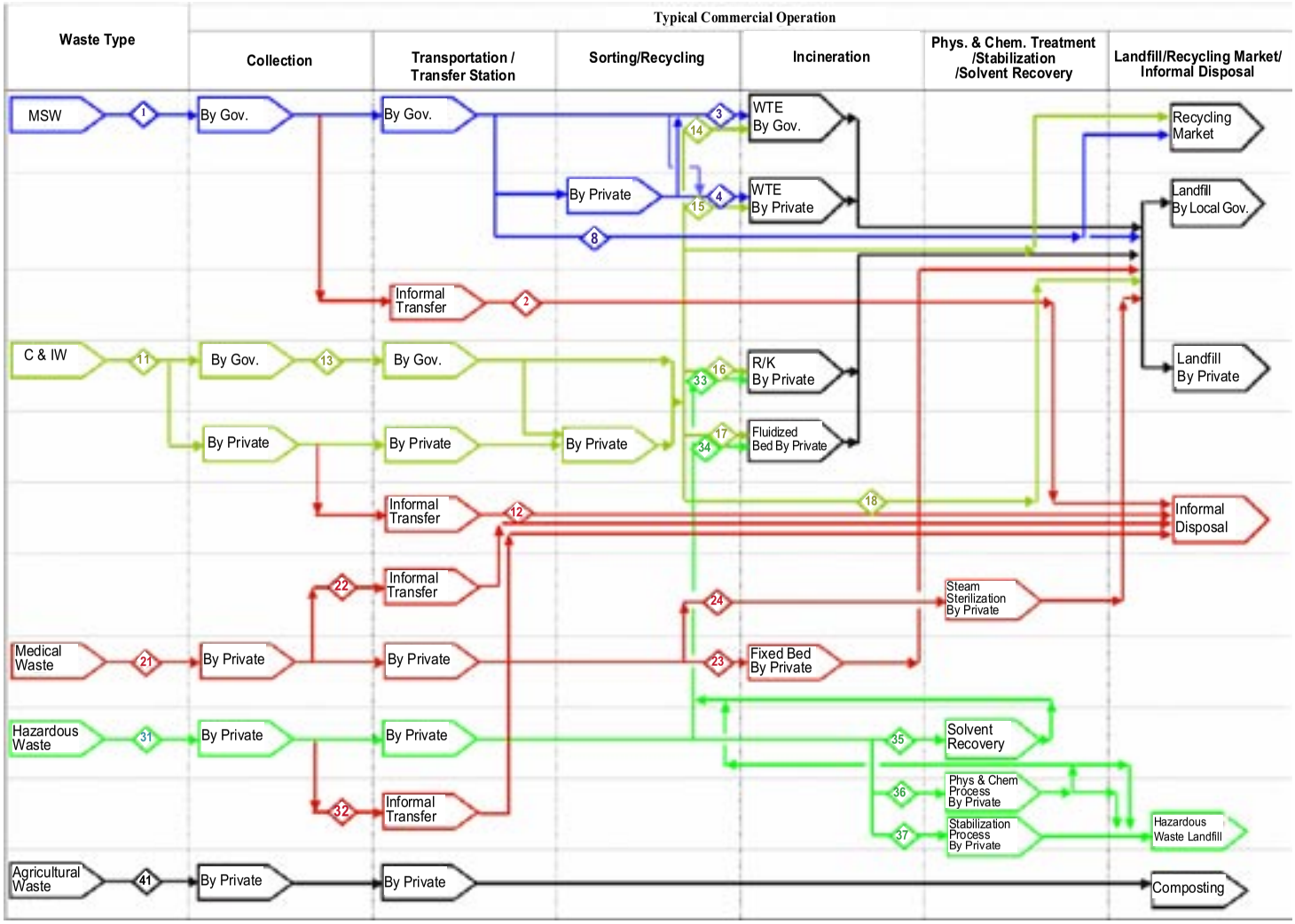
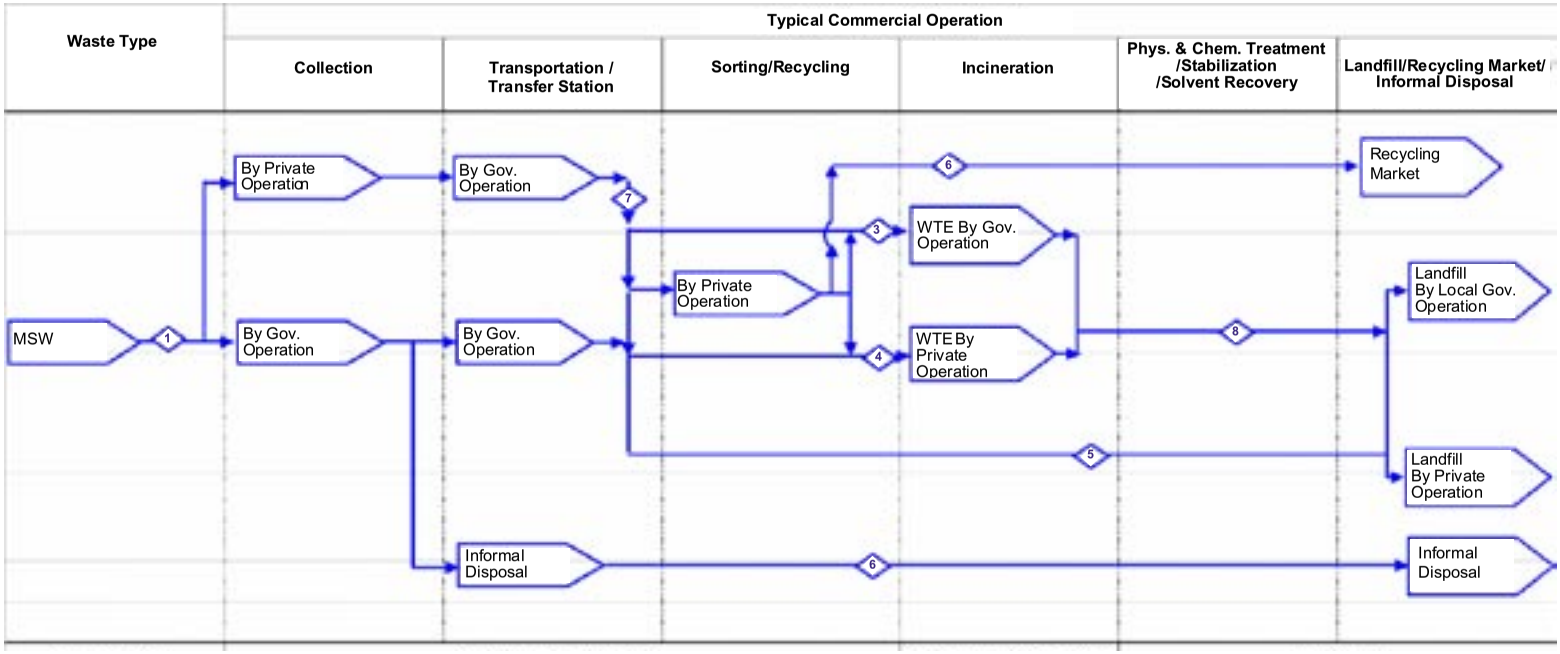


Figure: 8 Overall Waste Flow Quantity Distribution and in Taiwan

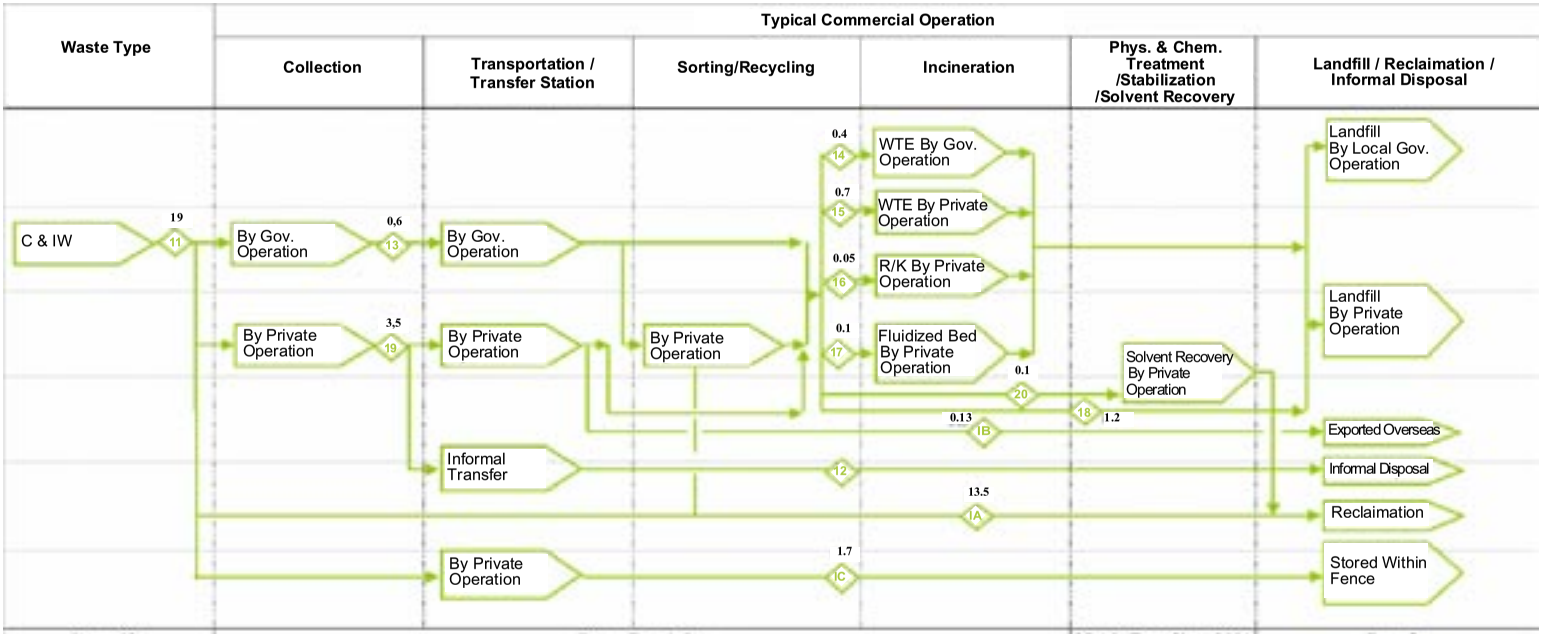
Stream Nº	Stream Description	Metric Ton / Year-2001	Remarks
1	MSW – total generation in Taiwan	7,839,470	
2	MSW – illegal dumping	Negligible	
3	MSW – incinerated by government-operated WTE plants	1,254,000	
4	MSW – incinerated by privately operated WTE plants	3,159,390	
5	MSW – directly disposed at landfills	2,841,350	
11	C&IW – Total generation in Taiwan	18,000,000	
12	C&IW – untreated / illegal dumping	Approx. 3,000,000	
13	C&IW – collection by Government (industrial park authorities and township/ Village trucks)	600,000	
14	C&IW – incinerated by Government-operated WTE Plants (Solid Waste)	400,000	
15	C&IW – incinerated by privately operated WTE Plants (Solid Waste)	700,000	
16	C&IW – incinerated by privately operated rotary kilns (Solid Waste + Sludge)	50,000	
17	C&IW – incinerated by privately operated fluidised bed incinerators (Sludge + Solvents)	200,000	
18	C&IW – directly disposed of at sanitary landfills (Solid Waste + Sludge + Ash)	1,500,000	
21	Medical Waste – total generation in Taiwan	120,000	
22	Medical Waste – illegal dumping	Approx. 15,000	
23	Medical Waste – combustible, incinerated by stationary hearth incineration	Approx. 75,000	
24	Medical Waste – non-combustible, treated by stream sterilization	Approx. 30,000	
31	Hazardous Waste – total generation in Taiwan	1,600,000	
32	Hazardous Waste – illegal dumping	350,000	
33	Hazardous Waste – combustible, incinerated by privately operated rotary kilns	120,000	
34	Hazardous Waste – combustible, incinerated by privately operated fluidised bed incinerators	120,000	
35	Hazardous Waste – organic compounds recycled or treated by solvent recovery operations	80,000	
36	Hazardous Waste – pre-treated by physical & chemical process (Sludge and Ashes)	250,000	
37	Hazardous Waste – inorganic compounds treated by inertization or stabilization process (Ashes)	300,000	
41	Agricultural Waste – total generation in Taiwan, most reused in composting process	TBP	

Figure: 9 MSW Flow and Quantity Distribution and in Taiwan



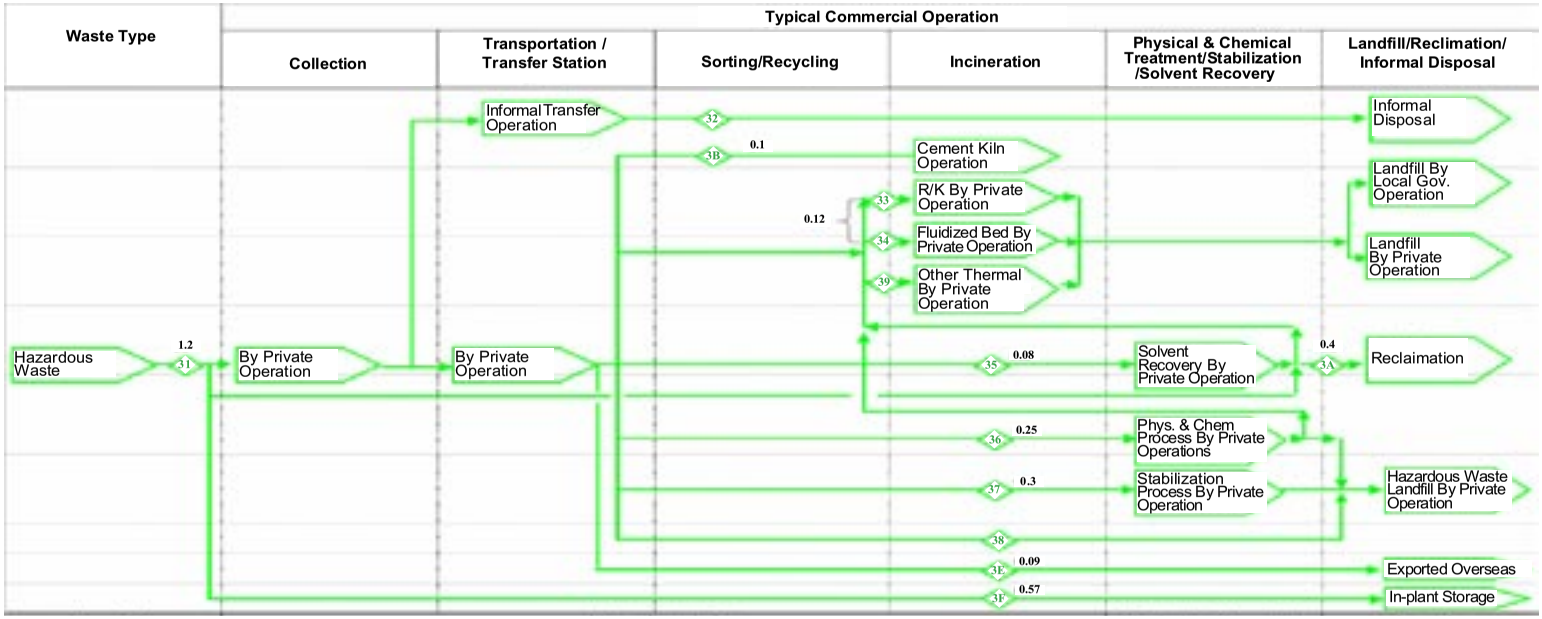
Stream N°	Stream Description	Metric Ton / Year-2001	Remarks
1	MSW – total generation in Taiwan	7,839,470	
2	MSW – illegal dumping	Negligible	
3	MSW – incinerated by government-operated WTE plants	1,254,000	
4	MSW – incinerated by privately operated WTE plants	3,159,390	
5	MSW – directly disposed at landfills	2,841,350	
6	MSW recycled and reused	584,730	
7	MSW collection by private companies	70,000	
8	Ash generated from WTE plants	882,678	

Figure: 10 Commercial and Non-Hazardous Industrial Flow and Quandity Distribution in Taiwan



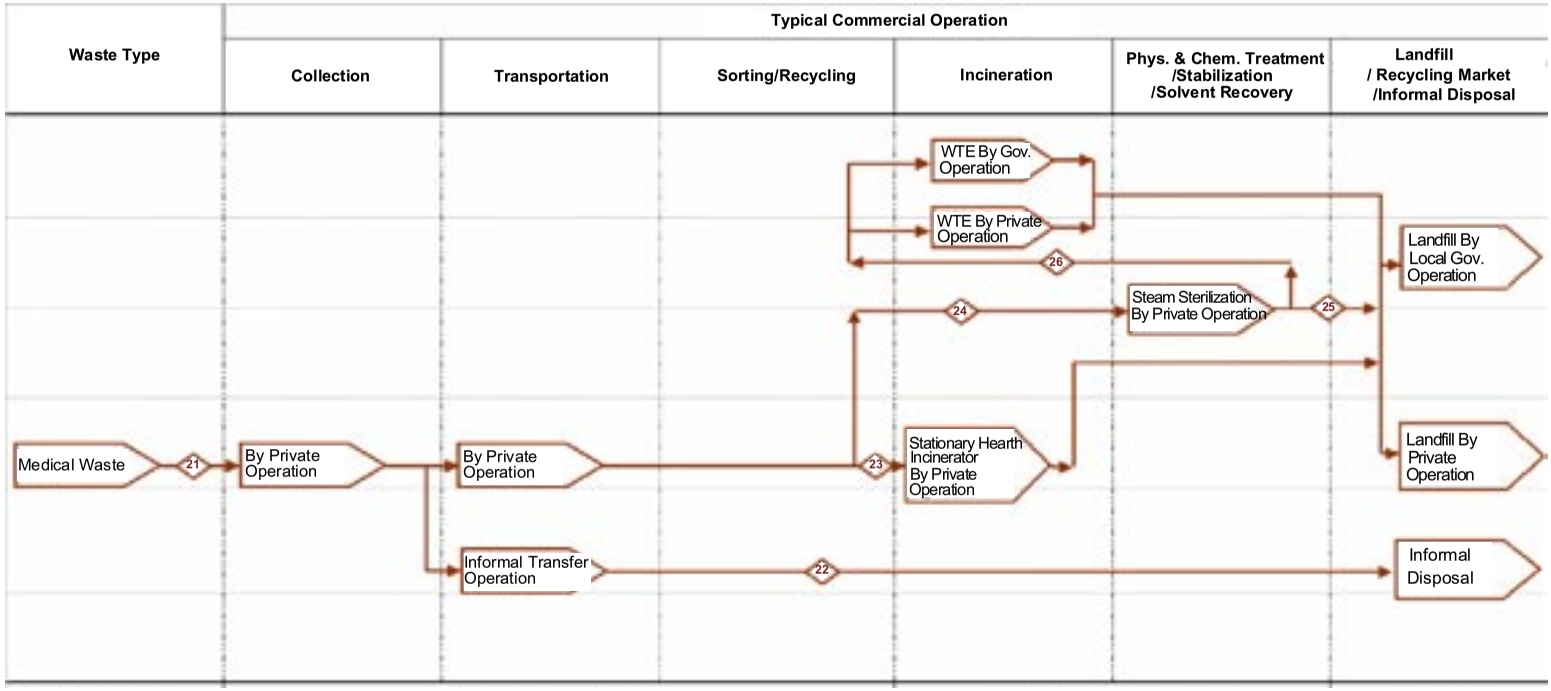
Stream N°	Stream Description	Metric Ton / Year-2001	Remarks
11	C&IW – Total generation in Taiwan	18,000,000	
12	C&IW – untreated / illegal dumping	Approx. 3,000,000	
13	C&IW – collection by Government (industrial park authorities and township/ Village trucks)	600,000	
14	C&IW – incinerated by Government-operated WTE Plants (Solid Waste)	400,000	
15	C&IW – incinerated by privately operated WTE Plants (Solid Waste)	700,000	
16	C&IW – incinerated by privately operated rotary kilns (Solid Waste + Sludge)	50,000	
17	C&IW – incinerated by privately operated fluidised bed incinerators (Sludge + Solvents)	200,000	
18	C&IW – directly disposed of at sanitary landfills (Solid Waste + Sludge + Ash)	1,500,000	
19	C&IW – collected by Private Company	3,500,000	This figure increased significantly since 2002 due to re-definition of waste codes
20	C&IW – collected and treated by privately operated solvent recovery facilities including cement + kilns	800,000	
1A	C&IW – recycled / re-used by waste generators directly or through Unified Treatment Systems	9,624,000	
1B	C&IW – exported and treated overseas (PCBs)	130,000	
1C	C&IW – temporally stored on site within fence	1,700,000	

Figure 11: Hazardous Waste Flow and Quandity Distribution in Taiwan



Stream N°	Stream Description	Metric Ton / Year-2001	Remarks
31	Hazardous Waste – total generation in Taiwan	1,600,000	
32	Hazardous Waste – illegal dumping	350,000	
33	Hazardous Waste – combustible, incinerated by privately operated rotary kilns	120,000	
34	Hazardous Waste – combustible, incinerated by privately operated fluidised bed incinerators	120,000	
35	Hazardous Waste – organic compounds recycled or treated by solvent recovery operations	80,000	
36	Hazardous Waste – pre-treated by physical & chemical process (Sludge and Ashes)	250,000	
37	Hazardous Waste – inorganic compounds treated by inertization or stabilization process (Ashes)	300,000	
38	Hazardous Waste – directly disposed of at hazardous waste landfills	‹5,000	
39	Hazardous Waste – incinerated by other thermal process	‹5,000	
3A	Reclamation	200,000	
3B	Cement kiln incineration (Solvents, Oils, etc.)	100,000	
3E	Hazardous Waste – exported and treated overseas (PCBs, Sludge)	90,000	
3F	Hazardous Waste – temporally stored within fence (in Year-2001)	70,000	

Figure 12: Medical and Infectious Waste Flow and Quantity Distribution in Taiwan



Stream N°	Stream Description	Metric Ton / Year-2001	Remarks
21	Medical Waste – total generation in Taiwan	120,000	
22	Medical Waste – illegal dumping	Approx. 15,000	
23	Medical Waste – combustible, incinerated by stationary hearth incineration	Approx. 75,000	
24	Medical Waste – non-combustible, treated by stream sterilization	Approx. 30,000	
25	Non combustible medical waste after stream sterilization	Approx. 25,000	
26	Combustible medical waste delivered to WTE plants after sterilization	Approx. 5,000	

Figure 13: WTE Facility Mapping Diagram in Taiwan

No	WTE Plant Description	Designed Max. Msw Throughput	Actual or Estimated Throughput (1)	
			MSW (TPY)	IW (TPY)
1	Nei-Hu(Taipei City)	900 TPD	0	N/A
2	Mucha(Taipei City)	1500 TPD	247,500	N/A
3	Pei Tou(Taipei City)	1800 TPD	445,500	231,000
4	Hsin Tien(Taipei County)	900 TPD	237,600	N/A
5	Shulin(Taipei County)	1350 TPD	330,000	N/A
6	Taichung City	900 TPD	231,000	N/A
7	Chiayi City	300 TPD	82,500	N/A
8	Tainan City	900 TPD	231,000	N/A
9	Hsinchu City	900 TPD	165,000	99,000
10	Pali(Taipei County)	1350 TPD	313,500	132,000
11	Kaohsiung City Central	900 TPD	297,000	N/A
12	Kaohsiung City South	1800 TPD	264,000	231,000
13	Kan Ting(Pingtung County)	900 TPD	186,150	N/A
14	Ren Wu(KH County)	1350 TPD	182,500	165,000
15	Hsi Chou(Chang Hua County)	900 TPD	262,800	N/A
16	Hou Li(Taichung County)	900 TPD	201,660	82,500
17	Gung Shan(KH County)	1350 TPD	140,000	132,000
18	Lu Tsao(Chiayi County)	900 TPD	157,680	165,000
19	Yi Lan County	600 TPD	TBD (2)	TBD (2)
20	Keelung City	600 TPD	TBD (2)	TBD (2)
21	Yong Kang(Tainan County)	900 TPD	TBD (2)	TBD (2)
22	Taoyuan County South (BOO)	1350 TPD	376,680	125,560
23	Taichung County Wu-Zhe (BOO)	900 TPD	TBD (2)	TBD (2)
24	Taitung County (BOO)	300 TPD	TBD (2)	TBD (2)
Total		27150 TPD	4,352,070 + TBD	1,363,060 + TBD

20-year O&M contract

6-year O&M contract awarded, will be retendered for 15 O&M contract from 2003 to 2005

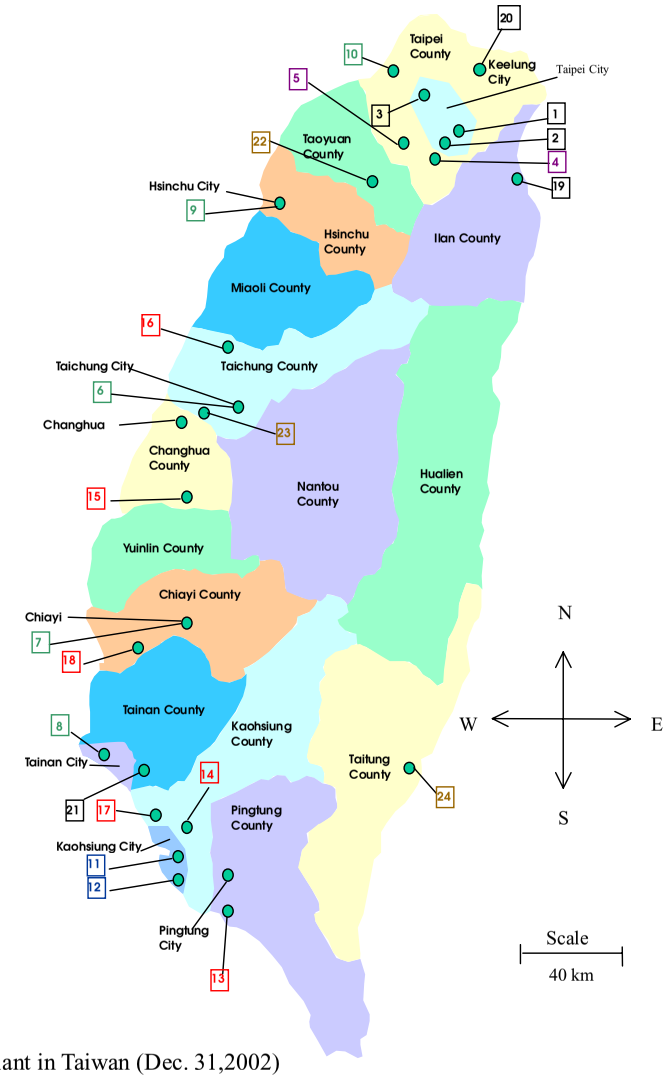
15-year O&M contract awarded after the first 6-year O&M contract expired.

to be privatized for long-term O&M services.

BOT/BOO Projects

Note: (1) Best estimation is provided for unfinished plants

(2) TBD = To Be Determined after plant operation starts



WTE Plant in Taiwan (Dec. 31,2002)

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List of Figures