

Waste-to-Energy Facilities in Taiwan

by Shang-Hsiu Lee, WTERE/Earth Engineering Center

National Plan for Waste-to-Energy (WTE) facilities

The total area of Taiwan is nearly 14000 sq. mi (36,000 sq. km) and the population is about twenty-two million¹. In 2000, the per capita generation of municipal solid wastes (MSW) in Taiwan was 381 kilograms, i.e. an annual total of 8.38 million metric tons². Table 1 shows the composition of MSW in Taiwan. The average water content of Taiwan MSW is about 50% and the Heating Value is about 9,945 kJ/kg.

Because the available landfill is very limited, the Taiwan EPA has adopted a strategy favoring combustion as the primary method of municipal solid waste treatment to be complemented by landfilling. Therefore, starting from 1991, the Taiwan government set up a long term plan for the construction of WTE plants. According to the Engineering Project for the Construction of WTE plants in Taiwan, 21 WTE plants were to be constructed by the government by 2005. These WTE plants will process an estimated total of 18,615 metric tons of MSW per day (85% of the design capacity of 21,900 metric tons), amounting to about 7.2 million tons per year or 65% of the total MSW generated by then³ (The projected daily amount of MSW is 28,487 metric tons in 2005). These plants are expected to generate 1.85×10^6 megawatt-hours of electricity per year⁴. The surplus electricity generated will be result in annual revenue of about \$47 million⁵.

Eighteen of these plants have already been constructed and are operating by the government while three more are under construction. The locations, capacity in metric tons of MSW per day and other information regarding details of these WTE plants are shown in Table 2.

Table 1 MSW composition of Taiwan⁶

Composition	wt (%)	Water wt (%)	Dry Weight	Heating Value (Kcal/kg)
Food Wastes	45	85	6.8	1100
Paper	15.1	20	12.1	4000
Cardboard	6	6	5.6	3900
Plastics	5.8	3	5.6	7800
Textiles	2.5	15	2.1	4200
Rubber	0.7	3	0.7	5600
Leather	0.4	10	0.4	4200
Garden Trimmings	10	65	3.5	1600
Wood	6	25	4.5	4500
Glass	2	2	2.0	40
Ferrous Metals	3.5	3	3.4	
Dirt Ashes Brick	3	9	2.7	
	100		49.3	

*Heating Value= 2,377 kcal/kg = 9,945 kJ/kg

Table 2 Waste-to-Energy Facilities in Taiwan^{7,8}

No	Location	Design Capacity (ton/d)	Design generating energy (MWh/day)	Process	Type of incinerator	Engineering Consultants	Construction company	Project stage	Operator
1	Neihwu, Taipei City	900	144	Mass Burn	Fixed bed (Takuma)	Sinotech Engineering Consultants (SEC)	Takuma Co. Ltd	completed January, 1992	Environmental Protection Bureau (EPB) of Taipei City
2	Muja, Taipei City	1,500	324	Mass Burn	Fixed bed (Takuma)	SEC	Takuma Co. Ltd	completed July, 1994	EPB of Taipei City
3	Beitou, Taipei City	1,800	1,080	Mass Burn	Fixed bed (Von Roll)	SEC	Marubeni Co. Ltd	completed June, 1998	EPB of Taipei City
4	Central District, Kaohsiung City	900	612	Mass Burn	Fixed bed	China Engineering Consultants, Inc. (CECI)	Tuntex distinct Corp.	completed October, 1998	EPB of Kaohsiung City
5	South District, Kaohsiung City	1,800	1,176	Mass Burn	Fixed bed (Martin)	SEC	Mitsubishi Heavy Industries, Ltd. / and CT Consultants, Inc (CTCI)	completed February, 2000	EPB of Kaohsiung City

No	Location	Design Capacity (ton/d)	Design generating energy (MWh/day)	Process	Type of incinerator	Engineering Consultants	Construction company	Project stage	Operator
6	Taichung City	900	312	Mass Burn	Fixed bed (Volund)	SEC	NKK Corp.	completed May, 1995	Ta-Ho Environmental & Technical Services
7	Chiai City	300	60	Mass Burn	Fixed bed (Volund)	SEC	Volund (Denmark) and Chung Hsin Electric & Machinery Mfg.	completed June, 1998	Ta-Ho Environmental & Technical Services
8	Tainan City	900	379	Mass Burn	Fixed bed (Volund)	CECI	Volund (Denmark) and Chung Hsin Electric & Machinery Mfg.	completed December, 1998	SINO Environmental Services Corp.
9	Shintein, Taipei County	900	391	Mass Burn	Fixed bed (Martin)	Fichtner in Germany	Mitsubishi Heavy Industries, Ltd.	completed May, 1994	SINO Environmental Services Corp.

No	Location	Design Capacity (ton/d)	Design generating energy (MWh/day)	Process	Type of incinerator	Engineering Consultants	Construction company	Project stage	Operator
10	Shulin, Taipei County	1,350	595	Mass Burn	Fixed bed (Martin)	Fichtner in Germany	Mitsubishi Heavy Industries, Ltd.	completed June, 1995	SINO Environmental Services Corp.
11	Bali, Taipei County	1,350	859	Mass Burn	Fixed bed (Volund)	Fichtner in Taiwan	Chung Hsin Electric & Machinery Mfg.	completed March, 2001	Chung Hsin Electric & Machinery Mfg.
12	Hsinchu City	900	569	Mass Burn	Fixed bed (Volund)	Fichtner in Taiwan	Chung Hsin Electric & Machinery Mfg.	completed April, 2000	Chung Hsin Electric & Machinery Mfg.
13	Houli, Taichung County	900	--	Mass Burn	Fixed bed (Von Roll)	SEC	Hitachi Zosen Corp.	completed April, 2000	SINO Environmental Services Corp.
14	Shijou, Changhua County	900	542	Mass Burn	Fixed bed (Von Roll)	SEC	Hitachi Zosen Corp.	completed September, 2000	Chinese Petroleum Corp.
15	Lutsau, Chiai	900	600	Mass Burn	Fixed bed (Takuma)	SEC	Takuma Co. Ltd/China Steel	completed August,	Ta-Ho Environmental &

No	Location	Design Capacity (ton/d)	Design generating energy (MWh/day)	Process	Type of incinerator	Engineering Consultants	Construction company	Project stage	Operator
	County							2001	Technical Services
16	Yung kang, Tainan County	900	N/A	Mass Burn	Fixed bed	CTCI	Chinese Petroleum Corp.	expected completion 2005	
17	Renwu, Kaohsiung County	1,350	809	Mass Burn	Fixed bed (Martin)	SEC	Mitsubishi Heavy Industries, Ltd. / CTCI	completed February, 2000	Swire SITA Waste Services-Taiwan
18	Gangshan, Kaohsiung County	1,350	912	Mass Burn	Fixed bed (Takuma)	SEC	Takuma Co. Ltd/China Steel	completed February, 2001	Taiwan Sugar Corp.
19	Kanding, Pingtung County	900	594	Mass Burn	Fixed bed (VKW)	CTCI	Kawasaki Heavy Industries, Ltd	completed August, 2000	Taiwan Sugar Corporation

No	Location	Design Capacity (ton/d)	Design generating energy (MWh/day)	Process	Type of incinerator	Engineering Consultants	Construction company	Project stage	Operator
20	Keelung City	600	N/A	Mass Burn	Fixed bed	CTCI	Ebara Kailay Environmental Engineering Co., Ltd / Hsin II Engineering Co., Ltd.	Expected completion May 2005	
21	Litze, Ilan County	600	N/A	Mass Burn	Fixed bed (Martin)	SEC	Mitsubishi Heavy Industries, Ltd	Expected completion August 2005	
Total		21,900							

The government has struggled with getting the land and communicating with the public since the beginning of the WTE plant construction project. Some of the plants faced delays that resulted in serious cost increases due to the continuing protests against construction. As a result, in terms of BOT (Build-Operator-Transfer) and BOO (Build-Operate-Own), the Taiwan EPA encouraged the private sector to construct incinerators and actively supervise and assist local governments in the bid tendering and construction-related operations necessary in order to ensure the completion of WTE plants. By 2004, there were two WTE plants which have been constructed by private sector and four WTE plants were under construction.

The map shown in Figure 1 indicates the locations of most of Taiwan WTE facilities. It can be seen that most of the plants are located at west coast of Taiwan where most of the people live. The two largest cities, Taipei and Kaohsiung City, have the highest population density and the largest number of WTE plants in their respective area.

To protect the public health from the effect of WTE plants emission, Taiwan EPA has set a strict emission standard for WTE plants. The dioxin emission standard for WTE plant which design capacity is equal to or bigger than 10 metric tons/hr or 300 metric tons/day is 0.1 ng-TEQ/Nm^3 (11% O_2 , 0°C , 1atm)⁹. Regarding to the mercury, the emission standard for the existing WTE plant (completed before 1992/12/02) which design capacity is equal or bigger than 10 metric tons/hr is 0.5 mg/Nm^3 , while the new WTE plant with the same design capacity has a tighter emission standard of 0.1 mg/Nm^3 ¹⁰.

Public and Private Enterprises to Construct and Operate Final Disposal Sites for General Industrial Waste. These expanded regulations allow local governments, based on their particular needs, to either construct both ash reuse facilities and final disposal sites on their own, or to construct final disposal sites and contract with existing ash reuse plants to convert ash into a useful material. For the establishment of final disposal sites and new ash reuse facilities, local governments will encourage private enterprises to adopt BOO or BOT investment methods, or will build and operate these sites and facilities themselves.

To provide greater incentives for private investment by reducing investment risks, the Taiwan EPA offers subsidies to local governments so as to guarantee post-incineration volumes and prices for treatment facilities. The Taiwan EPA guarantees a post-incineration volume equivalent to 20% of a WTA plant's design capacity. The Taiwan EPA also provides subsidies in order to guarantee prices up to a maximum of \$35 for each metric ton of ash. These guaranteed volumes and prices will be provided for three years from operating. These subsidies are expected to cost \$100 million¹³.

The Taiwan EPA will also offer guaranteed volumes and prices for local governments that choose existing ash reuse plants. These guaranteed volumes will be set according to contracts between local governments and ash reuse plants. As for subsidies for guaranteed prices, the Taiwan EPA will offer up to \$25 per metric ton to ash reuse plants¹⁴.

To establish a legal basis for the reuse of incinerator ash, the Taiwan EPA has also put in place a regulation for Municipal Waste Incinerator Bottom Ash Reuse. This regulation requires that Toxicity Characteristic Leaching Procedure (TCLP) testing be conducted once for every 500 metric tons of bottom ash prior to reuse. In order for the ash to be used beneficially, the TCLP tests of the WTE ash must meet hazardous industrial waste standards. WTE ash can be reused only as an aggregate in non-rebar concrete, asphalt concrete and bricks, as road base material, and as a substitute covering material for landfills¹⁵.

References:

- ¹ http://www.byte.com.tw/mates/mates_tw/taiwan-1.htm
- ² http://www.epa.gov.tw/b/b0100.asp?Ct_Code=02X0000002X0000108
- ³ http://www.epa.gov.tw/b/b0100.asp?Ct_Code=02X0000002X0000108
- ⁴ <http://ivy3.epa.gov.tw/swims/>
- ⁵ <http://ivy3.epa.gov.tw/swims/>
- ⁶ Y.M. Chang. (2000) Incineration Technology, New Wun Chin Development Publishing, Twaiwn.
- ⁷ Y.M. Chang. (2000) Incineration Technology, New Wun Chin Development Publishing, Twaiwn.
- ⁸ http://ivy3.epa.gov.tw/swims/home/wep_build.htm
- ⁹ <http://w3.epa.gov.tw/scripts/runisa.dll?HTLW.590050:LNameDisp:17959:04%A1G0168>
- ¹⁰ <http://w3.epa.gov.tw/scripts/runisa.dll?HTLW.590050:LNameDisp:17959:04%A1G0080>
- ¹¹ http://ivy3.epa.gov.tw/swims/img/upi2139_1.jpg
- ¹² http://www.epa.gov.tw/b/b0100.asp?Ct_Code=03X0000108X0000414
- ¹³ <http://w3.epa.gov.tw/epalaw/>
- ¹⁴ <http://w3.epa.gov.tw/epalaw/>
- ¹⁵ <http://w3.epa.gov.tw/epalaw/>