Waste Control in Japan

–The question: Which Technologies Will Survive the Struggle?

For ANACON'98 at Los Angeles Airport Marriott

December 7-9, 1998

Yasujiro Wakamura

Takuma Co., Ltd., Osaka, Japan.

Introduction

In April of 1997, Package Recycling Act was enacted in Japan in order to reduce waste generation, augmenting the first Recycling Act of 1991. It covers the packaging materials, which comprise 60% in volume of the total municipal solid waste (MSW). In addition, Appliance Recycling Act is scheduled to become effective in September 1998, mandating recycling of TV sets, washing machines, refrigerators and room air-conditioners, the four appliances that constitute major non-combustibles household waste. This trend necessitates the quick systematization of material recycling.

Due to the shortage of landfill sites, up to 74% of waste have been incinerated. Since dioxin became a social issue, existing incinerators are required to reduce their dioxin generation within the five-year implementation period. As for new facilities, official guideline has been issued to encourage building of RDF conversion plants instead, centralizing incineration by plants 100 T/D or larger, facilitating dioxin control.

Steps are also taken to control pollution of rivers and streams by stricter restrictions of effluent water from landfills. In addition, environmental hormone has emerged as an issue, and dioxins in the effluent have become the culprit besides other suspected chemicals. Another guideline has been issued to mandate retrofitting existing incinerators with ash melting units. The purpose is to turn ash into molten slag, thermally destroying dioxin in the process. It also prevents leaching of heavy metals from the ash, and the reuse of slag itself is being explored.

With this recent trend, a next-generation waste-control system capable of both material and energy recycling has been taken up by more than twenty firms. They include old names and new entrants, with their own research and development. This technology involves removing aluminum and ferrous metals during pyrolysis, melts residues by burning the generated gas, and recovers heat by boiler for power generation. It is called Pyrolysis Gas Melting System. It is necessary to treat incineration residue thermally in order to detoxify and reduce wastes in a limited land space, and this new system seems to fit the bill perfectly.

In the meantime, budget-stricken municipalities are considering PFI (Private Finance Initiative) which introduces private resources into construction and operation of waste treatment facility, a traditionally municipal effort. Many firms see a steady growth in environment-related businesses, and have begun to allocate funds into this area. The sudden demise, however, of bubbling fluidized bed project due to the high rate of dioxin generation, was a good example of the uncertainty as to what will be the mainline technology of the waste disposal in future.

1. The Outline of Waste Management in Japan

1-1 The Amount and Disposal Outline of Municipal Solid Waste (MSW)

According to published statistics, MSW generated per person per day kept increasing until 1990, as shown in **Figure** 1. Since 1992, however, this number leveled off at 1kg/person/day. A decrease is anticipated for the year 1998 mainly due to the turndown in economy and the progress in recycling.

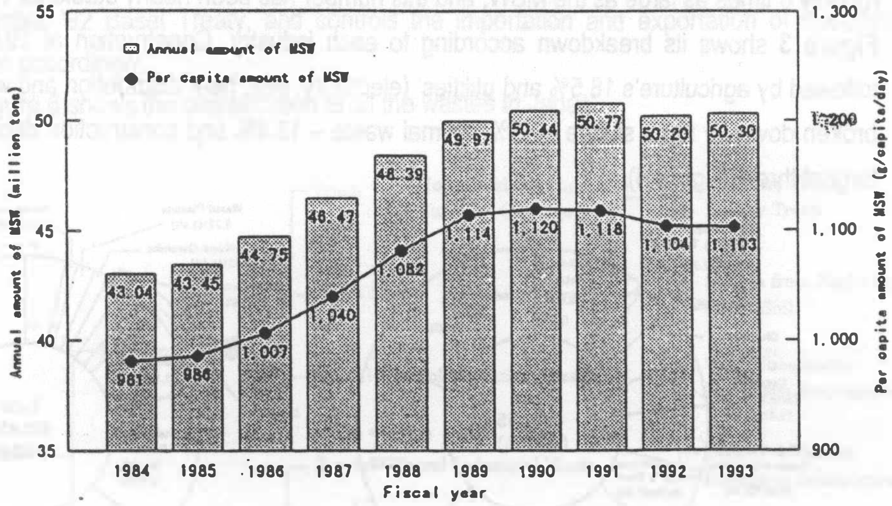


Figure 1. Amount of Municipal Solid Waste(1984-1993)

The breakdown according to disposal methods is incineration 74.3%, recycling 11.3% and landfilling 14.4% including incineration residue. (**Figure 2**) Consequently, the remaining life span for all landfill sites is estimated at 8.7 years as of 1994.

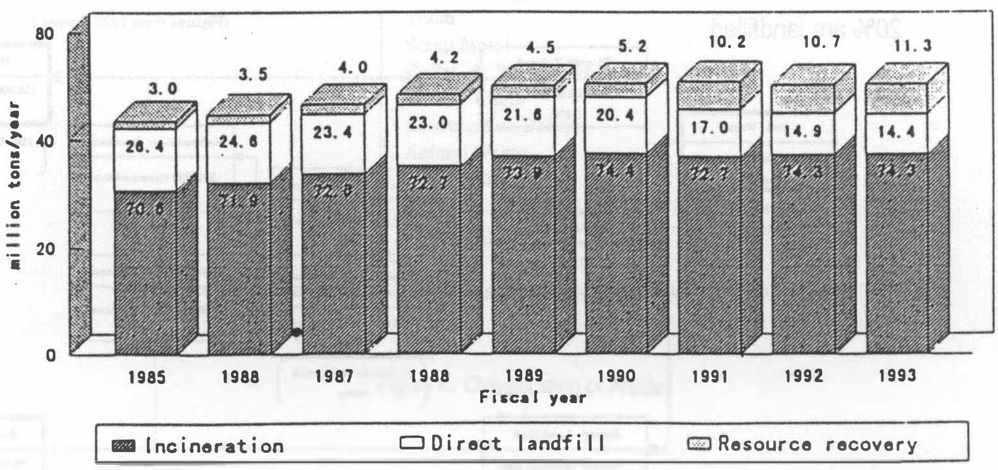


Figure 2. Treatment/Disposal of MSW(1985-1993)

1-2 The Amount and Disposal Outline of Industrial Waste

Among the wastes generated by the industrial activities, 19 items, including sludge, waste oil and waste acids, are designated as the industrial waste. The disposal of the industrial waste is the responsibility of the generators, and the wastes are disposed of by themselves, or by the disposal contractors. The total industrial waste generated per year nationally amounts to 400 millicn tons, roughly 8 times as large as the MSW, and this number has been nearly stable for the past few years. **Figure 3** shows its breakdown according to each industry. Construction at 19.0% heads the list, followed by agriculture's 18.5% and utilities' (electricity, gas, heat distribution and water) 18.4%. When broken down by form, sludge – 45%, animal waste – 18.4% and construction debris – 14.9% are the largest three (**Figure 4**).

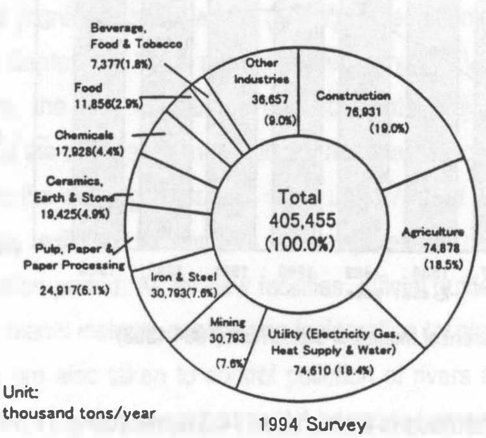


Figure 3. Waste Generation by Industry

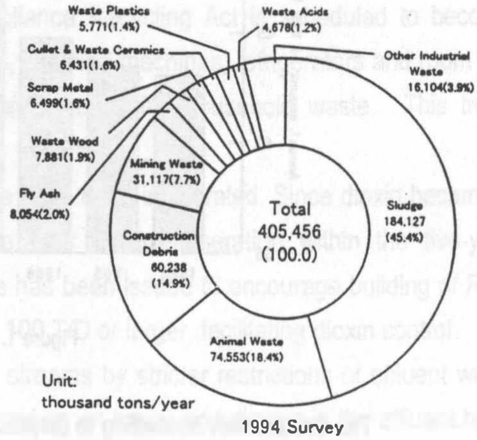


Figure 4. Waste Generation by Variety

As shown by the process flow in **Figure 5**, 77% of the total are processed and 38% are reused, while 20% are landfilled.

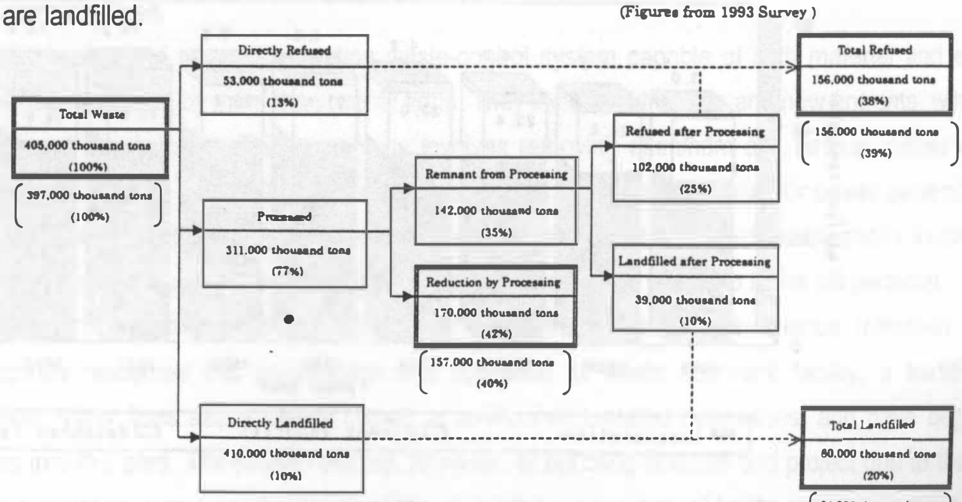
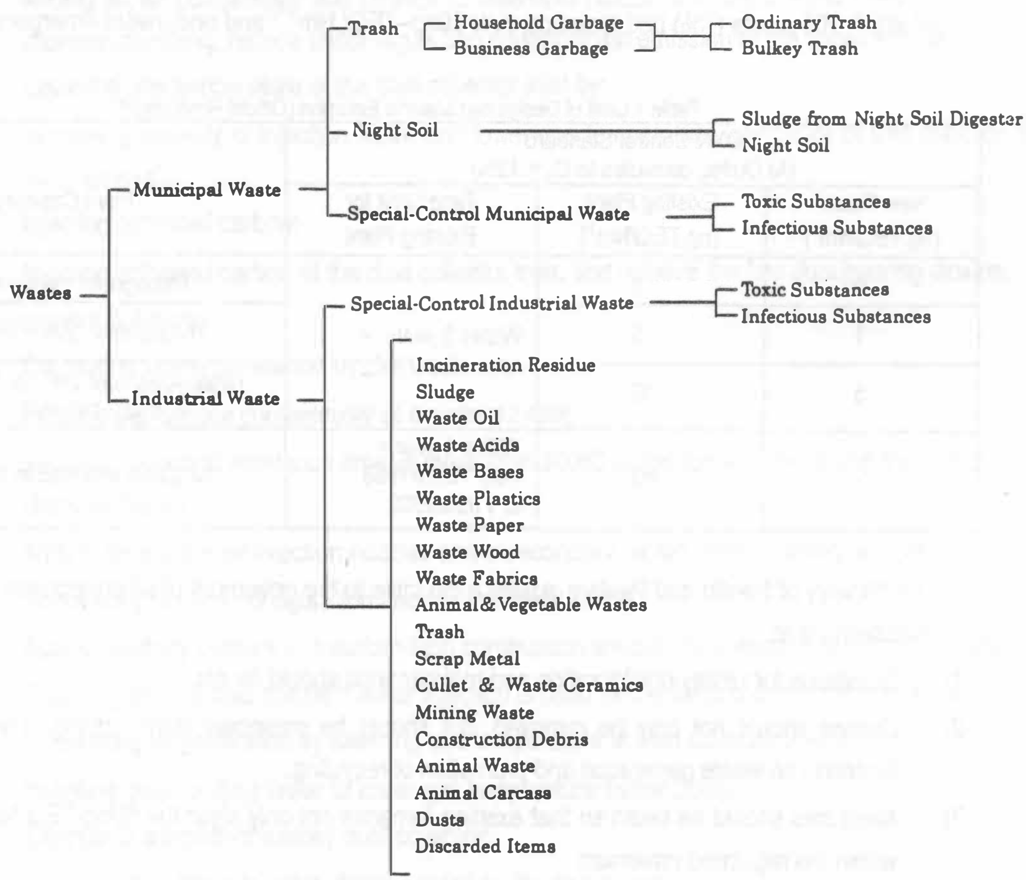


Figure 5. The Process Flow of Nationwide Industrial Wastes

1-3 Hazardous Wastes

A stricter regulation governing hazardous waste was announced in July of 1992. It classifies wastes potentially detrimental to human health and environment, such as explosives, toxic substances and infectious materials as Special-Control MSW and Special-Control Industrial Wastes. Items such as TV parts containing PCB, fly ash from incinerators and infectious waste from hospitals belong to the first category. Waste oil, waste acids and asbestos, etc. belong to the second. Japan has ratified the December '92 Basel Treaty, and controls the importation and exportation of specified hazardous wastes accordingly.

Figure 6 shows the classification of all the wastes in Japan.



< Classification is according to "The Law governing treatment and disposal of waste." >

Figure 6. Classification of Wastes

2. Dioxins and their Incineration

2-1 The History and Current Situation of Dioxin Regulation

"The Guideline for the Prevention of Dioxins Generation" was issued in December 1990. It recommended addition of CO meters to diagnose combustion conditions, and high-efficiency dust collectors to remove dioxin carried by the fly ash. Dioxin analysis has come in heavy demand ever since, and applications from laboratories for testing qualification have increased suddenly. Regulation on Dioxins was issued in August 1997. **Table1** [i] shows the regulation values. In April and again in June 1997, test results of dioxin concentration in the exhaust gas of existing waste incinerators were announced. Out of the total of 1,641 working incinerators, 1,500 facilities had their numbers published, of which 105 plants (7%) had emission over 80ng–TEQ/ Nm^3 [ii] and underwent emergency corrections.

Table 1. Limit of Designated Material Emission (Official Notification)

DXN Control Standard (At Outlet, corrected to O_2 = 12%)			Plant Capacity
New Plants (ng.TEQ/Nm^3)	Existing Plant (ng.TEQ/Nm^3)	Time Limit for Existing Plant	
0.1	1	Within 5 years = After 12/01/2002	Throughput : 4t/h and over
1	5		Throughput : 2t/h ~ under 4t/h
5	10		Grate Area over $2m^2$, or Throughput: 0.2t/h through 2.0t/h
-	80	Within 1 year = from 12/01/1998 to 11/20/2002	All plants included in the above

The Ministry of Health and Welfare issued a directive to the governors of all prefectures in January 1998 mandating that:

1) Standards for facility configuration and maintenance should be set.
2) Dioxins should not only be removed, but should be prevented from forming. This would include limitation on waste generation and promotion of recycling.
3) Measures should be taken so that existing furnaces not only clear the 80ng-TEQ/Nm^3 limit, but stay within the regulated maximum.

2-2 Methods of Improving Existing Furnaces

There are different approaches for furnaces to be decommissioned within a year or two, and for those which are planned to operate for a number of years.

1) Temporary measures for furnaces of short expectancy

The aim is a short-term remedy at a minimum cost.

① Controlling emissions by:

- Improving combustion by upgrading to continuous feeding;
- Raising furnace temperature by plugging air leaks;
- Adding an air compressor and change to dual-fluid nozzle, if it has a water injection. This will improve atomizing, reduce unburnt gas and control dioxin emission at the furnace outlet.

② Lowering gas temperature at the dust collector inlet by:

- Increasing quantity of injection water and lower gas temperature (upstream of lime injection for HCL removal).

③ Injecting activated carbon:

- Injecting activated carbon at the dust collector inlet, and remove the fine dust bearing dioxins.

2) Permanent Solutions

① Controlling dioxin generation by:

- Feeding the furnace continuously at a constant rate;
- Securing 2-second residence time at more than 800□C in the furnace by raising the combustion chamber height;
- Adding secondary-air injection nozzles and a secondary air fan, and reducing air invasion;
- Renovating furnace configuration and control mechanism;
- Adding auxiliary burners to maintain high combustion temperature, even during start-up time;
- Changing to dual-fluid nozzle if water injection is used and enlarging gas-cooling chamber.

② Preventing re-generation by lowering gas temperature at dust collector inlet by:

- Installing quick chilling tower to lower gas temperature below 200□C.

③ Change to a higher-efficiency dust collector:

- Adopting bag filters to catch dioxin carried by the fine fly ash.

It is best to avoid activated carbon injection as much as possible due to its high cost and subsequent increase in fly ash quantity.

2-3 New Furnaces – Regionalization of Waste Disposal

The Ministry of Health & Welfare in January 1997 announced a guideline for the regionalization of waste disposal. The essence of this guideline is as follows.

1) The necessity and merit of regionalization

① Promotion of recycling and reduction of incineration.

The recyclables will be gathered at a single location, reducing the amount for incineration.

② Promotion of ash disposal

Dioxin-containing fly ash and bottom ash can be melted and reused more easily if collected in one place.

2) Considerations needed for regionalization

① Scale of regionalization

To begin with, the geological and social conditions must be taken into account for grouping towns and villages. For efficient and economical waste collection and power generation, it should have a fully continuous incineration facility with at least 100 T/D capacity. When this is not possible, RDF conversion plant should be built that will feed RDF to a central incinerator.

② Timing for regionalization

It is advisable to consider regionalization at a time when existing incinerators and landfills reach renewal time.

An official guideline was issued back in August 1996 for the addition of fly ash and bottom ash melting/solidifying facilities to MSW incineration plant. Its purpose is to prevent dioxins' proliferation and elution by the fly ash, and to encourage recycling of bottom ash. The new guideline thus defines the eligibility for government subsidy as an incinerator larger than 100 T/D, equipped with ash melting facility.

2-4 The Agenda for the Future

1) Use of RDF

Smaller municipalities are encouraged to build an RDF conversion facility instead of an incinerator. It is aimed at regionalizing a number of municipalities and building a large-scale incinerator where dioxin can be controlled more easily, and waste heat can generate power.

The interests of municipalities often differ, however, and site selection can be a problem for a large incinerator.

2) Intake Limit

At present, WHO's TDI (Tolerable Daily Intake) of dioxins is 5~10pg/body weight in kg/day, and there are possibilities that these numbers may even be lowered. The current daily intake is 0.3~3.5pg/body weight in kg/day, which does not leave much room for reduction. It is being argued if further reduction is really necessary.

3) Environmental Hormones and POP's

A new problem area is called ED's – Endocrine Disrupters – which turn all animals into females, and dioxins are considered to be one. Coplanar PCB is said to have the same effect as dioxins, and talks are going on to curb its exposure. In addition, POP's – Persistent Organic Pollutants – were discovered newly, causing more opposition to waste incineration.

3. Ash Melting/Direct Melting

In March 1998, a guideline was issued to melt incinerator ash at 1200℃ or higher, and reusing the quenched molten slag. The fly ash from melting is required to be detoxified by means of solidification, using cement, etc.

3-1 Molten Slag

1) The followings are the uses suggested at present.

① Road aggregate

② Concrete aggregate, Asphalt aggregate

③ Excavation fill

④ Pavement block, hollow block, water-permeating block and other secondary concrete products

2) Leaching Standard for Molten Slag

Table 2 lists.the leaching standard.

Table 2. Regulatory Standard of Heavy Metals from Recycled Material

Item	Regulatory Standard
Cd	<0.01
Pb	<0.05
Cr^{6+}	<0.05
As	<0.01
THg	<0.0005
Se	<0.01

3) Points to be noted

- The melting furnace should be kept above 1200℃
- The fly ash from melting should be detoxified using such methods as solidification by cement.
- Exhaust gas control equipment such as bag filters should be installed.
- The molten slag should go through periodical test to assure stability and end-use.

3-2 Ash –Melting Furnace

There are several varieties of ash-melting devices. They are: Film Vitrification where ash is melted from the surface by oil or gas burners **(Figures 7 & 8)**; Electric Arc Furnace **(Figure 9)**; Electric Resistance Furnace **(Figure 10)** and Plasma Arc Furnace **(Figure 11)**. **Table 3** lists the number of actual plants according to each system.

Table 3. MSW Incineration Residue Melting Plants

Type	Number
Surface melting	10
Coke bed	1
Electric arc	4
Plasma arc	3
Electric resistance	2
Total	20

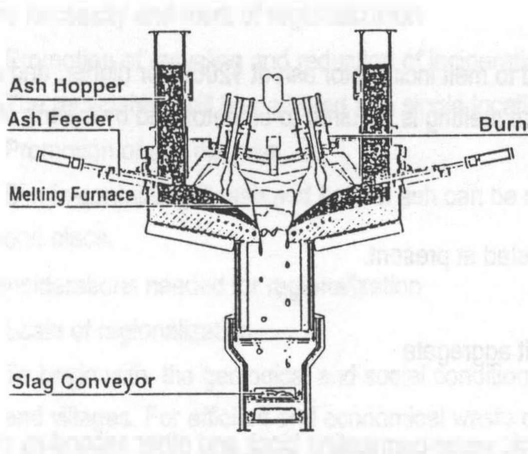


Figure 7. Surface-melting Furnace

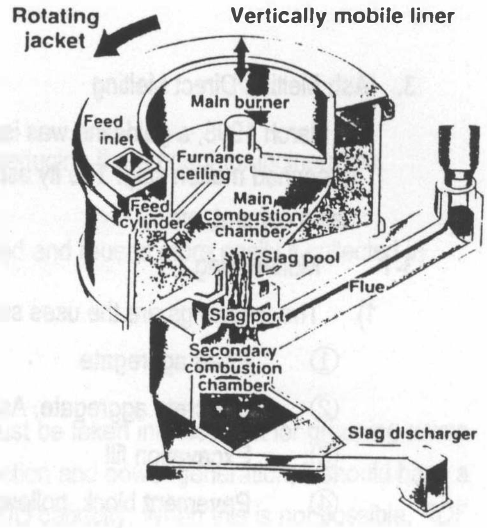


Figure 8. Dual standing cylinderical construction

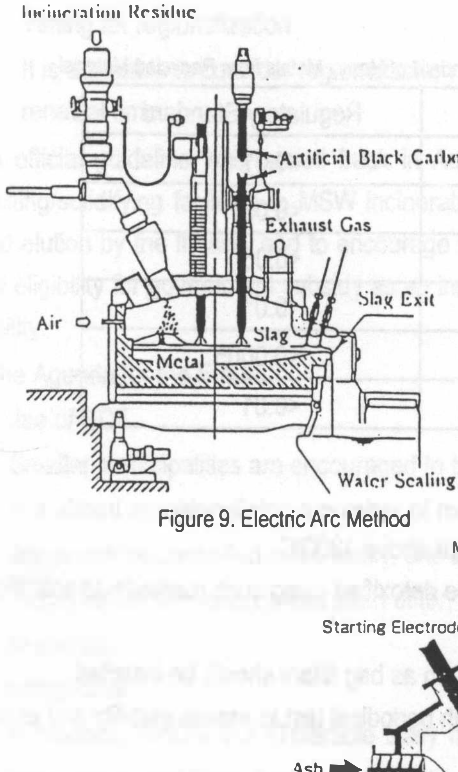


Figure 9. Electric Arc Method

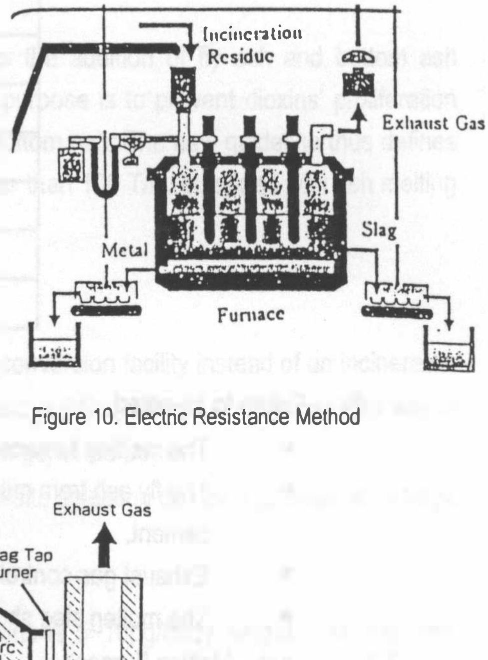


Figure 10. Electric Resistance Method

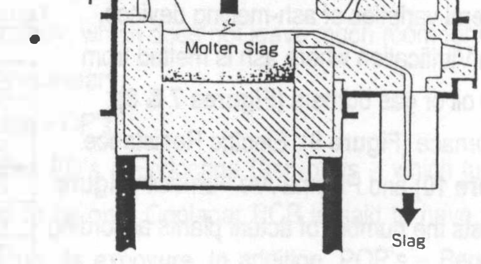


Figure 11. Plasma Melting Furnace

3-3 Direct Melting Furnace

Table 4 shows the systems by which waste can be turned directly into molten slag. The Torax and Burox system plants were built in the 1970's, and are no longer in operation.

Table 4.

SYSTEM	NUMBER
TORRAX	1
PUROX	1
INTERNAL MELTING	1
COKE BED	6
TOTAL	9

3-4 Comparison of Economics of Melting Furnaces

Table5 [iii] lists the comparison of economics of each melting furnace. Municipalities that have a controlled landfill with leachate-treating unit tend to remain cool toward adopting ash melting, while those without suitable landfill in the neighborhood are bound to show keen interest. Currently, cost for disposing ash is ¥30,000~¥40,000 per ton. The cost of turning it into molten slag. Currently, the cost for diposing ash is ¥30,000~¥40,000, and these will be the numbers targeted as the cost of ash melting.

However, developing molten-slag reuse market is somewhat beyond the capability of most municipalities. Many are tempted by offers from furnace manufacturers to take off their slag with the understanding that it will be fed into blast furnaces. Some research are going on in which molten slag is crystallized for widening the scope of usage, but the cost will have to be in line. This will be an item for further study.

Table 5. Examples of Ash-Melting Operational Costs [a)]

		Burner (Surface Melt)	Revolving Surface-Melt	Arc	Electric Resistance	Plasma–Water-cooled Metallic Electrode	Internal-Melting	Secondary Material Melting (Coke Bed)
Melting System / Slag Cooling System		Water-cooled	Water-cooled	Water-cooled	Water-cooled	Water-cooled	Water-cooled	Water-cooled
Furnace Size		9.6t/24h	12.3t/16h	75t/24h	9.6t/24h	52t/24h	15t/24h	30t/24h
Furnace Allowance		30%		50~67%	5%	10% of ash	approx. 5~10%	planned: 25% current:: 69%
Melting Temperature		1,300~1,350℃	1,300~1,350℃	>1,300℃		>1,400℃	1,350~1,400℃ (estimated)	1,600~1,700℃
Energy Source (/ton of ash)	Kind	Kerosene	Kerosene	Electricity	Electricity	Electricity	Electricity: approx. 130kwh; Kerosene: approx.100l	Coke
	Average	875l	303.5l	750kwh	3,847kwh	1,100kwh		planned: 350kg
	Maximum	1,000l	341.56l	950kwh	5,180kwh	1,300kwh		actual: 560kg
Date Completed		11/01/1990	03/23/1987	02/25/1993	03/29/1996	03/01/1994	09/30/1995	11/30/1995
Construction Cost including Building		a) ¥256 mil. ¥26.9 mil. /ton of ash	¥580 mil. ¥47.0 mil. /ton of ash	¥2,500 mil. ¥33.33 mil. /ton of ash	¥1,500 mil. ¥156.25 mil /ton of ash	¥3,500 mil. ¥67.0 mil. /ton of ash	Approx. ¥9,500 mil. ¥16.67 mil /ton of ash	¥2,678 mil. ¥89.27 mil /ton of ash
Normal Operating Cost	Kind of Energy	Kerosene	Kerosene	Electricity 10,217MKWh (65% generated, 35% bought)	Electricity & LPG	Electricity (Only when generating power)	Kerosene & Electricity	Coke
	Maintenance Expense	¥37,897,000/ year	Heating/Ligh-ting ¥16,402k Fuel ¥31,598k Chemicals ¥12,699k per year	Utility cost @.¥5.82/kWh ave. ¥59.463 mil/yr in1995	¥22,501,000/ year	¥13,000/year	¥21,694,000/year	¥35,000k approx. figure estimated from actual record April/Sept. 1996
Ash Melting Cost	per ton of raw waste per ton of Raw Waste +Ash	¥22,110/t	¥ 7,000/t	¥12,256/t	–	¥12,118/t	–	¥12,990/t
	b) per ton of Ash	– (¥147,400 per ton of ash)	¥13,000/t ¥93,000/ton of ash	¥17,232/t ¥41,305/ton of ash	– 40,394/ton of ash (operated for 20 years)	¥16,000/t ¥38,700/ton of ash	¥2,166/t ¥17,368/ton of ash	¥19,220/t ¥50,100/ton of ash Cost high due to 60% load
Slag Disposal Cost		–	–	¥400/ton of slag	–	–	–	Sold with revenue

a) The cost of total incineration plant was ¥1,660 million.

b) This number becomes high when the ash quantity is low, as it is the quotient of annual operating expense divided by the quantity of melted ash.

4. Waste-to-Energy Power Generation (Thermal Recycle)

4-1 The Current Outline of Waste Energy

Figure 12 shows the history of power generation from waste in Japan. Since material recycling poses many limitations in its economics and scale, the importance of incineration is increasing as the means to deodorize, detoxify and reduce waste. Called thermal recycling, it uses its heat for power generation. The power generated is labeled as "Recycled Energy" which saves fossil fuels. The targets are 2,000 MW for the year 2000 and 4,000 MW for the year 2010.

(General Outline of New Energy Introduction, December 1994 – Ministry of International Trade and Industry)

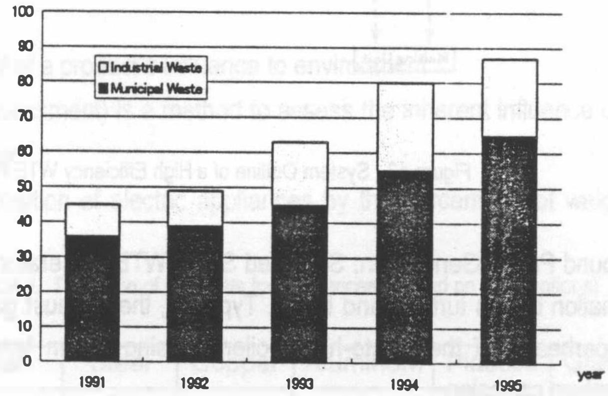


Figure 12. Waste to Energy Capacities

4-2 Problems and Solutions of Thermal Recycling

① Problems

In the arena of environment, generation of toxic substances such as dioxins, leaching of heavy metals from the bottom ash and the fly ash, and the shortage of landfill sites are the problems. In the economics, they include low efficiency in power generation and high capital cost due to small size of the plant.

One of the reasons for the low efficiency is because plants are usually located near a populous area and are required to use air-cooled condensers that do not exhibit unpopular plume, contributing to low vacuum. Another is the superheated steam temperature that is topped at 300ºC in order to prevent corrosion of superheater tubes by the HCl in the combustion gas.

In addition, the excess air is set at a high ratio to cope with the seasonal fluctuation of waste quality, lowering efficiency.

② Solutions

- High-Efficiency Power Generation: The methods for attaining the target efficiency level of 30% include raising the combustion temperature eventually to 500ºC by upgrading superheater tubing material, reducing excess-air ratio by improving furnace configuration, and lowering gas temperature at the economizer and at air-preheater outlet to 200ºC or below.

The conceptual drawing is illustrated in **Figure 13.**

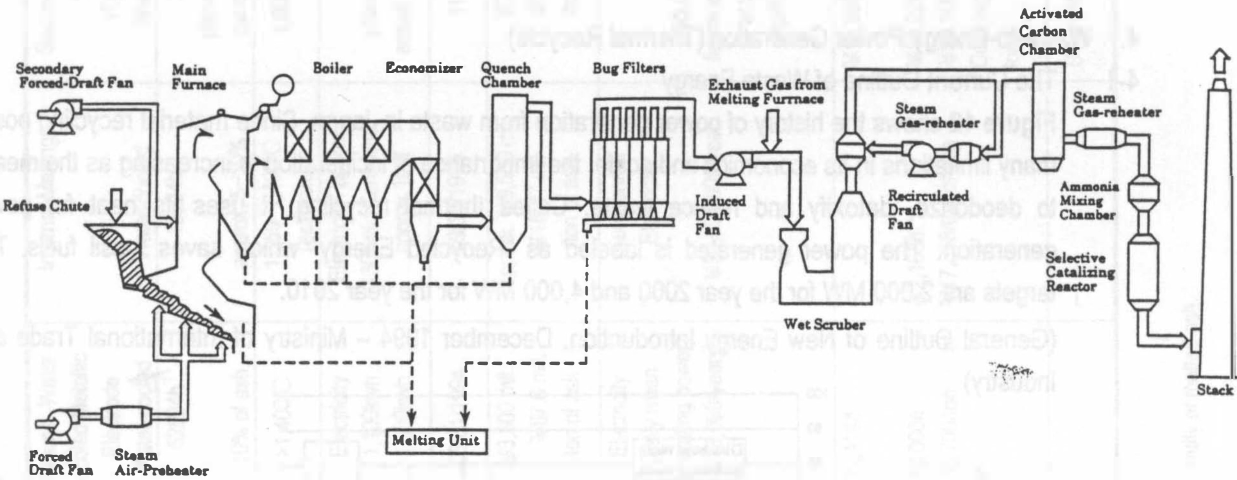


Figure 13. System Outline of a High Efficiency WTE Power Plant

- Compound Power Generation: So-called Super WTE Generator is being chosen lately. This is a combination of gas turbine and boiler. Typically, the exhaust gas from the gas turbine is led to the superheater of the waste-heat boilers, raising steam temperature without causing high-temperature corrosion.
- RDF Power Generation: Here, RDF is collected from a number of RDF conversion plants, and burned in a fluidized bed furnace for an efficient power generation.
- Larger Facilities: The per-unit capital cost of waste incinerators goes down as the capacity goes up. Figure 14 shows that a 150T/D plant costs ¥80,000,000 per one ton of waste per day, while a 1,800T/D plant can be had for ¥50,000,000 per one ton of waste per day.

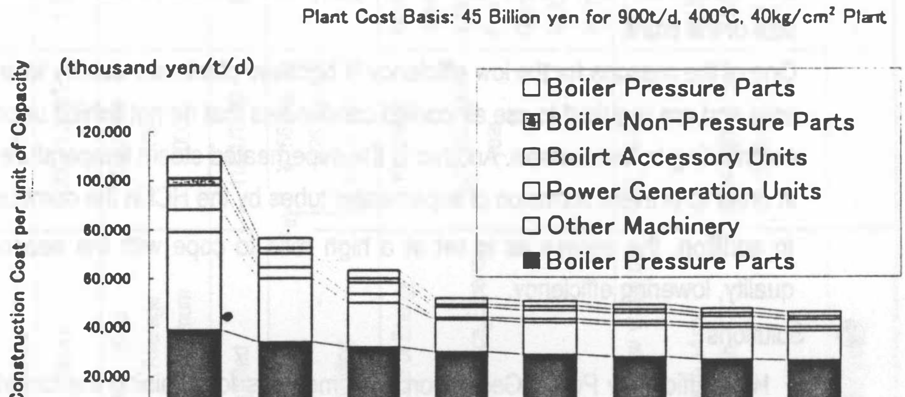


Figure 14. The Plant Capacity and Per-Unit Capital Cost

5. Material Recycling

Manufacturers of consumer goods are now obliged to design products with recycling in mind, as the official guideline on package recycling becomes effective, and the four appliance items (TV sets, Refrigerators, washing machines and room air-conditioners) are now legally recyclable.

5-1 Development of environment-friendly products

1) Shift to easier-to-recycle materials
2) Change design for easier disassembly
3) Examine influence to the environment throughout the life-cycle of a product, from manufacturing to disposal

5-2 Method of appraisal of a product's influence to environment

LCA (Life Cycle Assessment) is a method to assess the inherent influence of a product. It has been adopted increasingly.

The material composition of electric appliances by the percentage of weight as of 1982 is shown below in **Table 6**.

Table 6. Transition of Materials for Appliances (based on assumptions)

Unit: % by weight

Appliance	Year	Steel	Copper	Aluminum	Plastics	Glass	Wood	Others
Refrigerator	Built 1982	50	4	3	40	-	-	3
Washing Machine	Built 1982	53	4	3	36	-	-	4
TV Set	Built 1982	10	3	2	23	57	-	5

Metals such as iron and steel, copper, aluminum, etc. have been recycled, but the reuse of plastics is difficult. Customarily, iron and steel were recovered, and the rest was landfilled as shredder dust. The newly developed appliance recycling facility will recover each ingredient with high concentration, reducing dust for landfill to less than 10%. At the same time, it recoups chlorofluorocarbons and chlorofluorocarbons from insulation foam products at a high recovery rate. Plastics can be crushed at low temperatures, especially PVC, which has a high brittle point and is easy to separate. For the ease of mixed melting, straight-chain polyolefins such as PE and PP are separated from styrenes with benzene rings such as PS & ABS by the specific gravity. Table7 lists the characteristics of various plastic materials.

Table 7. Examples of plastics and the brittle temperatures

Category	Name of Plastics	Brittle Temperature	Specific Gravity
Olefins	Polypropylene (PP)	-50℃	0.90~0.94
Styrenes	Polystyrene (PS)	-40℃~-50℃	1.02~1.05
-ditto-	ABS Resins (ABS)	-30℃	-ditto-
Vinyls	Polyvinyl Chloride (PVC)	-20℃	1.35~1.44
Olefins	Polyethylene (PE)	-100℃	0.90~0.94

6. Next Generation Waste Disposal Facility

6-1 Pyrolysis Gassification Melting System

This system is known as the one that embodies both material recycling and thermal recycling. More than twenty firms have announced their participation, and pilot plants are now being built. (Table 8)The process first removes valuable ingredients from the waste, and the combustible materials undergo thermal decomposition by pyrolysis. The resulting gas and the carbon will be burned to melt the ash at temperatures above 1,200℃. The ash will be turned into molten slag, and the heat will be recovered by the boiler for power generation.

The followings are known to represent this group.

Low-Temperature Indirect Gassification (Indirect Kiln system)

Low-Temperature Direct Gassification (Fluidized Layer system, etc.)

Direct Combustion Melting (Coke Oven system)

Table 8–1 Waste Control Technologies – Pyrolysis-Gas Ash Melting System (Domestic Vendors) [8)]

Pyrolysis System Classification	Incineration Plant Manufacturer	System Outline	Development Status: Size of Pilot Plant or Working Plant	Development Status: Plant Location, etc.	Development Status: Start-up
Fluidized Bed Type	(1) Ebara	Internally Circulating Fluidized Bed + Swirling-Flow Melting Furnace	20 t/day 450 t/day (2x225)	Fujisawa Plant, Ebara Co., Ltd. Aomori RER Co. Plastics Wastes, 17,000kw	July '97 June '98
	(2) Kawasaki Heavy Industries	Fluidized Bed + Swirling-Flow Melting Furnace	30 t/day	Somagaura City, Chiba Pref.	March '98
	(3) Kobe Steel	-ditto -	30 t/day	Chubu-Kamikita Regional District, Aomori Pref.	August '98
	(4) Hitachi Shipbuilding	-ditto-	33 t/day	Nannoh Sanitary District, Gifu Pref.	Sept. '98
	(5) NGK Insulators	-ditto-	25 t/day	Ena County Sanitary District, GifuPref.	April '98
	(6) Mitsubishi Heavy Industries	Pyrolysis + Incinerator + Heat Recovery + Melting Furnace	4 t/day	Kanazawa Plant, Mitsubishi Heavy Industries	
	(7) Babcock-Hitachi	Fluidized Bed + Swirling-Flow Melting Furnace	10 t/day	Takehara-Akitsu Environmental Center, Takehara Regional District, Hiroshima Pref.	Sept. '98
	(8) Kurimoto Iron Works (9) Sanki Kogyo (10) Toray Engineering (11) Unitica	Fluidized Bed + Melting Furnace	10 t/day	Joint Experiment of Kakegawa City, Shizuoka Pref. & (8)~(11)	April '98
	(12) Sumitomo Heavy Machinery	Recirculating Fluidized Bed + Rotary Kiln (Krupp-Uhde, Germany)	20 t/day	undecided	undecided
	(13) Tsukishima Machinery	Recirculating Fluidized Bed + Swirling-Flow Melting Furnace	20 t/day	Within Tochigi Pref.	undecided
Indirect Type	(14) Mitsui Shipbuilding	Kiln-Type Gasifier Furnace + Swirling-Flow Melting Furnace (Siemens Type)	2 x 110 t/day	West Yatsume Regional District, Fukuoka Pref.	year 2001
	(15) Takuma	Kiln-Type Gasifier Furnace + Melting Furnace (Modified Siemens Type)	90 t/day ※1	Kumamoto Pref., Private, Shredded-Car Dust.	August '98
Kiln-Type	(16) Toshiba	Kiln-Type Gasifier Furnace + Swirling-Flow Melting Furnace Gas Cracking (PKA, Germany)		Existing Plants in Europe: 50 t/d, 60 t/d and 240 t/d.	
	(17) NGK Insulators	Noel System (Noel, France)		Existing Plants in Europe: 120 t/d and 750 t/d.	
	(18) IHI (19) Kubota	Kiln-type Gasifier Furnace + Swirling-Flow Melting Furnace	20 t/day	Aichi Plant of IHI. Joint Experiment of (18) & (19)	July '98
	(20) Sumitomo Heavy Industries		20 t./d (planned)		
	(21) Hitachi (22) Babcock-Hitachi (23) NKK	Kiln-type Gasifier Furnace + Melting Furnace (Tide, France)	20 t/day	Joint Experiment of Hitachinaka City Waste Control Center, Ibaragi Pref. & (21) ~ (23)	February '99
Pressure Type	(24) Kawasaki Steel	Pressure Gasification + Melting Furnace + Gas Refining (Thermoselect, Switzerland)		※2Existing Plants in Europe: 300t/d x 2, 600t/d, 900t/d x 2, and 1,200t/d	

※1 An additional entry is Takuma's City of Fukuoka Plant, 20 t/day, which began operation June 1998.
※2 Karlsruhe, Germany: 600t/d

Table 8–2 Direct-Melt Waste Processing by Shaft Furnace (Domestic Vendors)

Direct Melting Type	Incineration Plant Manufacturer	Melting Method	Development Status: Size of Pilot Plant or Working Plant	Development Status: Plant Location, etc.	Development Status: Start-up
Shaft Furnace Type	(1) NKK	Shaft-Furnace type High-Temperature Melting System	32 t/day	Tsurumi Plant, NKK	
	(2) Tsukishima Machinery	- ditto -	28 t/day		
	(3) Nippon Steel	- ditto -	Existing Plant		
	(4) Sumitomo Metals	Shaft-Furnace type HighTemperature Oxygen Melting System	20 t/day		
	(5) Kawasaki Engineering	- ditto –(Purox-Chiyoda)	24 t/day	Owari East District	August '98
	(6) Hitachi Metals	Shaft Furnace (Reasch, USA)	20 t/day		October '98

6-2 Others

Other systems such as liquefaction of plastics and biogas recovery are also being proposed.

End of Article

i) The Ministry of Health & Welfare – January 1997

ii) Toxic Equivalent Quantity to 2. 3. 7. 8 – TCDD

iii) Y. Ishikawa "Problems & Solutions of Building Ash Melting Furnaces for the Prevention of Dioxin Generation," (Data Section), Journal of Resources & Environment vol.34 No.8 (1998) p.50~57