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Risks Associated with the Construction and Operation of Environmental Plant and Equipment

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Foreword

Several reports covering the risks of environmental plants and equipment, especially on Waste Incineration, have been presented at IMIA conferences:

1997 Sun City; Waste Incineration (Update)
1996 Washington, D.C.; Environmental Pollution Risks and CAR/EAR Insurances
1995 Helsinki; Waste Incinerators
1993 Madrid; Waste Incinerators (Underwriting and Technical Aspects)

In order to avoid duplication and to make this report interesting to readers, this report focuses on the more fundamental issues, i.e., environmental problems from a global point of view in general, and the introduction of newly developed technologies and the risks associated with such advanced technologies.

1. Environmental problems and control plants

(1) Environmental problems

In developed countries, technology has transformed industry and private life. Similar transformations are under way in areas of the developing countries.

The consumption of energy and raw materials in the industrial countries of North America, Europe, and parts of East Asia is huge, and, likewise, the production of wastes and polluting emissions is immense. These economic activities are causing global environmental damage and widespread serious pollution and disruption of ecosystems.

On the other hand, developing countries are experiencing widespread degradation of renewable resources -- primarily forests, soil, and water -- caused by poverty and rapid population growth. Also, some areas are experiencing rapid urbanization and industrialization, creating high levels of air and water pollution, which often hit the poor the hardest.

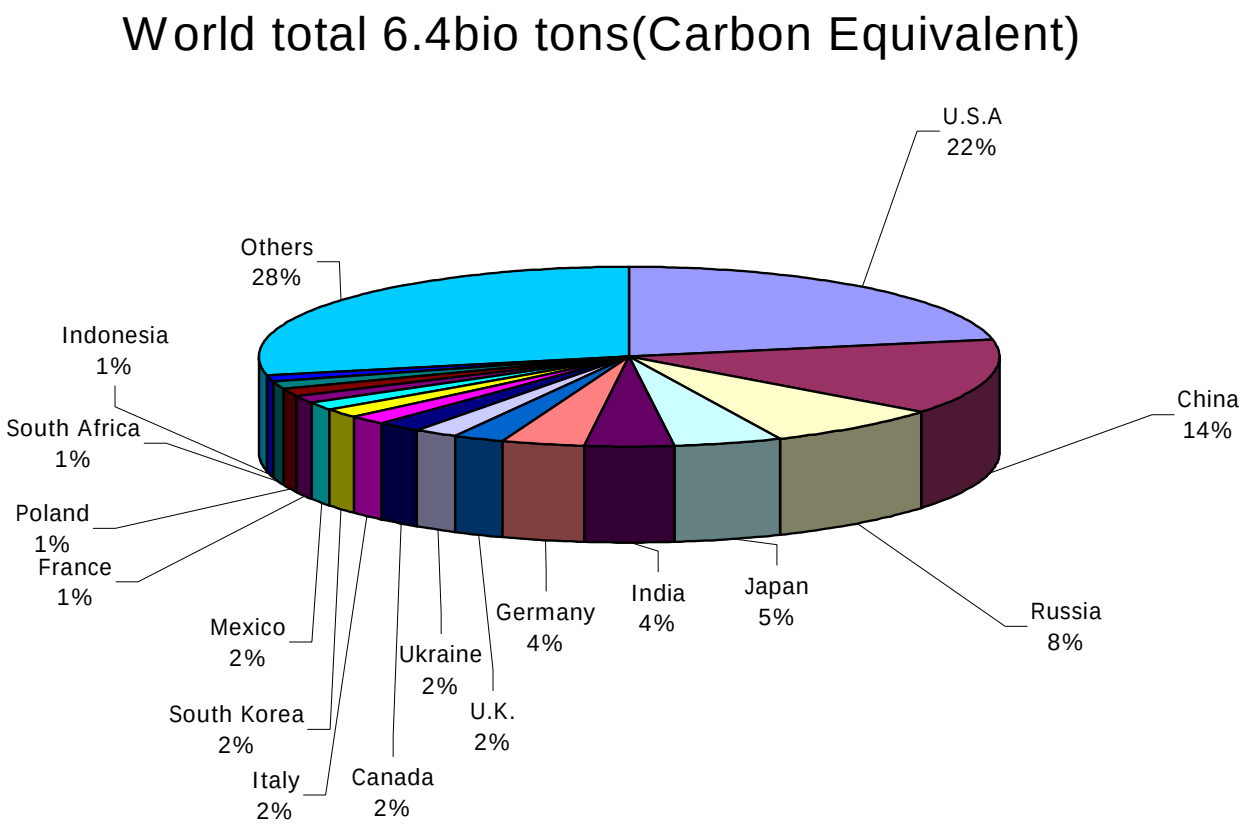
Currently, over 50% of the world's population lives in urban areas. This figure will reach 60% by 2020, at which time Europe, South America, and North America will

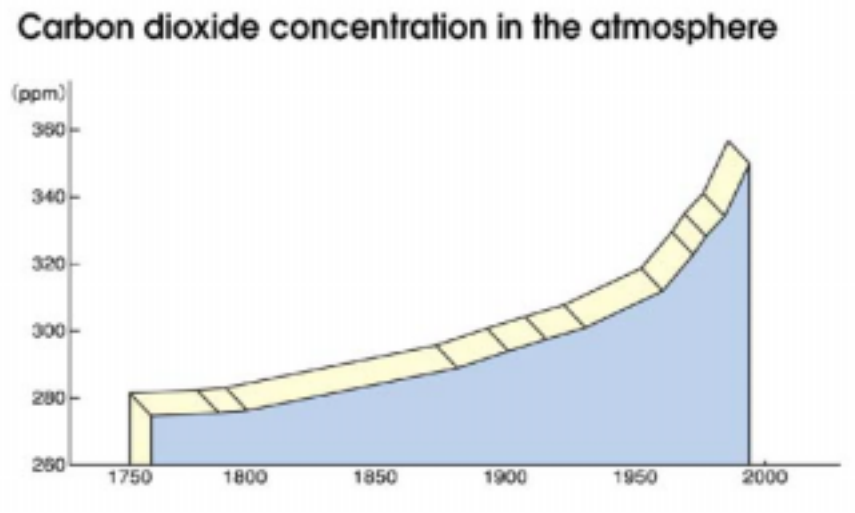
have more than 80% of their populations living in urban areas.

The production of wastes, the increased water and air pollution, and global warming are all matters of environmental concern. (See Appendix 1, Examples of Environmental Problems.)

Among these environmental concerns, global warming caused by greenhouse gas emissions is believed to be the most serious issue. The concentration of atmospheric carbon dioxide, a leading cause of global warming, continues to increase with world population growth and rising industrialization. One scenario described by the Intergovernmental Panel on Climate Change (IPCC) projects that a doubling of atmospheric equivalent CO2 concentration would increase the global temperature by about two degrees by the year 2100, resulting in a rise of about 50 cm (max. 95 cm) in the sea level of the world's oceans.

(Data source: United Nations Environment Program)





(2) Environmental protection

a. Thermal recycle and material recycle

Resource recycle or recovery may be defined as a combination of thermal recycle and material recycle. Thermal recycling recovers thermal energy from refuse incineration plants as steam or power, while material recycling is retrieving valuable materials from non-combustible wastes.

b. Environmental plants and industry

(a) Technology

Recently, environmental equipment technologies have made remarkable progress. Technological innovations, such as new materials, mechatronics, biotechnology, etc., have been accelerating the emergence of rapidly growing industries.

New Materials

Newly developed materials, such as fine ceramics, composite materials, high-molecular functional materials, etc., have accelerated the resource saving, energy saving and compacting of equipment. As an example, catalysts have been

developed to improve the efficiency in adsorption performance and to develop new resins.

Mechatronics, IT

In the 1980s, progress in the field of controlling machinery with a numeric control system (mechatronics) developed rapidly, allowing for highly accurate control. The environmental equipment has also been mechatronized.

Further advances in technology will bring progress such as:

--Equipment will be more automated and reduced in size.

--Control technologies will be introduced for the process of treating and disposing of contaminants or waste.

--An increase in efficiency of maintenance and management will be realized through centralized control.

Biotechnology

A rather traditional approach in environmental plants is to apply biological treatment. In water pollution control technologies, biological treatment has been playing an essential role. R&D activities with advanced biotechnology have been conducted while trying to renovate the conventional treatment systems, which introduce bio-reactors and separation membranes.

(b) Environmental industry

In industry, global environmental problems have been actualized while the waste disposal problem has been getting increasingly serious. As a result, consumers have been becoming more and more conscious of environmental conservation. To cope with these situations, some enterprises have begun to consider the environmental impact of their products. Coupled with a change in consumer behavior, a positive attitude in enterprises toward the environment has become very important from the viewpoint of creating a positive social image. (See Appendix 2, The Environment Industry.)

2. Risks of thermal recycle technologies

Using discarded refuse as a source of heat energy is relatively easy and is one of the most important technologies of recycling.

There are two main methods of thermal recycling. One is the recovery of waste heat as

energy from incinerating refuse, and the other is the utilization of discarded refuse as a heat source after the conversion into oil, combustible gas and artificial fuel.

The energy recovered can be converted into electrical power and can be used to provide heat for other applications such as greenhouses, heated pools / bathing areas, and for heating and cooling residential buildings, public facilities and botanical gardens.

In the current situation in Japan, the technology of the refuse incineration has been developed in connection with pollution control and electric power generation efficiency.

It is known that there are various dioxin substances in the fly ash of the refuse incineration plants. The dioxin substances problem is the most serious issue. The source of generation is various, such as the combustion of refuse, the electric furnace for the manufacture of steel, smoke from cigarettes and the exhaust gas from cars. Among them the combustion of refuse is the biggest. In Japan, in January 1997, "*The Guideline for the Prevention of Generating Dioxin Substances in Refuse Incineration"* was published to regulate this activity more strictly.

(1) Refuse incineration plant with power generation

The benefits of the refuse power generation system are as follows.

i) Most discarded refuse has been incinerated and to use the waste heat as an energy reduces the consumption of fossil fuel and restrains the generation of CO2.
ii) The power from a refuse power generation system is highly stable compared to other new power generation systems such as solar and wind-turbine systems.
iii) The refuse power generation system has less transmission loss as most plants are located in or near big cities, so they connect directly to homes and factories.

Country	Units	Output
U.S.A.	103	2,770 MW
Germany	50	1,000 MW
Japan	173	750 MW
France	90	160 MW
Switzerland	30	100 MW
Sweden	3	100 MW
Denmark	17	90 MW
U.K.		70 MW

Figure : Output from the refuse power generation systems
Source : 1999 NEDO Report

In an ordinary refuse power generation system, burning heat is collected by the boiler as steam, and the process steam for pre-heating the combustion air and the high-pressure steam using the burning heat are branched and then led to the turbine. There the turn of the turbine is transmitted to the generator to generate electricity. Exhaust steam having consumed energy at the steam turbine is condensed in the low-pressure steam condenser, and stored in the condensed water tank. Oxygen and carbon dioxide in the boiler water are removed at the deaerator, and then water is supplied to the boiler.

In this generation system, to prevent the corrosion of the boiler superheater, the steam temperature is suppressed to 300 degree C or lower. Therefore, the generation efficiency is limited to about 10-15%.

The recent development of technology to promote high efficiency is as follows:

-- The conventional system with high efficiency

-- **The combined electric power generation plant with the gas turbines and the refuse incineration facility**

-- **RDF**

-- The Gasification Melting System

Provided that the current situation in Japan to recycle the combustible refuse as a material as much as possible continues, and considering the publication of *"The Package Waste Recycling Law,"* it is necessary to take the reduction of combustible refuse into consideration in case planning on the new systems above.

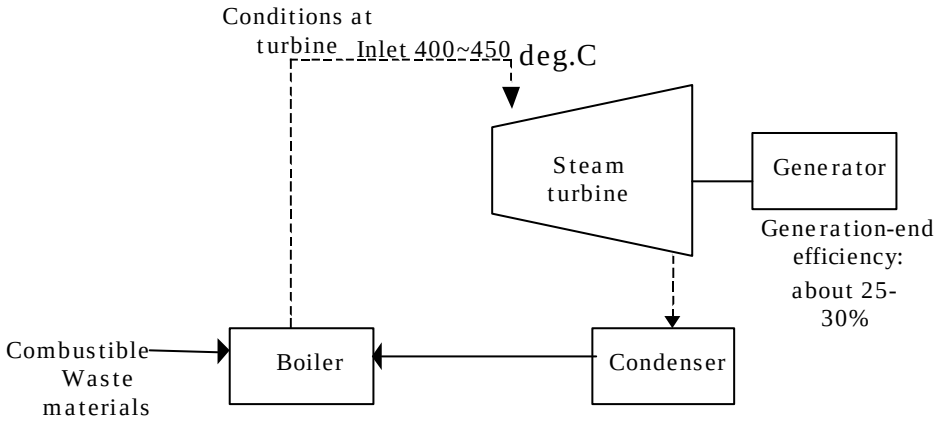
a. Conventional Development Method

This method attempts to introduce higher temperature and pressure for the steam conditions by improving the super-heating pipe materials (changed to stainless materials).

Recently, common pressure and steam temperature are 40 ata and 400 degrees C or

so. Generation efficiency is improved to about 20%. The goal is to achieve the steam conditions of 500 degrees C and 100 ata, and a generation efficiency of 30%.

Conventional development method



Examples for this method are shown below:

Example 1: This municipal refuse treatment plant processes 800t/day through four 200t/24h stoker furnaces. In the boiler superheater, the stainless steel of SUS309・SUS310 family is used for the high-temperature corrosion-resistant material so that the high temperature/pressure steam conditions 37 ata and 380 degrees C are guaranteed. The design output 24,000 kW and the design generation-end efficiency 20.6% are achieved by two condensing extraction turbines of exhaust gas pressure 0.22 ata.

Example 2: This municipal refuse treatment plant has a processing capacity of 330t/day through three 110t/24h stoker furnaces, in which the high temperature/pressure 40 ata and 400 degree C occur. An output 7,000 kW is realized by one condensing extraction turbine of exhaust gas pressure of 0.12-0.18 ata. The design generation-end efficiency is 21.9% when high-quality refuse is processed in the 2-furnace operation with no extraction.

<Risks>

Generation methods of this type involve the following risks:

- Since refuse of complicated shapes is burned, it is essential to provide sufficient combustion control and environmental protection measures.
- Chlorine is contained in the refuse in high concentration (salt in foods and chlorine

in plastics), which could cause to corrode the boiler.

- To improve generation efficiency, it is necessary to raise the steam temperature and pressure at the turbine inlet. The chlorine in the boiler can corrode strongly enough to contribute to an increase in steam temperature.

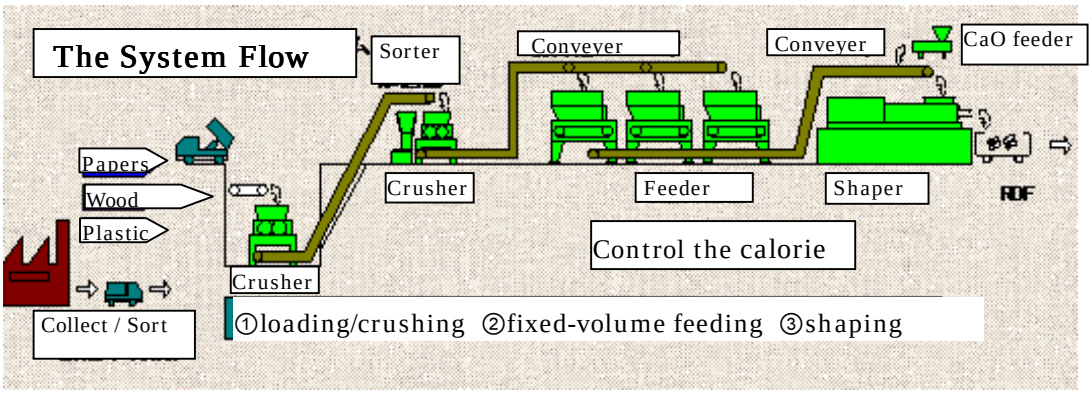
b. RDF (Refuse-Derived Fuel fired boiler) Method

Refuse Derived Fuel (RDF) is a representative method to utilize discarded refuse as a heat source after its conversion into artificial fuel. It is expected to be a valuable resource that will play an important role in energy supply in consideration of the shortage of fossil fuel and other environmental problems.

In the U.S., ASTM (American Society of Testing and Material) has classified RDF into 7 classes by its state. In Japan, RDF is generally thought of as fuel in a solid state shaped in the process of crushing and drying the refuse.

In the production of RDF, water is removed thereby making the pellets stable. RDF products have good features and are used widely in the same manner as coal. The merits of RDF products are as follows.

i) High caloric value and less fluctuation (easy to control burning)
ii) High specific gravity (easy to transport)
iii) Low water content (do not degrade -- storable)
iv) Volume reduction of the incineration residues with collection of the unburnable products.
v) The condition of the exhaust gas is clean by blending with CaO or Ca(OH)2.

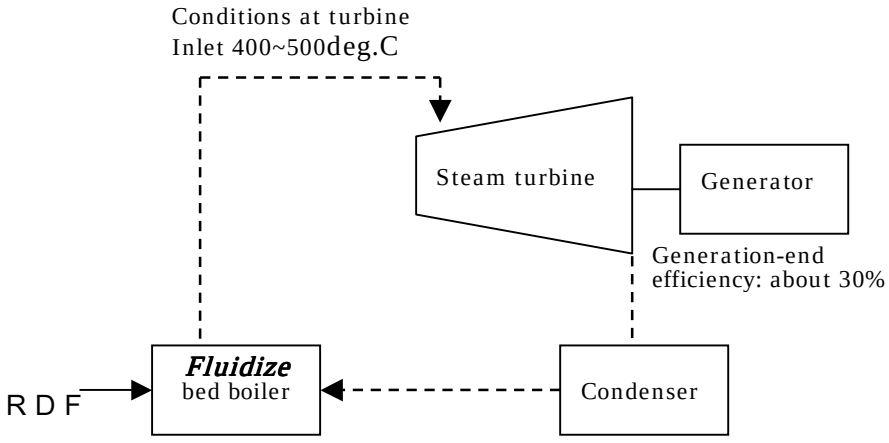


RDF is demonstrated to have low levels of dioxin substances and HCl in combustion under the effects by its uniformity and the Ca component in the lime added in the production process. While refuse is solidified in RDF, the characteristics of the exhaust gas are improved by added lime, eventually leading to a highly efficient generation. Steam temperature can be raised to a high level of 500 degrees C, and this enables us to expect to realize a highly efficient generation of about 30% as compared with the conventional generation efficiency of 10-15%.

Also in the power generation by RDF, generation efficiency is increased by the expansion of the generation scale. Therefore, the overall energy efficiency calculated by subtracting the energy required for the manufacture and transport of RDF is still higher than the generation efficiency in the conventional type of refuse power generation system.

The boiler for power generation which uses RDF is of the circulating fluidized bed type and is classified as an internal type or external type according to the fluidized bed boiler being placed in/out of the main unit. The entire generation system is configured in the same way as in the conventional refuse power generation, but the conventional in combustion furnace (boiler) is replaced with the circulating fluidized bed boiler burning RDF.

Currently, the steam conditions/efficiency are 450-500 degrees C, 40 ata and about 25%. These are expected to increase the steam temperature to 500 degrees C and the generation efficiency to 30% in the future.

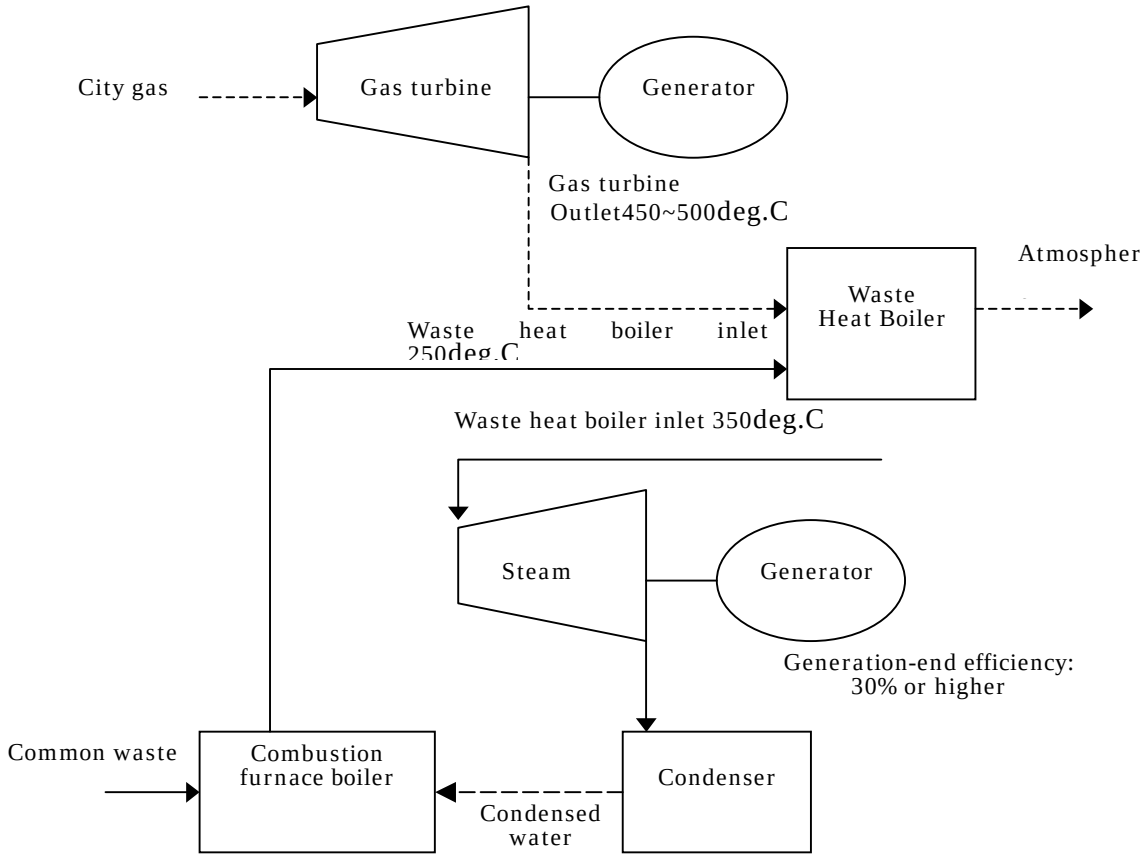


<Risks>
In the RDF method, the fluidized bed type boiler is used, and this unit could have the biggest risk. The main risks:

- Since generation efficiency is high in this type, the steam temperature at the final superheater outlet is specified about 500degrees C. Therefore, the temperature at part of the boiler tube could reach 500degrees C or higher, which may suffer the corrosive environment by complex salt. In the corrosion by chlorine, the salt and chlorine in the metal combine with each other to produce iron chloride. When oxidized continuously, the iron chloride discharges chlorine again, and further corrodes the metal.
- Recent designs prevent heat transfer tubes from contacting the fluids directly, and the wearing and corrosion of the heat transfer tubes are improved remarkably.
- Even in the improved types, however, risks of wearing/corrosion persist because the heat transfer tubes are exposed directly to the combustion exhaust gases.
- There is another risk that elements other than the fuel RDF could be trapped and can damage the heat transfer tubes or the furnace walls.

c. Gas Turbine Complex Method (super refuse power generation)

In this system, the steam produced by the combustion furnace is reheated into high temperatures and pressures by the waste heat of the gas turbine in the so-called Combined Cycle so that higher efficiencies can be achieved.



Examples of this type are shown below:

Example 1: In this power plant, a gas turbine system burning natural gas is added to the existing combustion system in the scale of 450t/d, for a complex power generation by connecting the steam produced from the existing combustion furnace.

Steam produced by the stoker furnace of 20 ata and 255 degrees C is super-heated to 400 degrees C by the exhaust gas from the gas turbine of a generation output 15,000 kW. An output 10,000 kW is obtained at the condensed water type steam turbine. Designed overall generation efficiency is specified as 34.3%.

Example 2: In this plant, an emergency gas turbine of an output 4,100 kW is operated

normally at day time at the facility of 460t/day having two 230t/24h stoker furnaces so that conditions 28 ata and 300 degrees C are available and an output of condensing extraction type steam turbine 12,400 kW is realized. Designed overall generation-end efficiency is 21.1%.

<Risks>

- In this method, risks by gas turbine should be taken into account. However, the scale of the gas turbine used is not so large, and the combustion temperature is not high either. Therefore, this is different from the so-called large-scale gas turbine in its risks. Even if the gas turbine is a small to medium scale one, the use of new design concepts or materials need to be evaluated.
- This system is the most complex one among those introduced here. Even if the components use well-established technologies, whether the whole system can work normally or not is another risk to be determined. Any defect or nonconformance in the system could surface as damage to the component at the maximum load.

(2) Advanced incineration technology

The conventional type of stoker incinerator has its drawbacks as follows:

- The refuse may not be completely incinerated, so the volume of fly and bottom ash is significant.
- It may be difficult to recover usable metal resources, except for iron.
- The heat recovery ratio is relatively low.
- The dioxin substances in exhaust gas are higher in small and mid-sized incinerators.

To improve these problems, newer incinerators are being rapidly developed. Among the many new methods, the ash-melting method and refuse direct melting method including thermal cracking gasified melting method are the most prevalent to date.

a. Ash-melting method

The melting process is performed utilizing the heat from fuel or electric power through the overheating of municipal solid waste (MSW), ash or sewage sludge at 1,200~1,500

degrees C. The melted refuse, like lava from a volcano, is cooled down into glass slag.

The produced slag will lose its volume to 1/2 ~ 1/3 compared to ash and 1/20 ~ 1/30 compared to the original refuse. Because SiO2 contents in ash forms net structure where the heavy metal contents are held and the net structure prevents elution of the heavy metal out of the slag, then the slag is stable for a long time.

Many methods have been introduced, which may be roughly categorized into "**Fuel melting method"** such as Surface melting process (rotary, fixed and reflecting), Circle flow process, Internal melting process, Coke bed process and Rotary kiln process and "**Electric melting method"** such as Arc melting process, Plasma melting process, Electrical resistance process and Induction heating process (high frequency and low frequency).

The fuel melting method is melting the ash with the heat from burning fossil fuel such as kerosene, heavy oil, coke, or gas.

The electric melting method is melting ash by the heat produced by arc discharge plasma, electrical resistance of the ash or induction heating. In cases where electrical power from the waste heat recovery power plant is available, this process has merit since the ash melting system is relatively compact and the exhaust gas is only from the ash.

In comparison with the fuel melting method, the melting temperature is relatively higher in the electric melting method. Thus, more iron content is exhausted in ash and recovered from the slag, and the allowance for iron content is relatively higher.

On the other hand, the operation of a fuel melting method plant is much easier and there is more flexibility as to feedstock. However, the larger volume of exhausted gas caused by fuel burning and lower melting temperature cause some problems such as the iron sticking to the refractory brick at the bottom of the furnace and the volatility in properties of melted slag.

b. Refuse direct melting method

In this method, the refuse is thermally cracked as a first stage with relatively lower

temperature at 450 ~ 550 degrees C converted into thermal cracked gas and char. Then the refuse is burned at high temperature utilizing the energy in the gas and char. The remaining ash is finally melted.

This process has three merits. First, non-oxidized metal, such as good quality iron or aluminum is recovered; second, dioxin is dissolved in the melting furnace; and third, high-performance power generation utilizes the waste heat at high temperature.

The process may be categorized into **"Thermal cracking gasified melting method"** such as Vertical shaft furnace (coke bed) process, Outer heated kiln process and Fluid bed process and **"Other methods"** such as Rotary kiln process, Internal melting process and Furaff burn process.

c. Examples

(a) Combined thermal cracking gasified melting method and ash melting

[NEW PYROLYSIS and ASH MELTING SYSTEM]

A New Pyrolysis and Ash Melting System has been developed as a practical application of waste-to-energy systems, burnt-residue-recycling systems, reduction of flue gas amount and pollution-free-waste treatment systems.

The benefits of this system are:

- This highly efficient waste- to-energy system and ash melting system can treat wide varieties of MSW in its properties and compositions.

- High temperature steam recovery system makes the power generation efficiency higher.

- Cans, after treated by this Pyrolysis System, and molten slag can be recycled.

- The construction and running cost of a flue gas treatment system can be reduced due to small amount of flue gas generating.

The features are:

- Superheater corrosion has been substantially mitigated because boiler steam in the superheater can be heated by clean gas generated in the pyrolysis furnace where char (pyrolytic residues) is burned completely.

- Incinerated reusable materials such as cans are easily recovered because bulky incombustibles are discharged out of the pyrolysis chamber without oxidation .

- Pyrolytic gas melts ashes directly.

- The life of the melting furnace wall is longer because the wall is protected by water-cooled refractories and a self-coating solid slag layer.

- The secondary combustion chamber in the pyrolysis furnace and the melting furnace has multiple combustion stages so that less NOx is generated due to a self de-NOx system, and fewer CO/dioxins are generated to complete the combustion system.

- The flue gas amount is low due to the low air combustion ratio.

Outlines of the principle:

- MSW in a feeder is charged into the pyrolysis furnace and efficiently treated during the pyrolysis process at about 450 degrees C and is sent back from incinerator.

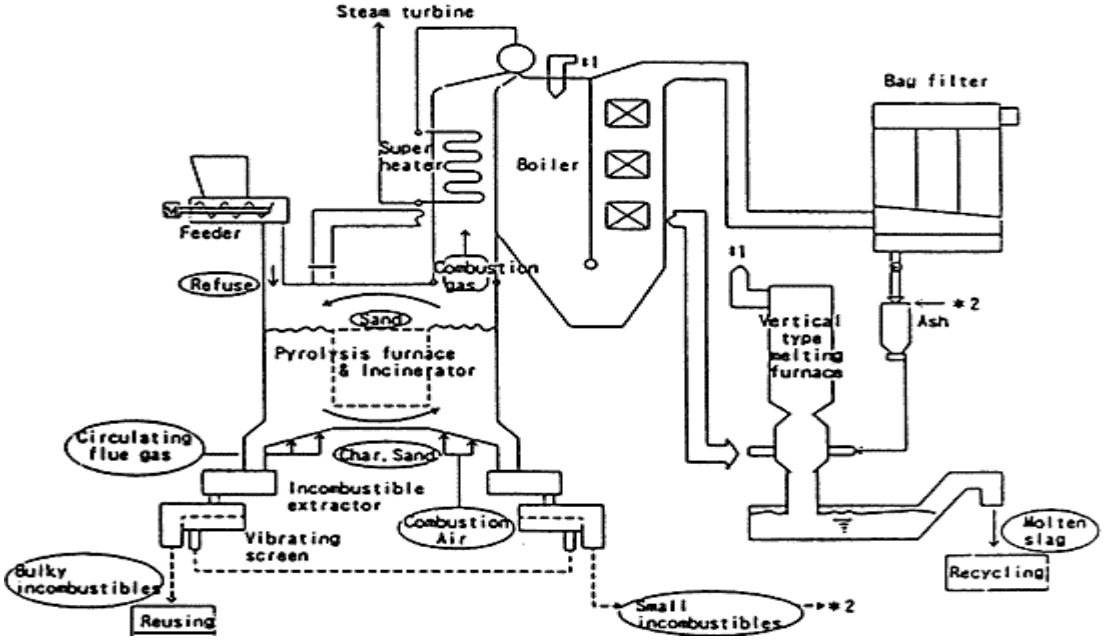
- The pyrolysis gas generated in the pyrolysis furnace is sent to the melting furnace where this heated gas becomes a heat source for the ash melting. In the meantime, char, formed in the pyrolysis chamber, together with the sand, is discharged into the incinerator and completely burnt.

- Meanwhile, in the boiler of the incinerator, waste energy is very efficiently recovered by clean combustion gas.

- In a vertical-type melting furnace, flue gas is emitted from the top whereas molten slag goes out of the bottom. Pyrolytic gas and air-transported ashes are blown into whirl section at the bottom of the melting furnace where ashes are melted and fall down along the furnace wall, finally being discharged from the bottom.

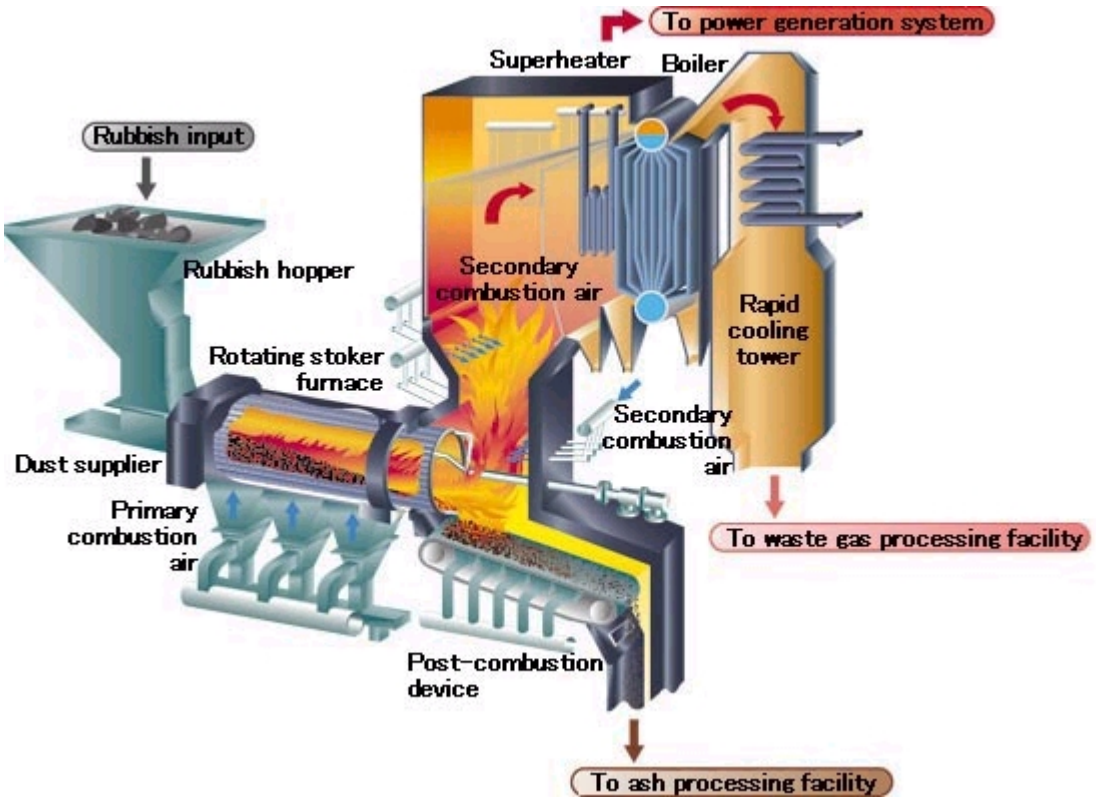
(source: Mitsubishi Heavy Industries)

< Flow chart >

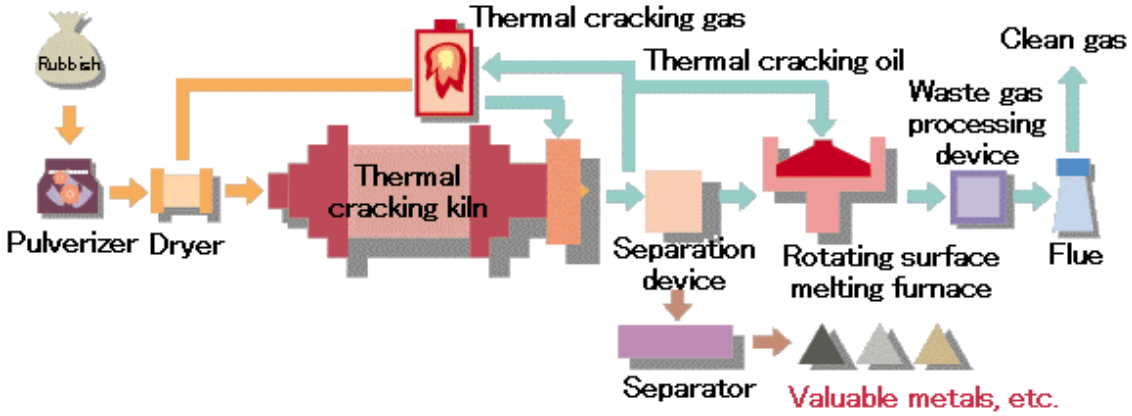

Steam turbine
*1
Bag filter
Super heater
Boiler
Feeder
Refuse
Combustion gas
Sand
Pyrolysis furnace & Incinerator
*1
Vertical type melting furnace
*2
Ash
Circulating flue gas
Char, Sand
Incombustible extractor
Combustion Air
Vibrating screen
Bulky incombustibles
Reusing
Small incombustibles
*2
Molten slag
Recycling

(b) Rotary kiln direct melting method

(source: Ishikawajima-harima Heavy Industries)



Rotating stoker furnace



<Risks>

Risks related to the leading edge technologies introduced above are as follows;

1. The sorting and crushing process prior to loading the waste materials into the furnace should be carefully controlled and monitored. Some foreign materials may generate dust or melt and stick to the furnace wall. If sorting or crushing is insufficient and these materials are allowed to enter the furnace, they may adhere to areas such as the furnace walls and cause damage to refractory bricks, etc.
2. Dust particles and molten waste can damage and reduce the overall efficiency of the equipment through this adhesion process.
3. At a gasification-melting furnace, flammable gas is produced, so any failure to prevent the emitted gas from mixing with the air may cause an explosion.
4. Although there are rather few rotating portions as a whole, some portion exposed to huge amount of dust and high temperature may suffer damage.
5. Heavy metal and chlorinate contents in refuse may cause corrosion damage resulting in mechanical problems during the test and operational phases.

(See Appendix 3. CO2 Recovery Technology)

3. Risks of Material Recycle Technologies

(1) From waste disposal to recycling-based society

The 20th century saw humanity, a newcomer to the Earth, consuming a lot of Earth's resources and producing a quantity of wastes. As a result of economic activities and using various chemicals which have now become indispensable to our daily life, the dumping of used products has become a significant problem.

At the end of the 20th century, *the "Basic Law for Establishing the Recycling-based Society" (abbreviated as the Recycling-based Society Promotion Law)* was established in Japan. This law provides the principles of waste reduction and the promotion of recycling as well as basic concepts regarding the shared roles of businesses and consumers.

It is still fresh in our memory that the international conference on global warming in Kyoto in December 1997 set numerical targets for emissions of greenhouse effect gases, such as carbon dioxide. At the conference, Japan promised to make a 6%

reduction in the period between 2008 and 2012 compared to the emission level in 1990. Accordingly, the government established the "*Law for Promotion of Measures to Cope with Global Warming"* in April 1999, and *the "Law concerning the Rational Use of Energy" (abbreviated as the Energy Conservation Law)* was amended and rendered more stringent.

'Deregulation' is the trend of the time whereas *laws concerning waste disposal and recycling* have been amended and rendered more stringent for these one or two years and environment-related matters are becoming subject to regulation.

If we ignore this movement, businesses cannot persist or expand. Businesses are required to take environmentally friendly measures in accordance with the movement by the sustainable-growth-oriented society and the policies.

Factors behind the establishment of environment-related laws, details, and the effects of the laws on business activities in the future will be discussed.

(Appendix 4. Legal regulations on material recycle in Japan)
(Appendix 5. Japan's trends in addressing environmental problems)
(Appendix 6. Summaries of main legal regulations in Japan)

(2) System for reclaiming oil from waste plastics

Examples of systems for reclaiming oil from waste plastics are often seen in those plants that first remove vinyl chloride from the plastics. Here, however, we will introduce a system that can process waste plastics in one block in a safe and pollution-free manner by using an advanced dehydrochlorination process.

Speaking of the quality of the reclaimed oil, about half is an oil equivalent to the heavy oil A and the other half is light oil. The light oil is consumed within the facilities such as by the heating furnace, while the heavy oil A is consumed at public facilities.

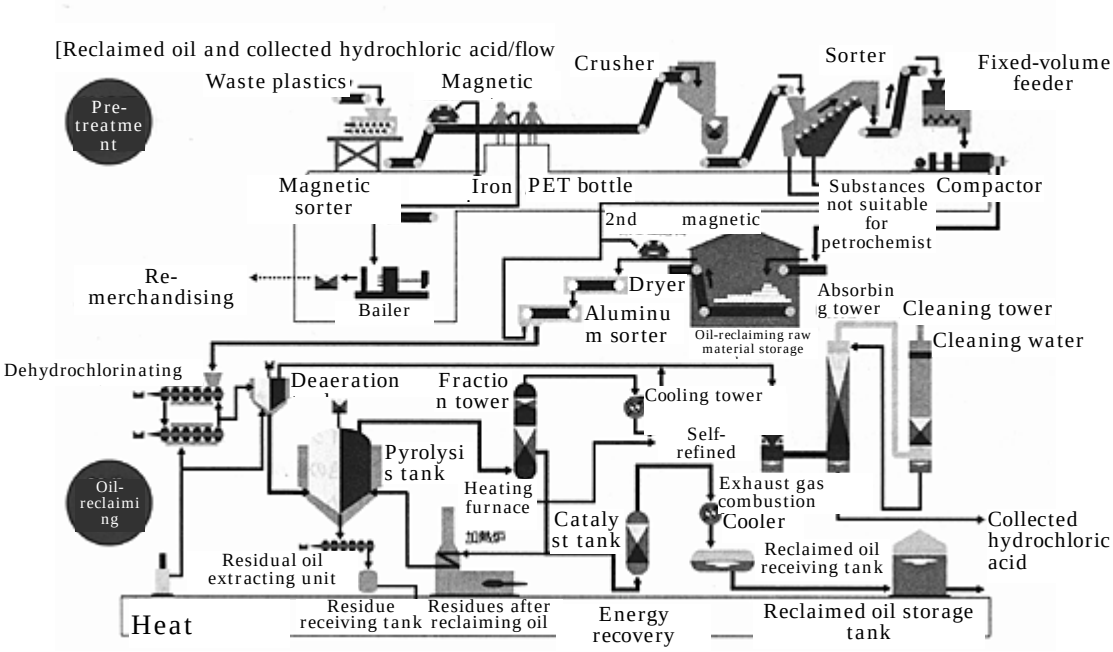
The system consists of the two processes: one for crushing, compacting and flake processing; and another for reclaiming oil. The former process is performed only during the day, while the oil-reclaiming process is performed around the clock.

The processing flow is as shown in the drawing. The main part is the first process in which PET bottles are sorted manually, and metals such as iron and aluminum and other substances not suitable for oil reclamation process are removed through several processes by a magnetic sorter, air-force sorter and aluminum sorter. The rest is processed into a flake-shape raw material suitable for petrochemical reclamation of oil.

In the process of reclaiming oil, on the other hand, the key process is the dehydrochlorinating unit. The dehydrochlorinating unit, which is divided into two lines, melts the raw material at about 300 degrees C. By circulating this, high dehydrochlorinating rates are realized. The temperature of pyrolysis is about 450degrees C. Heat required in the decomposition is supplied efficiently from the heating furnace using the produced light oil.

Exhaust gas is combusted at a high temperature of 1,000°C or higher, and then hydrochloric acid is collected as hydrogen chloride via the absorption tower and the cleaning tower (2,000-3,000 tons in 10% dilution). The collected hydrochloric acid can be reused.

The residues produced after decomposition will also be recycled by recovering the steam and thermal energies.



<Risks>

1. The supplied refuse is sorted plastics. However, foreign matters such as metals and spray cylinders could also be contained in the supply. These may cause overload to the units in the first process or compactor and may cause mechanical damages or explosion.
2. At the Dehydrochlorinating Unit, hydrochloride is produced through the process, so corrosion damage to the equipment should be carefully prevented.
3. In addition to the explosion risk at the Pyrolysis tank due to chemical reaction, consolidation and sticking caused by lack of heat may lead to serious damage.
4. In the process of reclaiming oil, the risk of explosion at the heating furnace due to ignition failure should be noted.
5. Hot air of the heating furnace is sent to the dust collector. However, a defective cooling unit could cause a temperature rise in the dust collector. This could lead to fire.
6. This plant as a whole is a reverse process to polymerization plant in the petrochemical industry. Similar risk to such petrochemical plant should be considered.

4. Conclusion

The consumption of energy and raw materials and production of wastes and polluting emissions worldwide is huge and is causing numerous and serious environmental problems including global warming caused by greenhouse gas emissions.

Resources should be recycled. This is the common understanding to prevent further damage to the Earth. Resource recycle or recovery may be defined as a combination of thermal recycle and material recycle.

Thanks to the recent technological innovations, such as new materials, mechatronics, biotechnology, etc., environmental equipment technologies have made remarkable progress. Keeping pace with these technological innovations, a new category of industry, the environmental industry, has been developing in various fields and also in many countries.

The environmental plant and equipment is believed to be one of the most growing and innovative areas not only for the engineering industry but also for engineering insurers in the 21st century.

Risks related to environmental equipment are summarized as follows.

(1) Corrosion

Wastes, feedstock to the plant, contain chlorine, sulfur, nitrogen, etc., all of which produce corrosive gas or liquid after reaction with oxygen. These byproduct chemicals corrode various parts of the plant. Damage due to corrosion may cause explosion at the pressured parts and may lead to a heavy loss.

(2) Fluctuation of load due to intermittent operation

Since the feedstock is the same as waste, the pace of supply may not be kept constant. These circumstances force intermittent operation and fluctuate load to the plant. Such operating conditions special to environmental equipment should be considered.

(3) Ubiquity of thermal load

Since calories of waste differ from time to time and are not homogeneous, burning conditions in the incinerator or melting furnace are not always the same. This causes partial overheat inside, which damages the refractory lining and other related parts, and leads to furnace damages.

(3) Change in quality of waste

If material recycling accelerates, the quality of the waste furnished to the incinerator would be deteriorated.

Environmental equipment with high technology would be required to overcome this condition, but we must not forget that at the same time several risks that we have been mentioning are sure to increase.

(See Appendix 7, Examples of Typical Losses.)

Appendix 1. Examples of Environmental Problems

1. Eastern Europe, South East Asia, and parts of South America and West Asia, face problems associated with rapid industrialization. Rising levels of pollutants and greenhouse gases create serious problems of acidification, urban air quality deterioration, and transboundary pollution, all of which pose increased health risks.

2. In Africa, West Asia, and parts of Asia-Pacific and South America, where food security and poverty alleviation are priorities, the primary emphasis regarding land is its availability, the abatement of land degradation, and efficient land and water management.

3. Degradation of drylands is an urgent global problem, placing some 1 billion people in 110 countries at risk, mainly in developing regions. In highly industrialized regions, ameliorating soil contamination and combating acidification are priorities.

4. In developing regions natural forest cover declined by 8 per cent in the 1980s. In Europe, air pollution (including acid rain), pests and diseases, and forest fires were the main causes for forest degradation.

5. Biodiversity is of particular concern both to South America and the Caribbean and to Asia and the Pacific, which together comprise 80 per cent of the ecological megadiversity countries of the world. As yet, no region-based assessment of the state of the world's biodiversity is available, and of a working figure of 13 million species, only 13 per cent have been scientifically described.

6. Every day, 25,000 people die as a result of poor water quality, and waterborne diseases still represent the single largest cause of human sickness and death world-wide. Some 1.7 billion people, more than one third of the world's population, are without safe water supply. In addition, an estimated one quarter of the world will suffer from chronic water shortages in the beginning of the next century. The development and efficient management of water resources is a priority concern in West Asia, Africa, Asia and the Pacific. In Europe and North America, the protection of water resources from contamination, acidification, and eutrophication

are highest on the agenda.

7. In South America, some 50 per cent of the mangroves are affected by forestry and aquaculture activities. Oil spills are particular threats in West Asia and the Caribbean, while infrastructure development for the tourism industry puts stress on natural coastal areas around the world, particularly in small island developing states.

8. All major cities in the world suffer urban air quality problems. In Eastern Europe, air quality is considered the most serious environmental problem. Despite coordinated action worldwide, damage to the ozone layer continues faster than expected, with the next 10 years predicted to be the most vulnerable. Cases of non-compliance and growth in illegal trade in ozone-depleting substances are emerging problems.

9. In addition to the risks above, Theo Colborn, John Peterson Myers and Dianne Dumanoski warned about the risk caused by endocrine disrupting chemicals, which are generally known as Environmental Hormones**,** in their "*Our Stolen Future"*:

> Mothers who ate moderate amounts of fish from Lake Michigan and Lake Ontario shared the chemicals in the fish with their babies -- babies who also had similar neurological decrements at birth -- and, with a new battery of tests, were found to be hyper-reactive to unpleasant events, just like rat pups whose mothers were fed Lake Ontario fish. Hyper-reactive individuals do not respond well to stressful situations.
>
> Mothers from the Netherlands also shared the chemicals in their bodies with their babies -- babies with measurable neuromotor decrements at birth. These babies also had reduced immune competency and reduced levels of thyroid hormone. This hormone guides brain development and the growth of children. These effects were associated with the amount of a group of chemicals in the mothers' bodies similar to the chemicals found in the mothers from the Great Lakes. But in the Netherlands the mothers represented a cross-section of the population, not necessarily fish eaters. Like the Great Lakes infant studies, the concentrations of these chemicals in

the mothers were well within the normal range of the average population in the developed world.

But this problem is not restricted to Europe and the United States. As researchers tracked the polar migration of persistent chemicals toward the North Pole they found that Native American mothers in eastern Arctic Canada share with their babies seven times more contamination than the mothers in the Great Lakes and Netherlands. The native youngsters have 20 times more middle ear infections than children in the lower North American continent and they have difficulty producing sufficient antibodies when vaccinated for childhood diseases.

Appendix 2. The environment industry comprises the fields as follows:

1. Environmental Support Related Field

--Pollution Control and Environmental Conservation Equipment

Manufacturers of air pollution control equipment, water pollution control equipment, noise and vibration control equipment, CO2 control equipment and so on,

--Waste Recycling Equipment

Manufacturers of municipal refuse treatment plant, industrial waste treatment equipment and so on

--Environment Analyzers

Manufacturers of instrumentation to measure environmental data, etc.

--Environmental Consulting

Service industry that renders such services as an environment assessments to evaluate the effects upon environments, and monitoring/ supervising services in entrepreneurial activities, etc.

2. Waste Disposal/Recycling Related Field

--Waste Disposal and Sewage Treatment Operations:

General wastes, industrial wastes, sewage and night soil are treated.

--Recycling Operations:

Wastes are recovered, screened and regenerated as resources.

--Used Goods Distribution and Repair Operations:

Products are to be reused.

3. Environmental Rehabilitation / Creation Related Field

--Environmental Rehabilitation Operations:

Lakes, marshes and rivers are purified while decontaminating the soil.

--Environment Creating Operations:

Rainwater and medium water are effectively utilized to plant trees in urban areas and on the premises of factories.

4. Environment - Harmonizing Energy Related Field

--Energy Supply Efficiency Increase-related Operations:

Operations covering the production of highly efficient energy equipment, such as co-generation equipment, multi-functional heat pump equipment and so on; the fabrication of a regional heat supply system by making effective use of unused energies in an urban area.

--New Energy Related Operations

Operations covering the production of solar-light electric conversion equipment, wind-force power-generating plant, waste power generating plant, solar-heat utilization equipment, fuel cells, etc., and the supply of energy by the use of such equipment and plants.

5. Environment-Harmonizing Type Product Related Field

--Developing Those Products That Are Meant to Reduce an Environmental Load in their Service Stages:

Improve the efficiency in utilizing energy, and reduce the volume of emission, etc.

--Developing those Products That Will Reduce the Environmental Load in Disposal Stages:

Make it easier to recycle. Reduce the volume of wastes and so on.

--Developing Those Products That Will Reduce the Environmental Load by Making Use of Regenerated Resources and Raw Materials:

e.g., paper production, candles, glass

6. Environment-harmonizing Type Production Process-related Field

--Improve the production process to save energy and resources.

--Introduce a system to efficiently utilize unused energy, such as waste heat or the like, and make efficient use of industrial wastes.

--Modify the production process to reduce emissions, into the open air and into waters.

--Reduce the use of specified chlorofluorocarbons (CFCs) and any other harmful substances.

--Positively tackle with the R&D on an innovative environment-harmonizing type production process (clean process).

(Source: "Industrial Environments Vision," Global Environment Subcommittee, Industrial Configuration Examination Committee)

Appendix 3. CO2 Recovery Technology

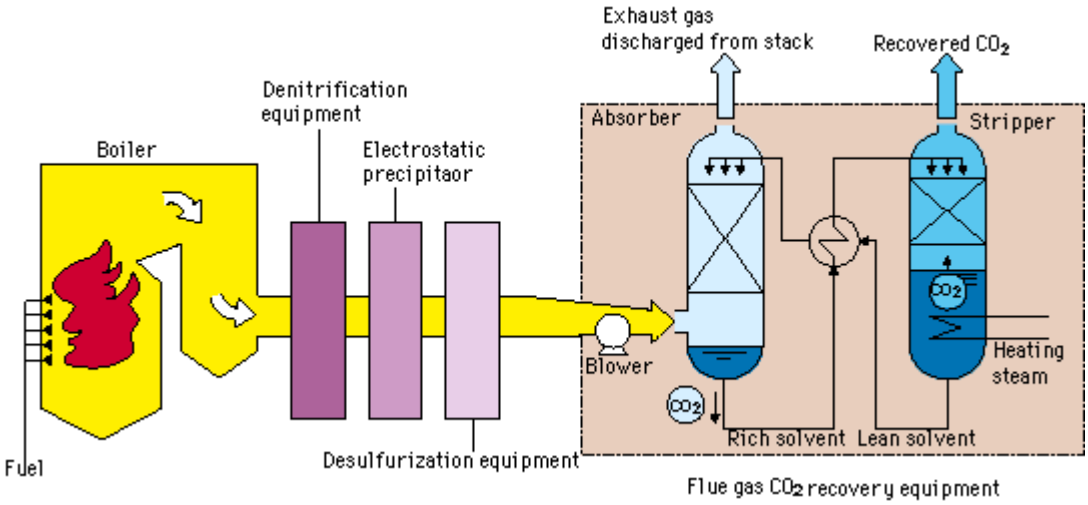
With the goal of eliminating CO2 from flue gas at fossil fuel power stations, Kansai Electric, Japan's second largest electric utility company has been researching chemical absorption methods since 1991, by operating a flue gas CO2 recovery pilot plant at Nanko Power Station (see photo and figure below) in Osaka city.

They have succeeded in reducing the amount of energy required to recover CO2 by using newly developed absorbent liquids, and they are evaluating the optimum system configuration based on these results. The research is being integrated into a joint research project by Japanese electric power companies to further promote effective R&D in this field. They are working to solve problems such as the large amounts of energy still needed to recover CO2 and the environmental impact from disposal of

recovered CO2.

They are conducting comprehensive CO2 recycling studies, such as synthesizing methanol and dimethyl ether from CO2 and using water electrolysis with solar batteries to produce the hydrogen necessary for synthesis.
Flue gas CO2 recovery pilot plant at Nanko Power Station (LNG fired 600Mw x2, Boiler/ Steamturbine power station)

Mechanism of flue gas CO2 recovery equipment (chemical absorption method)

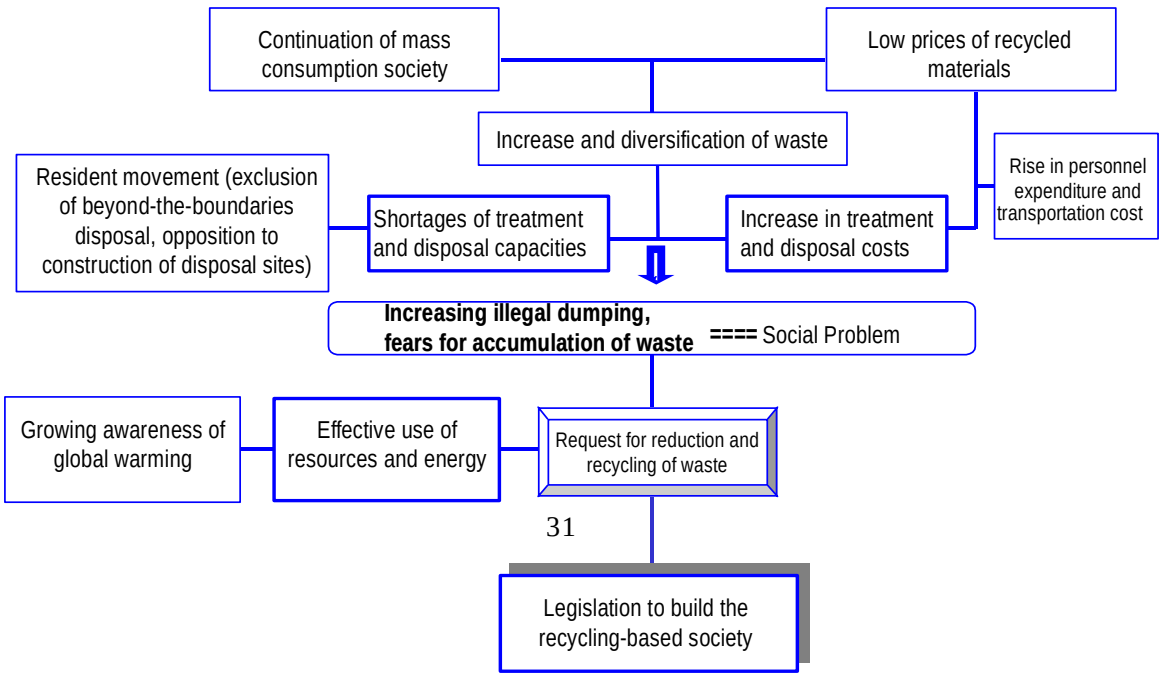


Appendix 4. Legal regulations on material recycle in Japan

Illegal dumping of waste became a social problem due to a scarcity of final disposal sites in Japan. And in the ordinary session of the National Diet in 2000, this year was named as 'the year of the recycling-based society' and six recycling-related laws and amendments including *the Basic Law for Establishing the Recycling-based Society* were passed. Specific promotion measures are being examined by the competent ministries and agencies.

In the 1990s, the destruction of the environment, including soil pollution by toxic chemicals contained in used products and generation of dioxin due to inappropriate incineration, became apparent in the area near disposal facilities. Although the Ministry of Health, Labor and Welfare followed these problems by amending *the Wastes Disposal and Public Cleansing Law (abbreviated as the Waste Disposal Law)* to render them more stringent, they could not do away with the idea of 'appropriate' disposal of waste and valuables. As a result, the recycling rate remained very low, at a level of 11% for general waste containing mainly household waste and 41% for industrial waste (as of 1997).

The Law for Promotion of Use of Recycled Resources became effective in October 1991, in order to encourage easy-to-recycle design and to promote recycling of electric appliances which are difficult to recycle. The law was not a basic solution to the problem when consumption increased. However, waste and recycling measures have recently been discussed as the same problem at last.



The Recycling-based Society Promotion Law, which provides basic policies on disposing of used products and waste, was passed by the National Diet in May 2000 and issued and became effective in June. Under this law, the following two laws stand: *the amended Waste Disposal Law*, which obligates emitters to confirm final disposal, and *the Law concerning Promotion of the Rational Use of Resources (abbreviated as the Recycling Law, an amendment to the old law)*, which obligates automotive manufacturers and the like to reuse parts and prolong the life of the products. In addition, specific laws have been issued regarding recycling products and their waste, including:

--The Law concerning Promotion of Sorted Collection and Recycling of Containers and Packaging (abbreviated as the Package Waste Recycling Law), which was issued in June 1995 and mandates recycling PET bottles and glass bottles;

--The Law for Household Electric Appliances Recycling (abbreviated as the Household Appliance Recycling Law), which was issued in June 1998 and obligates appliance manufactures to reuse their own products;

--The Law concerning Promotion of Recycling etc. of Food Recycled Resources (abbreviated as the Food Recycling Law), which was established at the same time as *the Recycling-based Society Promotion Law* and obligates the food service industry, etc. to recycle food waste as animal food and compost; and

--The Law concerning Recycling, etc. of Materials for Construction (abbreviated as the Construction Material Recycling Law), which obligates persons who undertake construction to sort concrete, wood, etc. during dismantling and to recycle them.

These laws form a regulation scheme for promotion of recycling. Furthermore, *the Law concerning Promotion of Procurement of Environmentally Conscious Goods by the State, etc. (abbreviated as the Green Purchase Law)*, which obligates the state and other public corporations to purchase environmentally-conscious-products (so-called Green products), was issued at the same time, which formed an institutional framework of the recycling-based society.

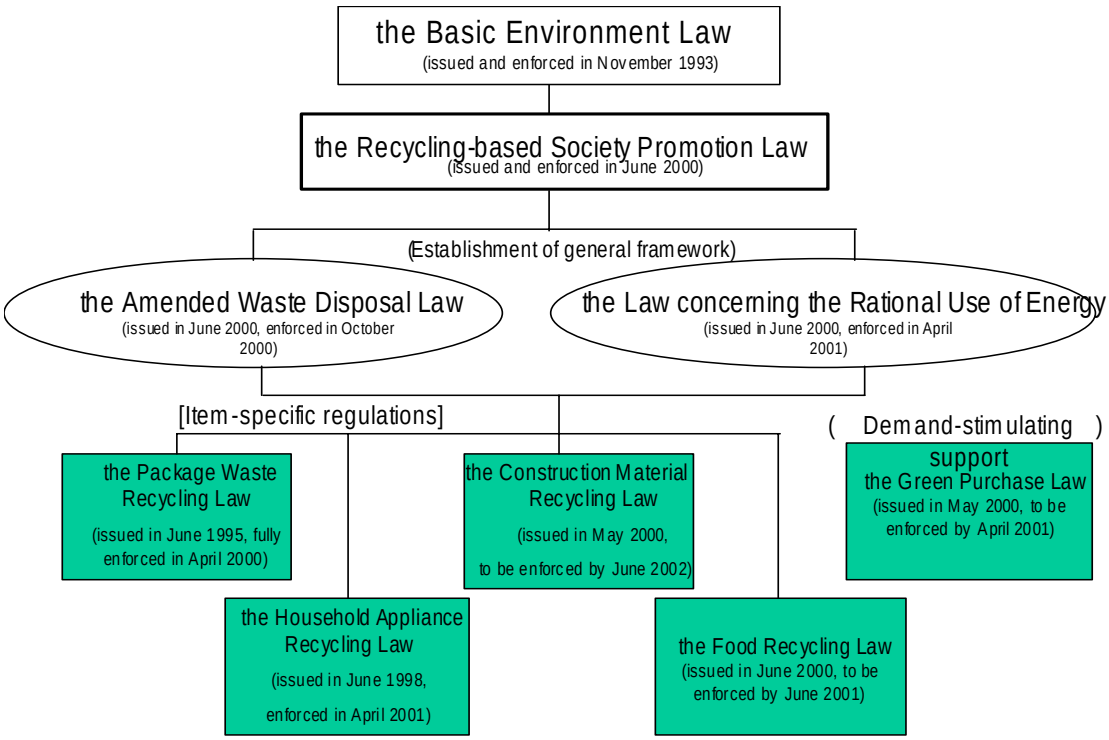


Figure 3. Recycling-related law system (Japan)

Appendix 5. Japan's trends in addressing environmental problems

The recent 30 years are divided into three parts and the feature in each decade is described below.

1. 'Industrial pollution' problems (1970s)

…Local pollution problems triggered various regulations. The feature of this time is that the party who caused the problem (wrongdoer) and the party who suffered the effect (sufferer) are different and 'old-fashioned' measures focused on diluting or putting the lid on pollution. These measures were origins of the system of environment-related laws such as the *Air Pollution Control Law* and the *Water Pollution Control Law* and brought about the effect that Japanese businesses established

pollution prevention technologies and systems and transferred these technologies to many countries outside Japan.

2. 'Urban- and life-related environmental' problems (1980s)

…An income increase due to the economic growth led to population concentration in urban areas and massive consumption of electric appliances and automobiles, which brought about urban waste, exhaust gas from automobiles and noise. The feature of this decade is that the wrongdoers and the sufferers overlap to a greater degree.

3. 'Global environmental' problem (1990s)

…Increasing social awareness of the global environmental problem, including the ozone layer depletion problem, prompted businesses to take advantage of environmental measures, which they had considered only as restraints by regulations, and to claim their products were 'environmentally friendly', a keyword used to create a good corporate image. At the initial stage mainly associations of manufacturers and the Federation of Economic Organizations dealt with the measures, but some advanced manufacturers started to issue their environmental reports as a way of public relations. The feature that the wrongdoers and the sufferers were almost the same led to a legal framework to induce manufacturers to take on voluntary measures. Businesses tried to produce more fruitful results than what the regulations required by reduction of environmental load and deepening of the public's understanding on their own responsibility and judgement. However, those problems were yet to be solved even in the late 1990s apart from successful reduction of some toxic air pollutants.

International standards of the environment ISO14001, which aims to integrate measures against the environmental problems into management to continuously address depletion of Earth’s resources and waste disposal, was established in September 1996 and more and more manufacturers are receiving ISO14001 certification. However, they deal with their own business sites that they can control and do not fully cover the products after consumption.

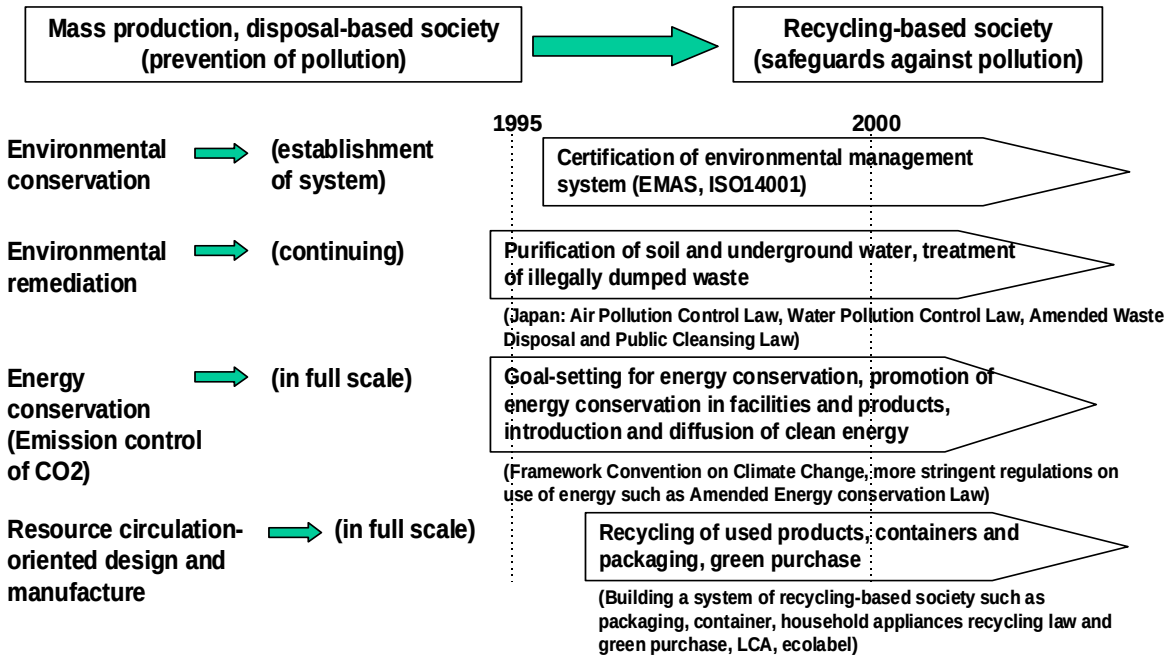


Figure 1 Trends in measures against environmental problems

In Japan, administration-led regulations including administrative guidance by vertical administration by the Ministry of Health, Labour and Welfare, and the Ministry of Economy, Trade and Industry have been prevalent even in the field of environmental problems.

Finally in 2000, a concept of recycling of 'waste' as valuable resources, rather than burning and landfilling, became widespread. Although a movement of centralization of the environmental administration to the Ministry of the Environment was seen during the restructuring of ministries and agencies, the Ministry of Economy, Trade and Industry deals with recycling-related matter as ever from the viewpoint of effective use of resources. Measures for reduction of environmental load attributed to toxic chemical-containing used-products and recycling measures are expected to be integrated.

Appendix 6. Summaries of main legal regulations in Japan

Summaries of main laws are next described focusing on promotion of recycling of used products.

1. The Recycling-based Society Promotion Law (The Basic Law for Establishing the Recycling-based Society)

This basic law was established in June 2000 as the first year of the recycling-based society. The law describes the recycling-based society as a society where the consumption of natural resources will be restrained and the environmental load will be reduced, as far as possible, by reducing wastes, etc. and ensuring recycling and appropriate disposal of resources.

Basic approaches to disposal are represented in the word of 3Rs. 3Rs means ***Reduction of generation (Reduce), Reuse of used products (Reuse) and Recycling into new products (Recycle)***. 3Rs are treated as priority matter, after which heat recovery is conducted followed by appropriate disposal. The law does not directly regulate productive activities of manufacturers and consumption activities by citizens but addresses the 'spirit' of broad manufacturers' responsibility (which burdens manufacturers with more responsibility than before on their products to become waste). However, manufacturers, consumers, and the state/local government shall have only limited roles and manufacturers do not necessarily have all the responsibilities. The government is to draw up a basic plan by October 1st, 2003 (the plan will be disclosed and reviewed every five years).

<Note> The four Rs

The four Rs

The U.S. Environmental Protection Agency (EPA) published "The Consumer's Handbook for Reducing Solid Waste" and claimed ;

> Americans live in a society where the creation and disposal of trash is an accepted part of life. Millions of tons of trash are generated each year in this country, and while most is stored and collected in landfills (which takes time, energy, and money), some is simply scattered in our city streets and countryside.
>
> With small changes in our lifestyles, we can dramatically reduce the amount of trash that is created, and we can change how we dispose of it. In the last several decades, great strides have been made in waste reduction and recycling, and there are simple things you can do at home to reduce your

contribution to solid waste production. In the process, you can make your home a cleaner and safer place to live.

EPA introduced and recommended **The four R's** to reduce solid waste.

REDUCE

1. Reduce the amount of unnecessary packaging.
2. Adopt practices that reduce waste toxicity.

REUSE

3. Consider reusable products.
4. Maintain and repair durable products.
5. Reuse bags, containers, and other items.
6. Borrow, rent, or share items used infrequently.
7. Sell or donate goods instead of throwing them out.

RECYCLE

8. Choose recyclable products and containers and recycle them.
9. Select products made from recycled materials.
10. Compost yard trimmings and some food scraps.

RESPOND

11. Educate others on source reduction and recycling practices. Make your preferences known to manufacturers, merchants, and community leaders.
12. Be creative: find new ways to reduce waste quantity and toxicity.

Among these four Rs, we put a focus on Recycle.

2. The Amended Waste Disposal Law (Amendment of the Wastes Disposal and Public Cleansing Law)

This law is a basic law regarding waste. This law was totally amended in the 'pollution-disputed session' of the Diet in 1970 to respond to the change in quantity and quality of wastes due to economic growth and improvement in life. The law had remained almost the same only with minor amendments from the viewpoint of 'how to dispose waste hygienically'. Recently, illegal dumping due to the difficulty in obtaining final disposal sites became a social problem, which led to the classification of specially controlled wastes and the introduction of the special tags for the waste ***(manifests)***. Furthermore, an amendment involving the concept of recycling was made in June 1997 and it became mandatory to attach manifests for all the industrial wastes.

In the latest amendment, emitters shall confirm the completion of final disposal by recovering the manifest from the person in charge of final disposal. Manufacturers which emit a large quantity of industrial waste shall submit a plan of reduction and

disposal of wastes to the governor and report on how the plan is being implemented. As a measure against illegal dumping, emitters were added to the list of subjects that prefectures could order to remove wastes.

However, the law was amended without a major change of the basic framework. The waste disposal law and the recycling law, which will be discussed in the next section, should be integrated into one to change to become a structure in which arteries and veins are linked by enhancing the upstream measures of material recycling.

3. The Recycling Law (the Law concerning Promotion of the Rational Use of Resources)

The Recycling Law, which was established in 1991 to promote effective use of wastes, was amended to respond to the upsizing of consumer durables and the increase in plastic-based waste.

The old law focused on recycling and obligated manufacturers to adopt structures and materials at the stage of development and design to promote effective use of regenerated resources, which enabled products to be recycled after use, and to place labels on products for sorted waste collection. In contrast, the new law is intended to promote 3Rs of wastes at each stage, such as manufacture and sales, in accordance with the spirit of ***the Basic Law for Establishing the Recycling-based Society***. When the law is enforced, the law designates automobiles, personal computers and the like as specified items and obligates manufacturers of these items to adopt designs and manufacturing methods which facilitate resource conservation and prolong the life of products, to improve repair systems, and to reuse parts recovered from used products.

With regard to the waste generated in plants, such as slug and activated sludge, the law obligates steel, paper & pulp and chemical manufacturers to reduce and recycle the waste.

	Names under old law	Names under new law	(Tentative) designated item
Use of reused parts	--	Special reuse business	Copier
Use of recycled material	Specific business	Special reuse business	*Glass bottle, *paper, sheet glass, hard vinyl chloride tube, gypsum board
Reducing-conscious design	--	Designated resource saving product	Automobile, large furniture, household electric appliances, pachinko machine, personal computer, gas/petroleum instrument
Reusing-conscious design	--	Designated reuse promoting product	Automobile, copier, personal computer, pachinko machine
Recycling-conscious design	Type 1 designated product	Designated reuse promoting product	*Automobile, *four items of household electric appliances, *nickel cadmium battery-containing product, large furniture, personal computer, pachinko machine, bath unit, built-in kitchen
Sorting-conscious design	Type 2 designated product	Designated labeling product	*PET bottle, *steel can, *aluminum can, *nickel cadmium battery, plastic- and paper-made containers and packaging, hard vinyl chloride tube

*Already designated

Figure 4 Responsibilities of manufacturers (tentative designated items: Japan)

source: July 28, 2000, Industrial Structure Deliberation Council, Waste Recycling Sectional Meeting

4. The Food Recycling Law (the Law concerning Promotion of Recycling, etc. of Food Recycled Resources)

This law was made as a system to increase the recycling rate of food waste such as cooking scrap and leftovers emitted from households, supermarkets and the food service industry such as restaurants. Current recycling rate is as low as below 1% of 16 million tons per year. The law obligates food manufacturers, food processors, food retailers and restaurants to reduce and reuse wastes. In case of non compliance with the law, offenders' name shall be disclosed and an improvement order or fines shall be issued on them. The target of the recycling rate is set at 20% in 5 years. Technologies and a basic system are required so that those engaged in agriculture, fishery and forestry, who use animal food and compost, can use recycled waste emitted every day from food-related manufacturers whenever necessary.

5. The Construction Material Recycling Law (the Law concerning Recycling, etc. of Materials for Construction)

Construction waste constitutes 40% of industrial waste, needs a lot of landfill sites, and is said to be the origin of the recent illegal dumping. Among construction waste, recycling rates for civil and construction-based waste such as concrete, asphalt, and wood are below 60% and those wastes are expected to increase as buildings constructed during the high economic growth period are completing their designated life-span. This law designates these three materials as subjects to be recycled at expense of the owner. The owners of a certain scale or more are obligated to submit sorted dismantling plans to the governor, and the contractors are obligated to state the methods of the dismantling process and dismantling costs in the contracts. Furthermore, wreckers shall be registered with the governor and shall retain technical supervisors. The prefectures are entitled to demand changes of plans and issue advice, recommendations or orders necessary for the implementation of recycling of resources and to fine offenders in case of disobedience of the orders and incomplete reporting.

6. The Package Waste Recycling Law (the Law concerning Promotion of Sorted Collection and Recycling of Containers and Packaging)

This law came fully into effect in April 2000. Containers and packaging waste, which are emitted mainly from households, constitutes 25% by weight and 60% by volume of general waste (about 50 million tons annually). This law stipulates a role sharing among the following three participants: consumers, who are obligated to dispose this kind of waste separately; the local governments, which are responsible for separate collection, transportation, sorting and storage on taxpayers' money; and businesses which manufacture or use containers and packaging, which shall pay the costs of recycling into products. This law partially came into effect in April 1997, and recycling of glass bottles and PET bottles into products started involving only large businesses. Small and middle-sized businesses are also involved from April 2000, and paper containers and packaging other than paper packs and plastic containers and packaging other than PET bottles joined the list of items to be recycled into products.

However, the incentives to retard excessive packaging and to switch to easy-to-recycle containers and packaging are not big enough for manufacturers. And the commission

paid to the designated corporations to recycle these waste is about 10 billion yen and the cost I

s expected to triple when paper and plastics other than PET bottles are on the list.

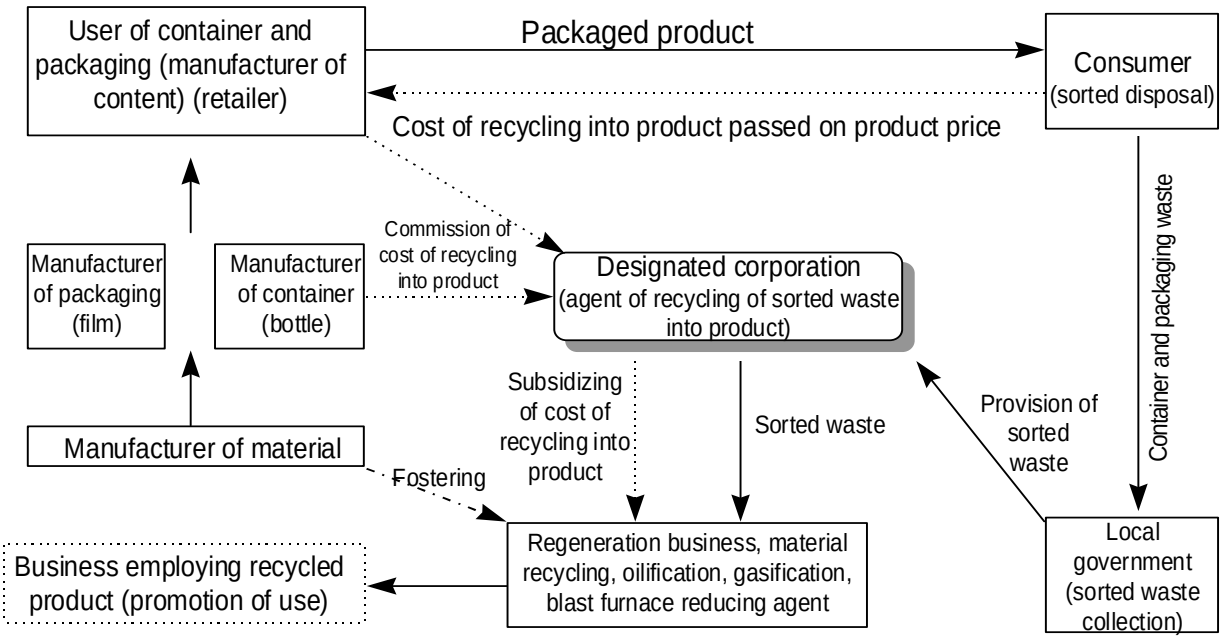


Figure 5 System of container and packaging recycling (Japan)

7. The Household Appliance Recycling Law (the Law for Household Electric Appliances Recycling)

Although dumped electric appliances are expected to amount to 600 thousand tons annually, which constitutes only about 1% of domestic waste, they are of importance in terms of recycling because of the following reasons.

1 They have a lot of recyclable parts made of copper, aluminum, etc.

2 They contain materials that damage the environment such as lead, CFCs, etc.

3 Their structures resist easy recovery and treatment.

Therefore, the law obligates manufacturers and importers to recycle used TV sets, refrigerators, washing machines and air conditioners as a first step.

Electric appliance manufacturers formed two groups: one is the group of Matsushita and Toshiba; and the other is that of Sharp, Hitachi, Mitsubishi, Sanyo and Sony. Each group is establishing a system to recover used electric appliances from consumers and

retailers and to treat them as an effective recovery route including making depots to store used products and building recycling facilities across the country.

Manufacturers are keen on designing products that are easy to separate and treat, reusing parts and examining and developing materials, but they bear a huge burden of building 13 recycling sites. Costs of recovery and recycling are not included in the price of products and will be collected from consumers at the point of disposal, as opposed to the above-mentioned case for packaging waste. The two groups recently disclosed the recycling costs for the four items such as 2,700 yen for a TV set and 4,600 yen for a refrigerator. In addition, transportation costs for retailers to carry used products from consumers to the depots of each manufacturer shall be paid by consumers. Consumers are now being questioned regarding their willingness to share costs in order to build the recycling-based society. And manufacturers and local governments should disclose the costs incurred at each phase of life cycle (resource extraction, manufacture, distribution, disposal, etc.) in some way so that consumers can answer that question. (Under the Package Waste Recycling Law, the recycling costs may be passed on to consumers, which is not actually being implemented.)

According to the government ordinance on 'recycling standards' issued in May 1999, the recycling rates for each product is as follows.

* 60% for air conditioners, 55% for TV sets, 50% for refrigerators and washing machines. (These figures are expected to increase to 80 to 90% targeted for 2008.)
* Metal, glass and CFCs used as refrigerants are recycled. Recycling of plastic will start in 10 years. Recycling of insulating material is to start soon.
* Domestic personal computers may join the four items in 2000.

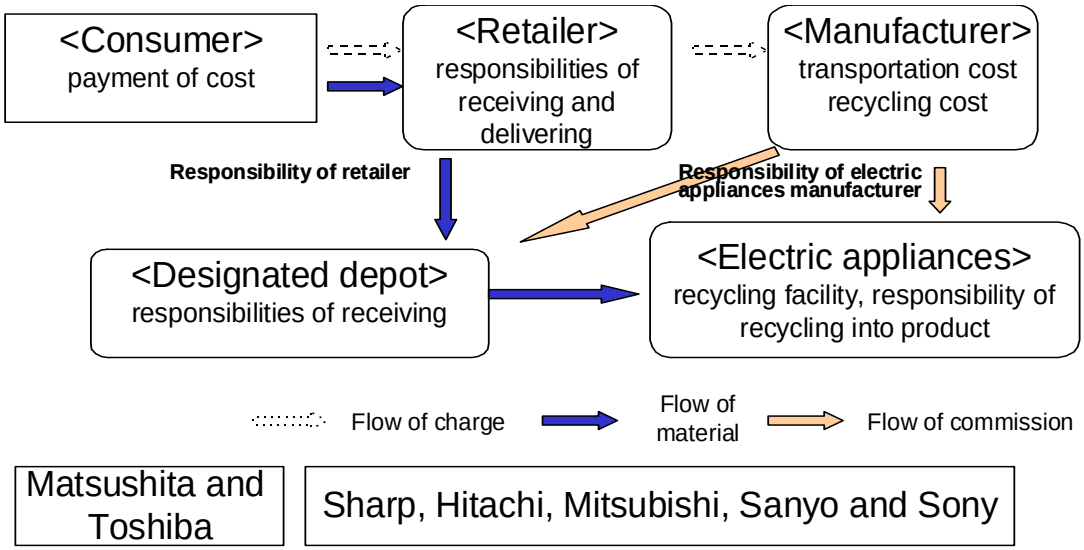


Figure 6 Flowchart of treatment in the Household Appliance Recycling Law (Japan)

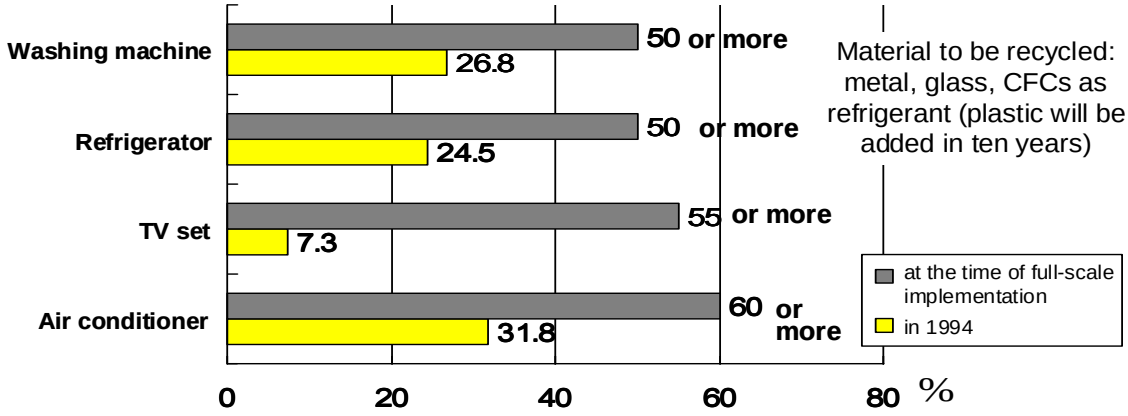


Figure 7 The targets of the recycling rates for four items (Japan)

8. The Green Purchase Law (the Law concerning Promotion of Procurement of Environmentally Conscious Goods by the State, etc.)

This law promotes demand-stimulating measures and provides a system in which the state, independent administrative bodies and local governments draw up procurement plans of environmentally conscious products in accordance with the state's basic policy. The results of procurement are disclosed. Manufacturers should watch what kind of products are to be purchased. Low pollution vehicles and recycled paper may be candidates for procurement.

Appendix 7. Examples of Typical Losses

A Under Construction

Type of insurance	Insured subject	Part damaged	Cause of loss	Claim amount in US$	Claim situation
EAR	Incineration Plant	castable refractory	Faulty design	$1,600,000	During performance testing, castable refractory of circulating section of the furnace was damaged due to vibration and thermal expansion by faulty design. The faulty design brought irregular circulation of sand in the furnace. Eventually, the sand encroached
EAR	Energy from Waste Facility	Whole plant which was under construction	Failure of trace heating elements	$760,000	Claim has now been settled off
EAR	Clinical Waste Incinerator	Fire Damage to the incinerator after it had been handed over	Failure of Defective water pumps within the cooling system	$625,000	Claim repudiated. A large proportion of the claim is in respect of Increased Cost of Working and Loss of Profit. Neither of which are covered by our policy. Along with the claim for defective parts and the building itself. The works were taken into use at the time of the loss. The claim is outstanding at a fairly small figure.
EAR	Incineration plant including gasification melting furnace	dust hopper & conveyer	Faulty design	$90,000	During the defects liability period, nitrogen gas was injected into the dust removal system to prevent the unusual combustion in the dust hopper. However, since the dust hopper was badly choked, the dust hopper and conveyer were transformed due to the high pressure produced by the nitrogen gas injection.

Type of insurance	Insured subject	Part damaged	Cause of loss	Claim amount in US$	Claim situation
EAR	Flue gas desulfurization plant of waste	Flue gas desulfurization plant of waste incineration	fire	$4,800,000	Fire during construction. Heavy damage to tanks and steel structure.

	incineration plant	plant			
EAR	Flue gas desulfurization plant of conventional power plant	Flue gas desulfurization plant of conventional power plant	corrosion as a result of an operating error	$3,350,000	The electrostatic precipitator and clean gas ducts were severely damaged by corrosion when SO_2 passed through the desulfurization plant of the power station. Damage occurred during hot test.
EAR	Flue gas desulfurization plant of conventional power plant	Flue gas desulfurization plant of conventional power plant	fire as a result of carelessness /negligence	$3,260,000	Damage to the desulfurization plant during construction caused by welding works resulting in a major fire.
EAR	Flue gas desulfurization plant of conventional power plant	Flue gas desulfurization plant of conventional power plant	wear and tear, fatigue, aging of material	$2,450,000	Spalling of tool pieces of the lime stone grinding mill. These pieces damaged the corrosion protection followed by extensive corrosion of the flue gas channels (washers are of INOX). 4 FGD blocks were damaged. Damage occurred during testing.
EAR	Hazardous waste treatment plant with power generation	Contamination of ground and base-water	faulty design of some pipe fitting and insufficient security basin belowplant	$1,200,000	Enhanced amounts of hazardous chemicals were found in the base-water in the vicinity of the plant. Rigorous pumping like 60.000 cubic meters per day has been performed to recapture the chemicals(mostly organic solvents) as much as possible from the base-water.

Type of insurance	**Insured subject**	**Part damaged**	**Cause of loss**	**Claim amount in US$**	**Claim situation**

EAR	Incineration Plant	furnace	foreign material	$3,758,000	During the test run of a sludge combustion system, an explosion occurred, and damaged the flow air pre-heater, flow air cooling unit and flow blower. It is suspected that combustible gas might have been produced, and such gas caught fire in the combustion furnace or that other combustible gas moved around in the pipe duct, and caught fire.
EAR	Incineration Plant	furnace & cashable brick	faulty design	$13,000	Sand entering through the seams of the bricks due to pressure difference occurred in the incineration flow unit and damaged the castables or heat-insulating board in the back of the bricks, eventually causing the brick walls to collapse. The cracks occurred at the seams due to thermal expansion and vibration, which caused a gas flow under pressure difference in defective designing. The resultant sand flow caused corrosion, and developed voids.
EAR	Incineration Plant	b r icks	foreign material	$625,000	During the test run, an abnormal combustion occurred and damaged the bricks in the furnace. Possible cause is a huge amount of iron oxide dust produced in the long energizing time in melting scraps in an oxidizing atmosphere, which caused an abnormal combustion in the furnace.
CAR	International Airport Development	Earth Noise Bund	Water ingress to earthworks	$450,000	During construction period heavy rainfall penetrated the earthworks requiring the removal of contaminated earth before work could re-commence. The bund also moved forward 3m .Established that there was defective design of the bund face.
CAR	Sewerage Storm Outfall	Pipeline	Extraneous Damage	$375,000	Pipe segments damaged during installation. Thought to be caused by blasting operations in adjacent area.
CAR	Sewerage Tunneling Works	Tunnel	Collapse	$54,000,000	Whilst project was under construction, section of tunnel collapsed. Primary causation factors are believed to be wind blown sand, under high water pressure, in contact with the tunnel and a leak permitting sand ingress.

B. In Operation

Type of insurance	Insured subject	Part damaged	Cause of loss	Claim amount in US$	Claim situation
MB	Refuse gasified fusion furnace	electric precipitator	malfunction	$4,790,000	In operation of the fusion furnace, explosion occurred on the electric precipitator. This explosion damaged to the electric precipitator and surrounding parts. The cause is that malfunction of pilot burner created unburned CO and the gas flew into the ele
MB	Crushing Plant	bearing and bearing house	foreign material	$210,000	Because a foreign material mixed into crusher in operation, bearing and bearing house were damaged.
MB	Industrial waste crushing plant (Crushing and sorting bulky industrial wastes)	N/A	N/A	$50,000	Cracks were produced to the crusher and conveyer linked to the crusher by some extremely hard piece beyond the capacity of the crusher. Such material should have been removed before wastes were sent to the crusher. However, the staff could not discover the material mingled in the wastes.
MB	Incineration Plant	furnace	faulty operation	$3,991,000	When dust and other particles were being removed from the high-temperature gas generated after burning common waste materials in the melting furnace, an explosion occurred and damaged the surrounding units. The pilot burner for combusting the CO gas produced from refuse combustion furnace mis-fired and could not ignite the CO gas for combustion. At that time, unburned gas flowed into the electric dust collector, and ignited by an element spark, which led to an explosion.

Type of insurance	Insured subject	Part damaged	Cause of loss	Claim amount in US$	Claim situation
MB	Crushing Plant	rotor shaft & conveyer	foreign material	$592,000	An explosion occurred in the brusher, and its blast broke the blast sheet on top of the crusher, thus activating the limit switch to stop the whole system. The rotor shaft was displaced, and the conveyor and monitoring camera were damaged or deformed.
MB	Incineration Plant	dust collector	foreign material	$308,000	A steam explosion occurred at the bottom of an electric dust collector. A large amount of ash containing water, which must have dropped from the gas cooling chamber provided on top of the combustion furnace, was evaporated rapidly in the combustion furnace. Such steam is suspected to have raised the pressure in the furnace.
MB	Crushing Plant	roller	foreign material	$175,000	In the work of crushing, hard substances were entrapped and displaced the crusher roller shaft and damaged the bearing and the bearing housing case.
MB	waste material processing plant	dust collector	poor maintenance	$125,000	At a waste material processing plant, an operator was loading the target substances into the furnace. At midnight, the underwater pump for supplying cooling water failed, and thus the cooling water supplied to the facilities and the units in them was stopped. Therefore, high-temp exhaust gas came into the dust collector, and burned the bag filters. Such heat then burned the member materials of the gas rapid-cooling unit, thus causing burnout, damages and cracks.
MB & BI	Incineration Plant	Ceramic Filtration Candles	Faulty Design	MB $110,000 and BI $540,000	During operation the ceramic filtration "candles" fractured causing the filtration process to operate unsatisfactorily with the result that emitted particulates were in excess of the maximum size under the Environmental Agency limits. The plant was shut down.
MD	Contractors Plant on Landfill Site	Waste Compactor	Fire	$160,000	Compacted waste material accumulated and ignited in the transmission area of the vehicle whilst the vehicle was working on site. Vehicle was burnt out.
MD/ICOW	Waste Incineration Plant	Watertube Boiler	Overheating due to loss of water	$656,639	Boiler failed due to loss of water. MD costs in replacing approx 1/3 of boiler tubes. ICOW incurred in sourcing other means of disposing of Waste. Boiler operator failed to see low water condition and alarms failed to operate correctly.

Examples of losses can be summarized as follows:

1. Construction and Test Run (Construction Insurance)
   - Accidental explosion caused by combustible gases produced from burned substances
   - Furnace walls damaged by the defective cooling and defective gas flow control in the gasification melting furnace and ash melting furnace
   - Corrosion caused by acid produced from the acid and exhaust gas

2. Operation (Machinery Insurance)
   - Accidental explosion caused by combustible gases produced from burned substances
   - Furnace walls damaged by loading a large amount of any target substance of extremely high calorie.
   - Furnace walls damaged by an abnormally high temperature caused by failed temperature sensor
   - Damages caused by reckless operation by the operator
   - Crusher damaged by trapped foreign matters