2007

Technologies to Support a Sound Material-cycle Society

—Development of 3R and Waste Management Technologies—

reduce
reuse
recycle

Ministry of the Environment
Government of Japan

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TECHNOLOGIES TO SUPPORT A SOUND MATERIAL-CYCLE SOCIETY

—*DEVELOPMENT OF 3R AND WASTE MANAGEMENT TECHNOLOGIES*—

Executive Summary

Waste is inevitably produced in the course of human activity. Once produced, this waste needs to be treated and disposed of hygienically and quickly, with all due consideration for the protection of our environment. All countries produce waste, and as such, a country's efforts to tackle its waste problems provide a yardstick for that country's efforts on environmental problems.

In Japan, efforts to solve waste problems fell behind in the process of high-level economic growth after the war. This led to the widespread practice of illegal dumping and the accumulation of toxic substances. A shortage of final disposal sites for waste became a serious problem, meanwhile, owing to the limited availability of land in Japan. Through these experiences, Japan has pushed through major reforms in the field of waste and recycling policies over the past ten to twenty years. And today, we are striving to create a sound material-cycle society ("SMS"), in which the consumption of natural resources will be reduced and the burden on the environment mitigated through our use of the so-called 3R activities (Reduce, Reuse, and Recycle waste).

Japan's attempts to create a SMS involve continuous efforts not only by the central government but also by local authorities, businesses, the general public, and all other sectors of our society. The platform for these efforts is provided by technologies related to waste management and 3R. As our socio-economic activities have expanded and people's lives have become more affluent, the generation of waste has also increased and the types of waste have proliferated. Technologies to combat waste have also evolved in response to these changes, and some excellent technologies have been introduced following reforms in the field of waste and recycling policies. Japan, a country with meager natural resources, has also amassed abundant experience of effectively using resources through the application of recycling technology.

Today, the problem of waste is one that not only affects Japan but is shared across the globe. Some developing countries are finding it different to cope with the increased generation of waste resulting from rapid economic growth. Meanwhile, recyclable resources such as scrap metal and waste paper are circulating not only inside Japan but also across our borders. And beyond this, the sustainable use of natural resources is now an issue of global proportions.

Given the present situation as described above, this year's White Paper will focus on the technologies that support the creation of a SMS in Japan. It will also evaluate development of 3R and waste management technologies as well as the roles of technology, and examine the outlook for future progress. By focusing on these technologies, the following two effects are expected to arise. Firstly, our understanding of 3R and waste management will be improved. Waste is produced in our everyday lives, and we all cause waste problems at the same time as suffering their consequences. As such, it is important to know how items that we discard are reused or recycled, and how they are correctly managed as waste. Various technologies are involved in this process. Understanding the processes of 3R and waste management through these technologies will awaken our self-awareness as producers of waste, and this will serve to promote 3R initiatives. Secondly, our understanding of these technologies will serve to encourage the people engaged in developing and introducing them. Technologies lying at the foundation of 3R and waste management have been developed and introduced as the fruit of hard labor, as well as trial and error, by many technicians, experts and researchers. As such, understanding these technologies will also help us to understand the efforts of these people, and could stimulate them to tackle the development of even more advanced technology in future.

As the composition for this document, the need for global promotion of 3R and expectations of Japan's technology will first be explained, followed by an examination of the basic technologies that support Japan's SMS, divided into their respective purposes. Finally, the policies that have promoted the development and introduction of these technologies will be summarized, and the future outlook for 3R and waste management technologies will be examined.

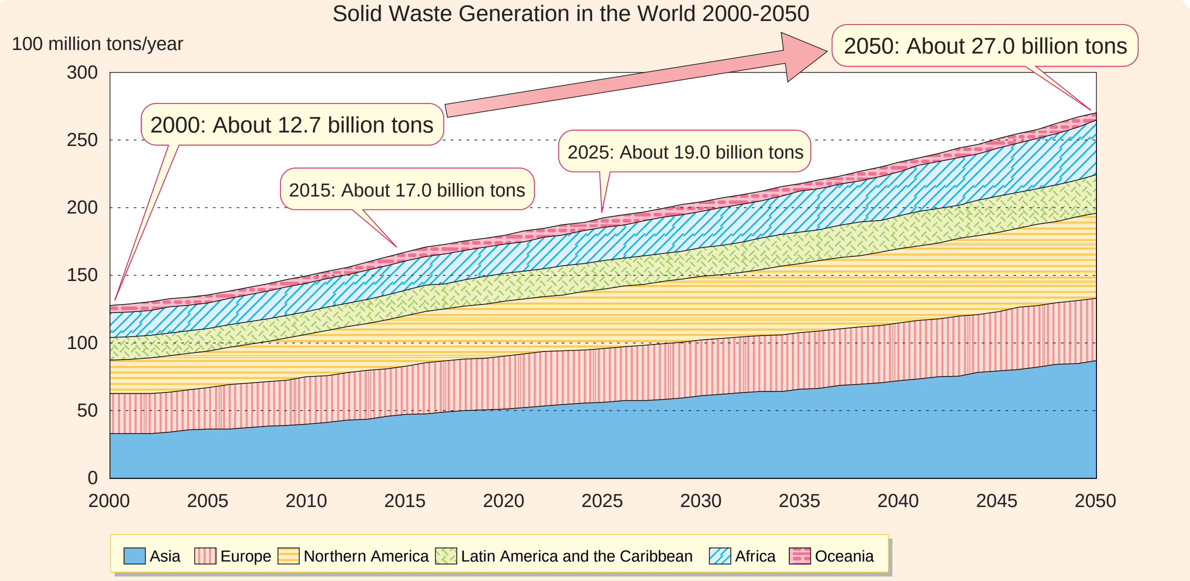
SECTION 1
THE NEED FOR GLOBAL PROMOTION OF THE 3RS AND THE ROLE OF JAPAN'S TECHNOLOGIES

1 The global problem of waste and the situation in Asia

Global growth in economies and populations, particularly in Asia, has been accompanied by an increase in the amount of waste produced worldwide. The nature of that waste is also proliferating into areas such as medical waste and discarded electrical and electronic products ("E-waste"). Moreover, prices of resources and energy have become inflated by expanding demand, a trend that has even extended to metal scrap, waste paper and other recyclable resources.

At a Ministerial Conference on the 3R Initiative held in Japan in April 2005, the participating countries stressed, as a common global task, that we are all confronted by an increasing generation of waste and non-sustainable waste management. According to future forecasts of global waste generation carried out by Okayama University, the world's total volume of waste was about 12.7 billion tons in 2000, but this is predicted to rise to about 19.0 billion tons in 2025 and to about 27.0 billion tons in 2050 (Fig. 1-1). The predicted increase in the Asian region is particularly significant.

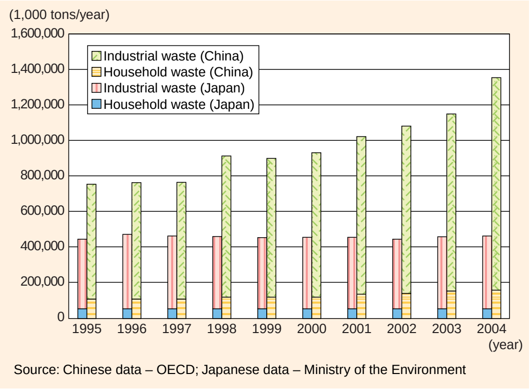
Fig. 1-1 Future predictions of global waste generation levels



Source: Paper by professor Tanaka of Okayama University

In China, where economic growth is notably conspicuous, the amount of all waste produced rose to 180% over the nine years from 1995 to 2004 (Fig. 1-2). To address this situation in China, the OECD, in a review of environmental policies carried out in 2006, recommended that the Chinese government strengthen its efforts aimed at a recycling economy while at the same time promoting the development of waste management facilities, the construction of waste collection, reuse and recycling systems, and so on.

Fig. 1-2 Waste generation in China



Meanwhile, there have recently been some tragic accidents related to waste management. The Leuwigajah final disposal site in Indonesia, which used to receive waste from Bandung City and surrounding areas, was a landfill site created by damming a river valley. In February 2005, a major disaster occurred when the dam collapsed after three days of torrential rain. As a result, about 860,000 tons of waste flowed out over a length of one kilometer and a width of 200-250 meters, killing 147 people. To make matters worse, left without an outlet for waste management, people started to dump their waste at random in the streets.

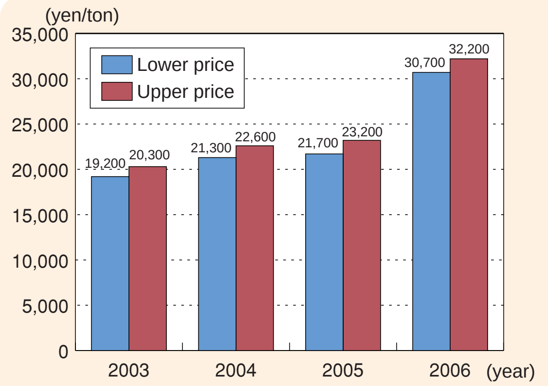
In recent years, meanwhile, the volume of discarded television sets, personal computers, refrigerators and other electrical and electronic products has also increased, and exports or imports of these for recycling or disposal have risen sharply. These discarded electrical and electronic products sometimes include lead and other harmful substances. In some reported cases, these are being recycled under environmentally inappropriate practices in developing countries.

2 The squeeze on resources and energy

Thriving demand for resources in China and elsewhere is reflected in inflated prices for natural resources. This, in turn, has had the effect of inflating prices for metal scrap, waste paper and other recyclable resources, and cross-border movements of these have become prominent recently. According to a survey by the Japan Iron and Steel Recycling Institute, the price of scrap iron in Japan was 20,000 yen per ton in December 2003 but had swollen beyond 30,000 yen in December 2006 (Fig. 1-3). Similarly, the Paper Recycling Promotion Center reports that waste paper prices have also been in a rising trend in recent years. The price of Corrugated cardboard, for example, was 6 yen per kilogram in 2002 but rose to about 10 yen in 2006.

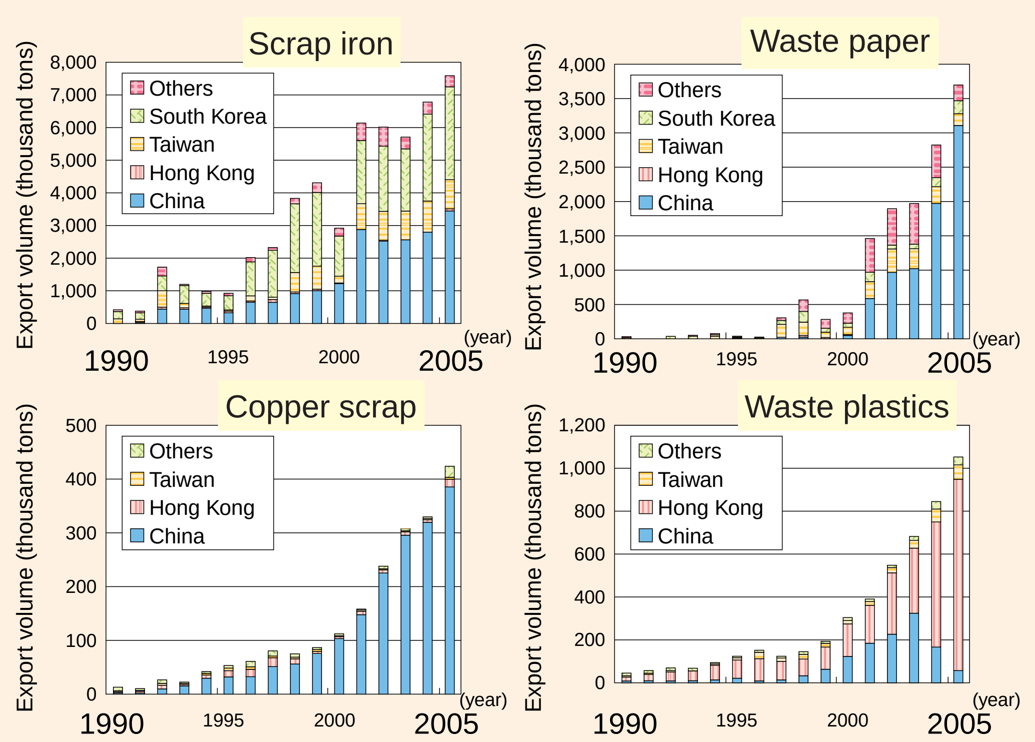
In Japan, exports of recyclable resources to China and other Asian countries are in a growing trend. Trade in recyclable resources that circulate for commercial gain (such as waste plastics) is now handled in the same way as other materials and products. With increased demand for resources associated with economic growth in China and other East Asian countries, the volume of exports to these countries in recent years has increased sharply (Fig. 1-4). For example, exports of iron and steel scrap from Japan to China were about 330,000 tons in 1995 but about 3.46 million tons in 2005, showing that in those 10 years the volume had increased more than ten-fold. In other words, movements of recyclable resources no longer terminate within our own country but have spread internationally.

Fig. 1-3 Trends in scrap iron prices



Note: Prices for scrap iron (steel scrap) are based on pre-H2 furnace cash prices in December each year.
Source: Japan Iron and Steel Recycling Institute

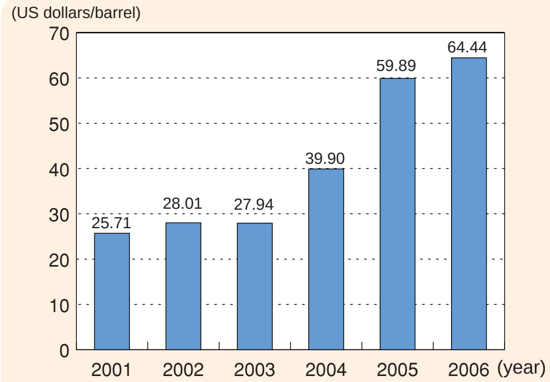
Fig. 1-4 Exports of recyclable resources



Source: Ministry of Finance Trade Statistics

Energy demand has similarly grown. With this, energy prices have also become inflated. Crude oil, for example, was traded at about 25 US dollars per barrel in 2001, but by 2006 this had risen 2.5 times to about 64 dollars per barrel (Fig. 1-5).

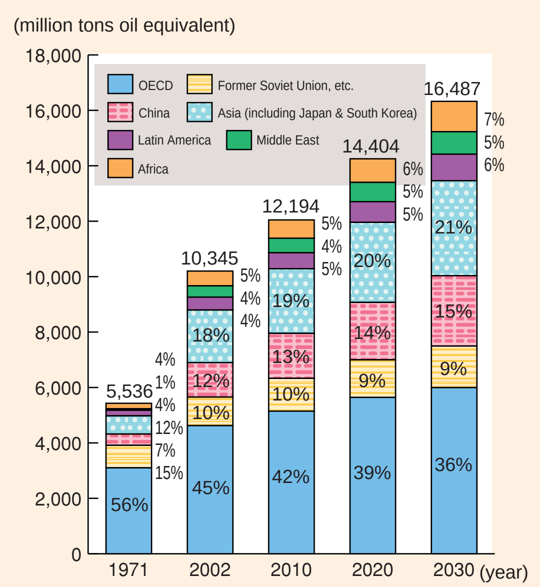
Fig. 1-5 Trends of imported crude oil CIF prices



Source: Ministry of Finance "Japan Trade Monthly Tables"

According to the International Energy Agency (IEA), the world's primary energy demand is expected to increase by about 50% in the period from 2003 to 2030 unless there is a major change in current policies on energy and the environment (Fig. 1-6). In particular, the proportion taken up by China and other Asian countries in 2030 is calculated to swell to 30% of the global total.

Fig. 1-6 Global prospects for primary energy demand



Source: IEA "World Energy Outlook 2004"

Meanwhile, vast quantities of carbon dioxide are being artificially released into the atmosphere owing to our habit of burning fossil fuels, etc., and fears have arisen that the planet is now overheating. With the advance of global warming, there are concerns that the human living environment and wildlife habitats could suffer grave consequences on a widespread scale. Cutting carbon dioxide and other greenhouse gas emissions is therefore a task of global importance in connection with our promotion of 3R.

3 The 3R initiative and the role of Japanese technologies

This aggravation of global waste problems and squeeze on resources and energy underline the importance of creating an international SMS. The Fundamental Law for Establishing a Sound Material-Cycle Society defines a “sound material-cycle society” as a society that is realized by reducing the generation of waste from products, suitably utilizing waste as resources whenever possible and appropriately disposing of waste that cannot be used in any way, thereby controlling the consumption of natural resources and reducing the environmental load. The international SMS may be seen as an extension of this definition into the global arena. The 2006 version of the SMS White Paper defines the basic concept behind establishing an international SMS in three terms, namely 1) to establish a domestic SMS in each country, 2) to enhance and reinforce activities to prevent illegal imports and exports of waste, and having achieved these, 3) to facilitate imports and exports of recyclable resources.

Japan has played a leading global role in establishing an international SMS by promoting “the 3R Initiative”. At the G8 Sea Island (USA) Summit in 2004, the former Japanese Prime Minister Junichiro Koizumi proposed “the 3R Initiative” to promote 3R efforts internationally, as a way of encouraging more efficient use of resources and substances. This proposal was accepted by all of the G8 leaders.

As a result, a Ministerial Conference on the 3R Initiative was held in Tokyo in April 2005, and promoting technologies suited to 3R was adopted as one of the themes for discussion. At the Conference, the participants agreed that technology had an extremely important role to play in achieving sustainable patterns of production and consumption. They also agreed that technology related to 3R would promote not only environmental protection but also the creation of new values and increased efficiency in industry, thus harnessing latent demand in society. The Conference also identified sectors in which research and technological innovation are required, including reproduction, waste reduction, recycling, recovery and other clean technologies, as well as eco-design to enhance resource efficiency and mitigate environmental burdens.

At the Ministerial Conference on the 3R Initiative, Japan announced its “Action Plan for a World-Wide Sound Material-Cycle Society through the 3R Initiative” (Action Plan to Promote Global Zero-Waste Societies). The Action Plan identifies activities for Japan, such as enhancing the knowledge base and technology base to realize zero-waste societies in Asia, as international cooperation for realizing world-wide zero-waste societies. It also states that an “East Asia Sound Material-Cycle Society Vision” will be formulated by 2012 as one example of this international cooperation.

Scenes from the Asia 3R promotion conference

In a follow-up to the Ministerial Conference on the 3R Initiative, a Senior Official-Level Meeting for the 3R Initiative was held in Tokyo in March 2006, when discussions were held on the development and transfer of technologies related to 3R. Among others, it was pointed out that, since development levels and socio-economic conditions differ depending on the country or community, economic aspects of 3R-related technology are also important.

Besides this, an “Asia 3R Promotion Conference” was held in Tokyo in October 2006, with the participation of 19 Asian countries and 8 international agencies. 3R was comprehensively promoted at the Conference, while various specific initiatives – such as 3R on household waste, 3R on electrical and electronic waste (E-waste), and medical waste – were introduced by the various countries, international agencies, networks of international NGOs, companies and others, resulting in a lively discussion. The participants not only shared awareness of the importance of promoting 3R in Asia, but also praised this Conference as the first opportunity for policy-makers from Asian countries and international agencies to discuss 3R. It was also confirmed, among other matters, that technology will be an important element in promoting 3R. Moreover, the required technologies do not necessarily have to be the latest versions, but should be socially acceptable ones that are environmentally appropriate and economically viable.

In this way, Japan has played a leading role in establishing an international SMS through the 3R Initiative, which has been highly praised by various countries and international agencies. In 2008, Japan will assume the presidency of the G8 group of nations. As such, Japan aims to display international leadership and promote the 3R Initiative in the runup to the G8 Summit. In this display of leadership, technology is expected to make a contribution to promoting 3R in specific terms. In particular, Japan has some superior technologies in the fields of 3R and waste management. The next section will examine some leading examples of these technologies.

SECTION 2
TECHNOLOGIES FOR A SOUND MATERIAL-CYCLE SOCIETY

SECTION 2

Japanese society, which aims to be a sound material-cycle society (SMS), is supported by various technologies. Our social and economic situation, as well as our activities, have changed remarkably over time and the amount and kind of consumed natural resources, products and service activities have changed accordingly. As a result, the quantity and quality of waste generated have also changed. In response to such change, various technologies for product manufacturing and waste management processes have been developed to sanitarily dispose of waste, remove hazardous substances and save resources and energy (Fig. 2-1).

Fig. 2-1 Progress of waste management and 3R

Reinforcement of laws and policies	Change of organization	Technological development
1954 The Public Cleansing Law		
1967 The Basic Law for Environmental Pollution Control		
1970 The Waste Management Law (Introduced the responsibility of waste-generating business)	1971 Environment Agency established	Improvement of hygiene
1976 Revision of the Waste Management Law (Clarified enterprise's responsibility for industrial waste disposal)		Measures against hazardous substances
1991 Revision of the Waste Management Law (Reduction of waste generation and recycling of waste) The Law to Promote Recycled Resource Use		
1995 The Law for the Recycling of Containers and Packages		Recycling
1997 Revision of the Waste Management Law (Measures against illegal dumping, etc.)		
1998 The Home Appliances Recycling Law		
2000 The Law for the Recycling of Construction Material The Fundamental Law for Establishing a Sound Material-cycle Society The Law for the Promotion of Effective Utilities of Resources The Food Waste Recycling Law		Reduce, reuse
2001 PCB Special Measures Law	2001 Ministry of the Environment established (Responsibility for the control of waste transferred to the Ministry of the Environment)	
2002 The End-of-life Vehicle Recycling Law		
2003 Fundamental Plan for Establishing a Sound Material-cycle Society		

Source: Ministry of the Environment

This section outlines various technologies that support the SMS of Japan, for example the following: waste-related technology for improving public health; hazardous substance countermeasure technology for reducing influences on human health and the ecosystem; 3R-related technology for enabling the 3Rs (reduce, reuse and recycle) of waste; and resource recycling technology that focuses on major metals. While some of these technologies were introduced from other advanced countries and used until now, there are also many technologies that have been developed by Japan. These original Japan technologies have the possibility of contributing significantly to the appropriate management of waste and the promotion of 3R activities, especially in Asian regions.

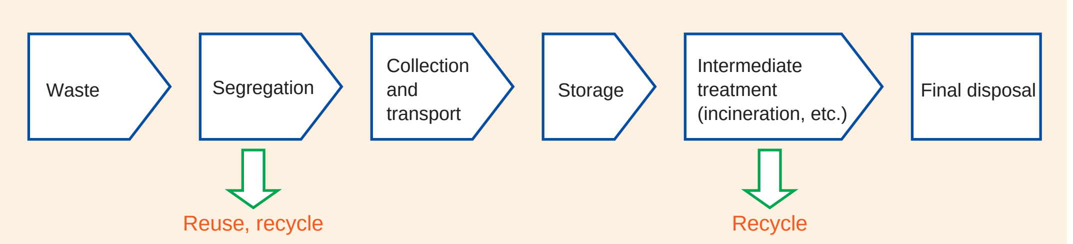
For example, Japan has been promoting incineration, considering its hot humid climate in summer, in order to sanitarily and rapidly dispose of waste. Japan's technology and experience can be shared with Asian countries that also have hot, humid climates.

1 Improvement in hygiene

The main purpose of waste management is to maintain a sanitary and comfortable living environment. The Public Cleansing Law was enacted in 1954 for the purpose of "improving public health by sanitarily disposing of waste and cleaning the living environment." The sanitary disposal of waste has contributed to the improvement in hygiene in Japan. For example, sanitary disposal of waste prevents vast numbers of mosquitoes and flies from breeding and is thought to be one factor that has enabled the Japanese to acquire a taste for raw food in their diet.

With the growth of the Japanese economy and resultant industrial development, waste generation became an issue, such as areas of polluted water due to illegally dumped waste oil. So, the Public Cleansing Law was amended in 1970 to become the Waste Management and Public Cleansing Law (hereinafter called "the Waste Management Law"). The present waste management law is enacted for the purpose of "preserving the living environment and improving public health through the restriction of waste discharge, appropriate sorting, storage, collection, transport, recycling, disposal, or the like of waste and conservation of a clean living environment" (Article 1). The term "appropriate sorting, storage, collection, transport, recycling, disposal" clarifies how to appropriately dispose of waste (Fig. 2-2). It not only means that waste should be sanitarily disposed of, but also that waste should be disposed of so as not to become a significant environmental burden. At each stage of waste management, various technologies are employed to play an active role in improving hygiene and protecting the environment.

Fig. 2-2 Waste management flow



Source: Ministry of the Environment

(1) Technologies for night soil disposal

The disposal of night soil, or excretory substances, is the origin of waste management. From ancient times in Japan, agriculture developed around rice farming and a sanitary recycling system used to exist whereby night soil generated in urban areas was used as fertilizer in suburban villages. However, due to urbanization, which began in the mid-1950s, the population balance between urban areas and suburban villages was lost. In addition, due to the spread of chemical fertilizers and increased demand for flush toilets, the development of night soil disposal facilities and the reinforcement of sewage systems in urban areas progressed rapidly.

Due to limited finances and time, however, the reinforcement of the sewage system could not keep pace with ever-expanding demand. So, a single type private sewage treatment system (which treats only night soil) became widespread after the mid-1960s.

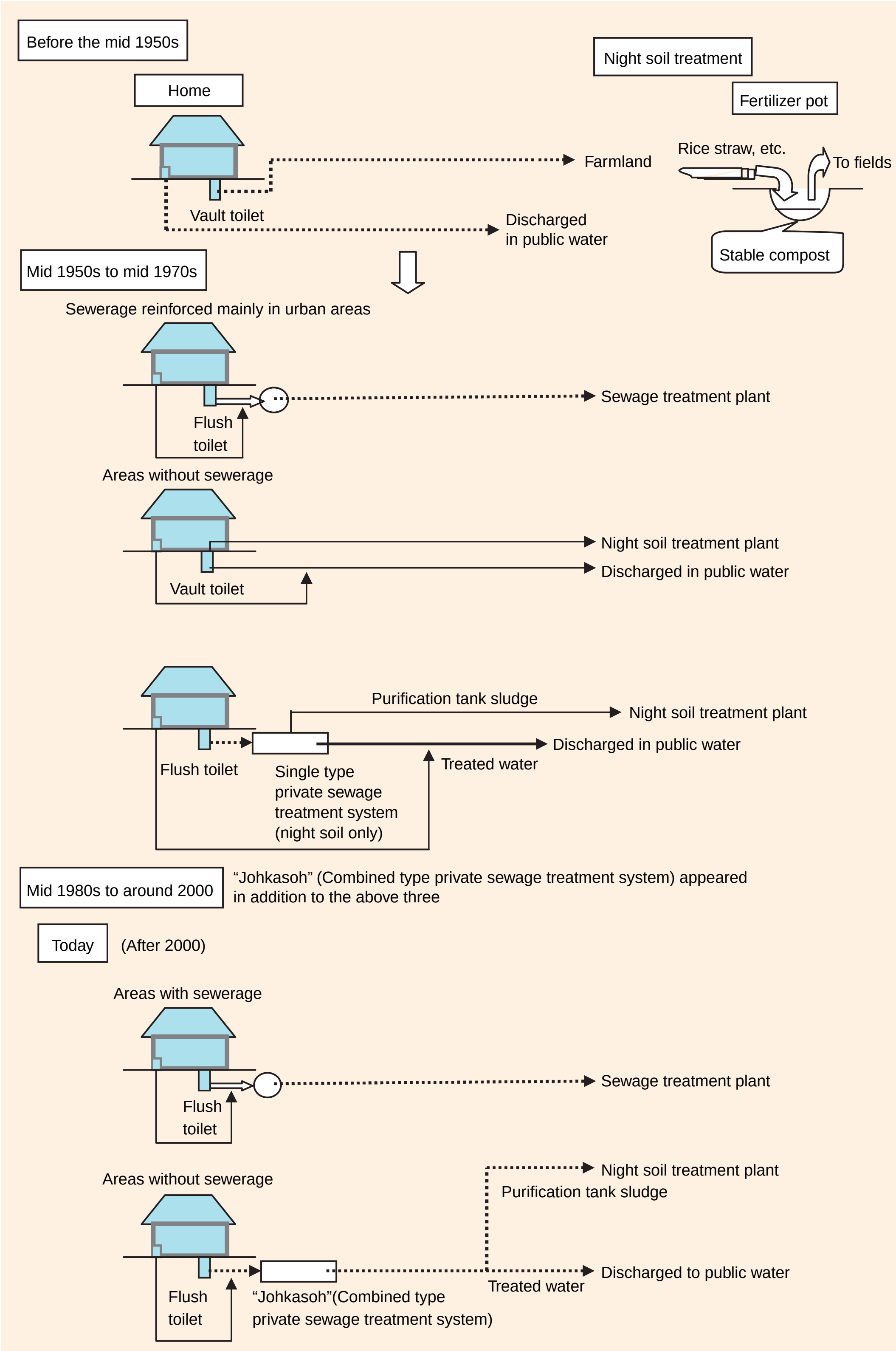
In 1983 the Purification Tank Law, which regulates each stage of purification tank processing, from manufacture through installation to management and maintenance, was enacted to control purification tanks. After that, a pressing need arose for reinforcing measures to be taken against one of the major causes of water pollution: domestic wastewater, and single type private sewage treatment systems, which were predominantly purification tanks. Therefore, the Purification Tank Law was revised in 2000, limiting purification tanks to combined-type private sewage treatment systems (which treat both night soil and miscellaneous drainage) and basically prohibits the installation of new single type private sewage treatment systems (Fig. 2-3).

As at the end of 2005, there were 10.93 million purification tanks (combined-type private sewage treatment systems): an increase of 310,000 (2.9% up compared to the situation at the end of 2004). The percentage of the population (diffusion rate) with purification tanks is 8.6%: an increase of 0.2% compared to the end of 2004 (8.4%).

While the sewerage wastewater treatment system was imported from Europe, purification tanks are a domestic wastewater treatment system peculiar to Japan, which was developed in consequence of the country's long history of night soil disposal. Purification tanks treat wastewater on site, using technology that converts organic pollutants contained in wastewater into purification tank sludge, which is composed mainly of microorganisms, while mineralizing the pollutant and separating sludge from the treated water. Purification tanks (combined-type private sewage treatment systems) have the advantages that they can treat wastewater in almost the same manner as other wastewater treatment facilities, that a system for an ordinary family can be installed in a space equivalent to that of one passenger car and that these can be employed efficiently in less heavily populated areas. So, these systems play an important role in Japan, especially as a pillar of domestic wastewater and public sewerage treatment. Besides, because purification tanks treat domestic wastewater on site, there is no great change in the flow of the water channel, etc. after a tank has been installed. Thus, these tanks contribute to constructing a water cycle that is environmentally sound.

Night soil collected from houses without flush toilets and sludge collected periodically from purification tanks are sanitarily treated in night soil treatment facilities, etc. The night soil treatment facility effectively removes not only organic substances but also nitrogen and phosphorus, which cause eutrophication, pathogenic microorganisms, etc. in an enclosed sea. Some recently developed night soil treatment facilities are equipped with facilities for recycling sludge, etc.

Fig. 2-3 History of night soil treatment



Source: Ministry of the Environment

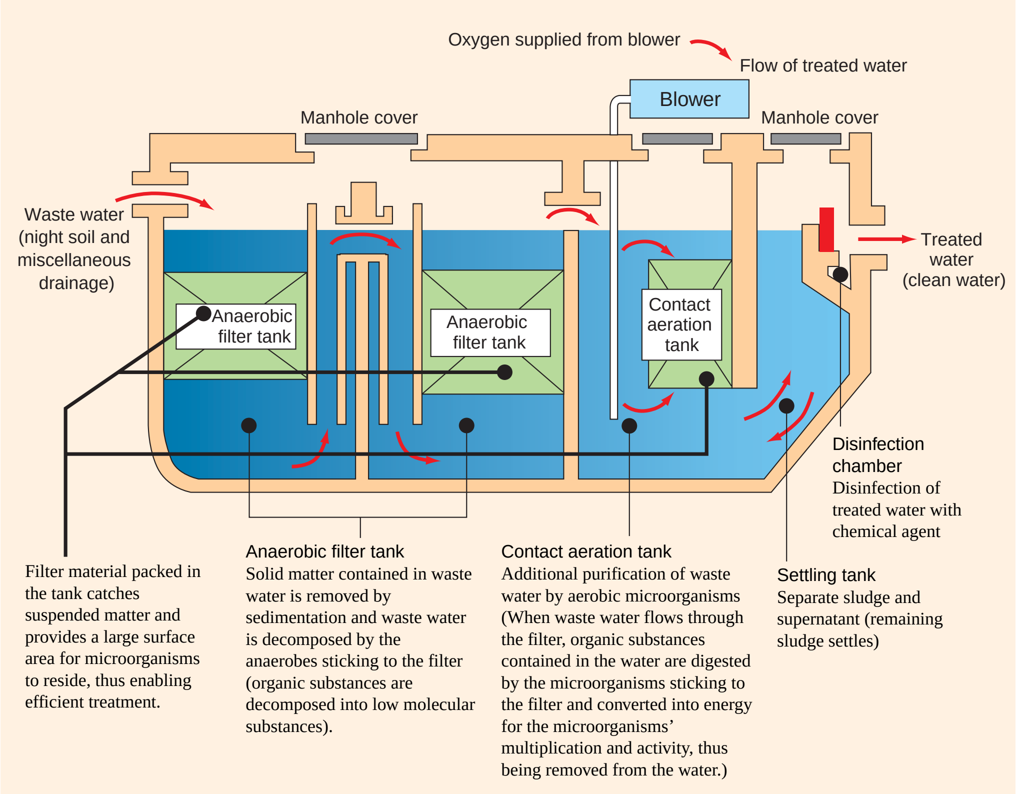
Mechanical waste collection vehicle (packer car)
Source: HP of the Resource & Waste Recycling Bureau, Yokohama City

Column

Treatment of domestic wastewater by Japanese - made "Johkasoh"

"Johkasoh" is "a Porification tank for treating night soil and miscellaneous domestic wastewater to discharge treated water in a channel other than public sewerage" (Clause 1, Article 2 of the Law for Combined Household Wastewater Treatment Facility). It is almost the same in mechanism as a sewage treatment plant, and is a wastewater treatment facility installed in individual houses. The "Johkasoh" has the advantages that treated water can be used for watering, etc., on the site, that sludge can easily be reused because of the little content of heavy metals, and that there is a double purification effect because treated water is naturally purified before flowing into a water body, such as a river.

Cross-section of purification tank (anaerobic filter contact aeration type)



Source: Japan Education Center of Environmental Sanitation

(2) Collection and transportation technologies

The collection of waste is important for keeping the living space of each house clean, thereby protecting the living environment. In each house, factory or business establishment, waste generated through biological means or mechanical operation is segregated into flammable and inflammable garbage, or according to different types of industrial waste. Thereafter, segregated waste is collected by the local authority or transported by the waste generator for appropriate treatment. Alternatively, its collection and transportation is consigned to a company that is qualified to collect and transport waste. These technologies are used for the efficient collection and transportation of waste without allowing it to become dispersed.

In Japan, in order to ensure safe and sanitary work and to collect waste quickly and efficiently, mechanical waste collection vehicles (packer cars) are predominantly used to collect domestic waste. The packer car is so structured as to press charged waste into a storage compartment, which is constructed in the vehicle, under mechanical force. For transportation of bulky waste or for transportation to a transfer facility, various types of vehicles, such as tippers and trucks with cranes, are used.

Collected domestic waste is transported directly to an intermediate treatment facility, such as an incineration plant, or transported to a transfer facility and transferred to a larger vehicle when the distance to a treatment facility is great. Besides collecting and transporting waste with a vehicle, there is also pipeline waste transportation technology that transports waste through a pipeline with compressed air, but this is not widely used today because of difficulties with waste segregation.

In developing countries, because of narrow roads that cannot accommodate waste collection vehicles and because the cost of labor is comparatively low, waste is manually collected by humans in many areas.

Column

Donating used equipment to developing countries

The collection and transport of waste is the first step of waste management, but in developing countries the system is insufficient to deal with all waste generated, resulting in waste being left on roadsides or street corners. To solve this problem, various activities are being conducted to transfer used, but still working, waste collection vehicles of Japanese local authorities to developing countries that require them. For example, 10 used waste collection vehicles of Osaka City were donated to Phnom Penh, Cambodia, under grass-roots grant aid for recycling. Although donating used vehicles is worthwhile, international cooperation will have greater value if

Japanese waste collection vehicles donated to Phnom Penh
Source: Overseas Environmental Cooperation Center

technologies for maintaining the vehicles or effectively collecting waste are also transferred to recipient countries.

(3) Intermediate treatment technologies, such as incineration

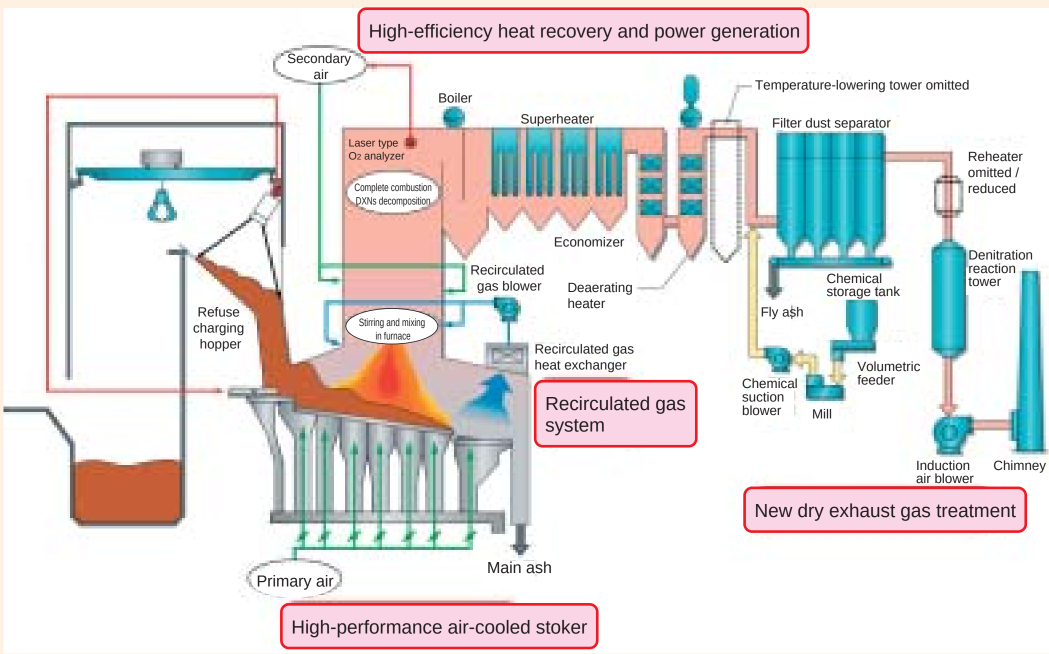
After being collected and transported, waste is subjected to intermediate treatment, such as incineration, composting, shredding and compaction, so as to become suitable for final disposal, including landfilling, or reuse. Thanks to such intermediate treatment, the volume of waste is reduced, stabilized and rendered innocuous.

Incineration is generally used in Japan for intermediate waste management. Because incineration reduces the volume of waste very effectively and destroys disease-causing bacteria, it is suitable for use in a country such as Japan where it is difficult to secure final disposal sites, due to limited land space, or where the temperature and humidity become high in summer. It is estimated that when incinerated, waste is reduced to approximately one-tenth of its weight and one-twentieth of its volume. In 2005, the amount of domestic waste generated was approximately 53 million tons, approximately 80% of which was incinerated.

Because the amount and quality of waste generated and the measures required for environmental preservation have changed, incineration technology as a core waste management method has developed accordingly. Because domestic waste in Japan has a comparatively high water content, advanced technology is required to achieve its complete combustion. By overcoming various challenges, incineration technology in Japan has attained the highest level in the world.

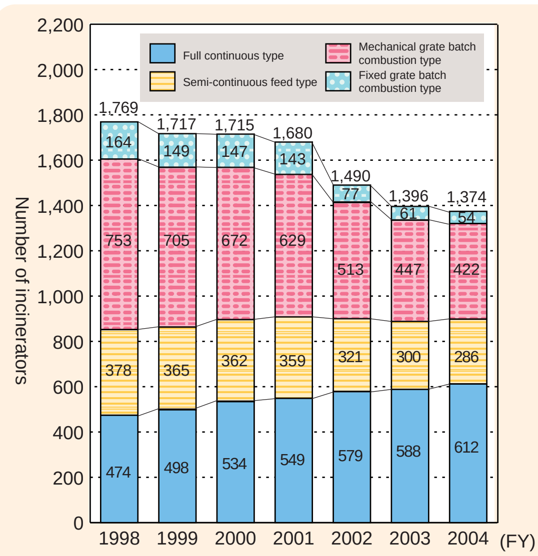
The enforcement regulations of the Waste Management Law define a structural standard for incineration plants for domestic waste, in which it is required to keep combustion gas temperatures above 800°C for incineration, to keep the temperature of gas flowing in the dust chamber below 200°C and to provide a waste gas treatment facility, etc. When classified by operating mode, there are three types of incineration plant: a batch fed incinerator is operated for 8 hours per day; a semi-continuous feed incineration plant is operated for 16 hours per day; and a full continuous type incineration plant is operated 24 hours per day (Fig. 2-5). When classified by the shape of the furnace, incineration plants are roughly grouped into 4 types: mechanical stoker type incinerators (Fig. 2-4) where a metal fire grate called a stoker is moved mechanically to transport and agitate waste and air is supplied from under the fire grate to burn waste; fluidized bed incinerators, where air is blown into a high-temperature sand layer to make it flow and waste is loaded into it and burnt; fixed floor furnace type incinerators where there is no fire grate and waste is burnt on a floor composed of refractory material with a flat recession; and rotary furnace type incinerators (rotary kilns) where a horizontal cylindrical incinerator, the inner surface of which is covered with refractory material, is rotated and waste is dried and burnt in it.

Fig. 2-4 Example of stoker type waste incinerator



Source: Takuma Co., Ltd.

Fig. 2-5 Trend in the number of waste incinerators classified by type of furnace



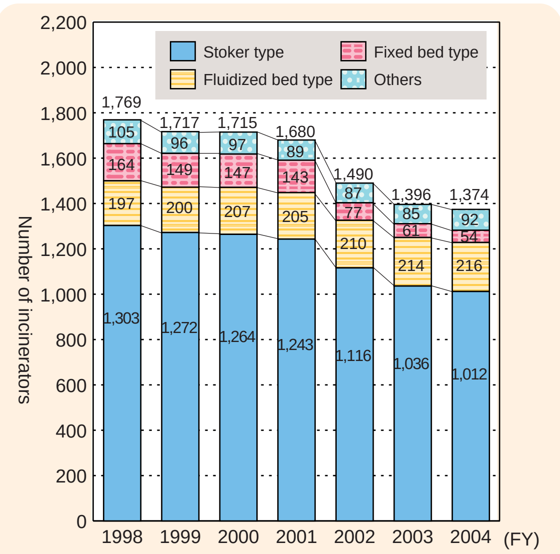
Source: Ministry of the Environment

While batch fed incinerators are used in small-scale facilities, the capacity of which is generally approximately 50 tons per day, full continuous type incineration plants that are operable around the clock are installed in cities where 150 to 200 tons of waste must be treated every day. In addition, when waste is burnt continuously, it is possible to utilize waste heat stably. So, most of the 300 ton/day or greater facilities are equipped with a boiler for power generation.

As at the end of 2004, there were 1,374 domestic waste incineration plants in Japan. While the number of plants is decreasing due to the promoted amalgamated treatment of waste as a measure against dioxins, the number of full continuous type incineration plants is increasing. Classified by type, mechanical stoker type incinerators hold a 70% or greater share (Fig. 2-6).

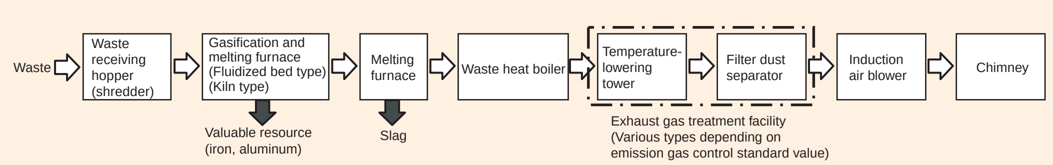
Waste incineration is closely related to the measures adopted against hazardous substances contained in waste gas, especially dioxins, and the recovery of heat (thermal recycling) from incineration plants. This matter will be explained in detail later (see Fig. 2-17 for the reduction of dioxins). Due to these social demands, a gasification and melting furnace has recently been actively introduced. A gasification and melting furnace (Fig. 2-7) is a facility that thermally decomposes waste into gas and carbide in a gasification furnace and burns these in a melting furnace to convert them into waste gas and slag. Gasification melting furnaces have the advantages of reducing the generation of dioxin with complete high-temperature combustion, that the amount of heat held in the waste is utilized to melt and solidify ash and therefore render the ash harmless and the molten slag utilized effectively, and that only a small amount of air is required for combustion so therefore high-efficiency heat recovery with a small amount of exhaust gas is possible. Gasification melting furnace technology has evolved in Japan by the addition of various devices after it was introduced from overseas. As at the end of 2004, gasification and melting furnaces and gasifying reforming furnaces are employed in 54 facilities in Japan and the number of these is increasing every year (Fig.2-10).

Fig. 2-6 Trend in the number of waste incinerators classified by type of treatment



Source: Ministry of the Environment

Fig. 2-7 Basic flow of gasification and melting furnace

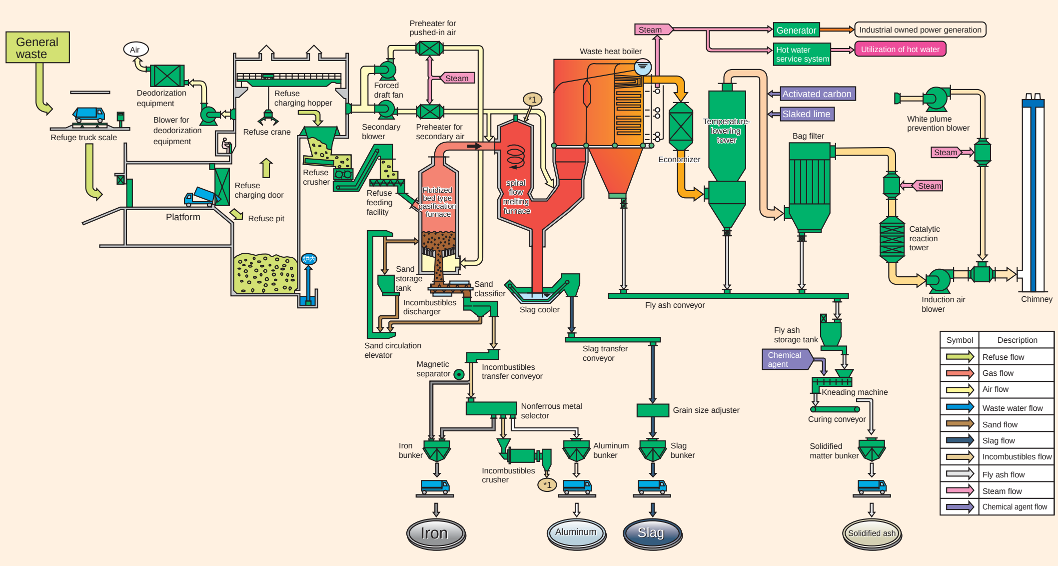


Source: Japan Waste Research Foundation

There are three types of gasification and melting furnace: a kiln type, fluidized bed type and shaft furnace type. Kiln type gasification and melting furnaces are composed of an external heat kiln type cracking furnace and a combustion melting furnace. It heats waste for thermal decomposition indirectly while shutting out air. For efficient thermal decomposition, waste is shredded into 150 mm or smaller pieces, which are dried by circulating air directly through them in order to stabilize their quality before being supplied to the thermal decomposition kiln, in which they are slowly dried indirectly for 1 to 2 hours and pyrolytically decomposed. Because the interior of the kiln is in a reducing state, free of oxygen, iron and aluminum contained in unburned material can be recovered in a state suitable for recycling.

Fluidized bed type gasification and melting furnaces burn part of the waste, which is loaded in a fluidized bed type gasification furnace, together with fluid sand, to partially oxidize the waste and pyrolytically decompose it, utilizing combustion heat. In fluidized bed type gasification furnaces, waste is dried slowly, pyrolytically decomposed and gasified at a comparatively low temperature of 500 to 600°C and at a super-low air ratio (Fig. 2-8).

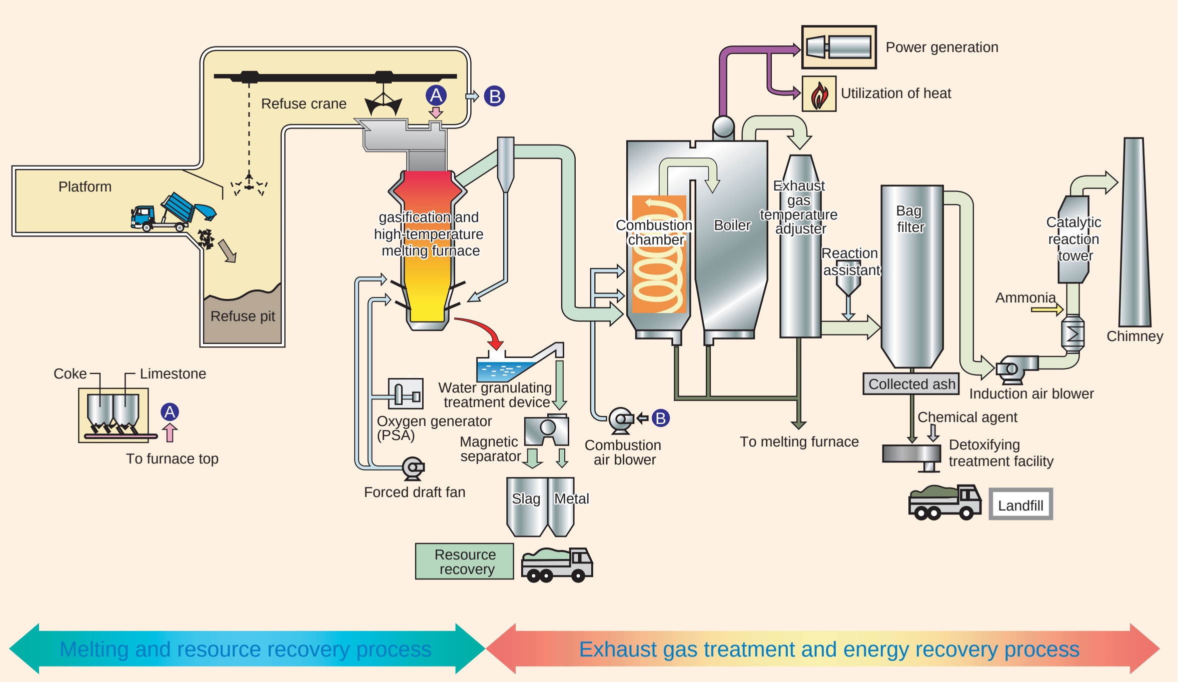
Fig. 2-8 Fluidized bed type gasification and melting furnace



Source: Kobelco Eco-Solutions Co., Ltd.

Shaft furnace type gasification and melting furnaces conduct both pyrolysis gasification and melting in a single furnace. The furnace is composed of a drying and pyrolysis gasification region and a combustion melting region, arranged vertically. In the gasification and melting furnace, waste is dried and pyrolytically gasified and remaining ash and unburned material are rendered as molten slug in the combustion melting region (Fig. 2-9).

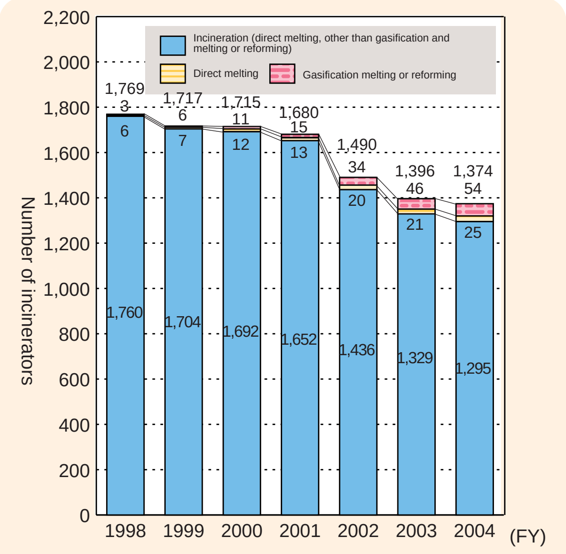
Fig. 2-9 Shaft furnace type gasification and melting furnace



Source: Nippon Steel Engineering Co., Ltd.

There are also gasifying reforming furnaces, which are technologically similar to gasification and melting furnaces. In this type of furnace, gas refined by thermal decomposition is held at a high temperature of approximately 1200°C for two seconds or more in order to decompose tar and thus to reform it into a high-calorie gas, which is quickly cooled to 70°C to prevent the resynthesis of dioxins. The gas obtained is refined and used for power generation or other industrial applications.

Fig. 2-10 Trend in the number of waste incinerators classified by type



Source: Ministry of the Environment

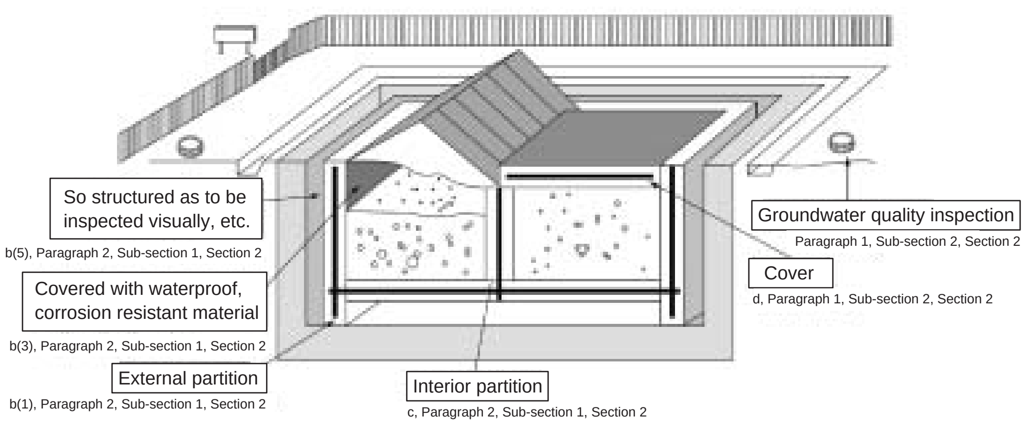
Intermediate treatment technologies, other than incineration, include technology that shreds bulky waste and segregates it into combustible material, iron, aluminum, etc., utilizing a magnet, a sieve, etc., and dehydration technology for reducing the volume of sludge and stabilizing it.

(4) Technologies for final disposal

Waste residue, after intermediate treatment, is disposed of at a final disposal site. For industrial waste, final disposal sites are classified into three types, i.e. strictly controlled landfill site, inert controlled landfill site and controlled landfill site, according to the type of waste to be disposed of. Various technologies are used for stable, high-technology construction, to treat leachate, etc.

In strictly controlled landfill sites, industrial waste that contains a hazardous substance, such as metal, which does not meet the criteria stipulated by the applicable law, is disposed of. In order to isolate hazardous substances from nature, strictly controlled landfill sites are enclosed in 35 cm or thicker reinforced concrete to completely isolate the waste contained in it from the environment. Furthermore, in order to prevent the inflow of rainwater, it is fitted with a cover (roof, etc.) and rainwater drainage system (open channel) (Fig. 2-11).

Fig. 2-11 Strictly controlled landfill site

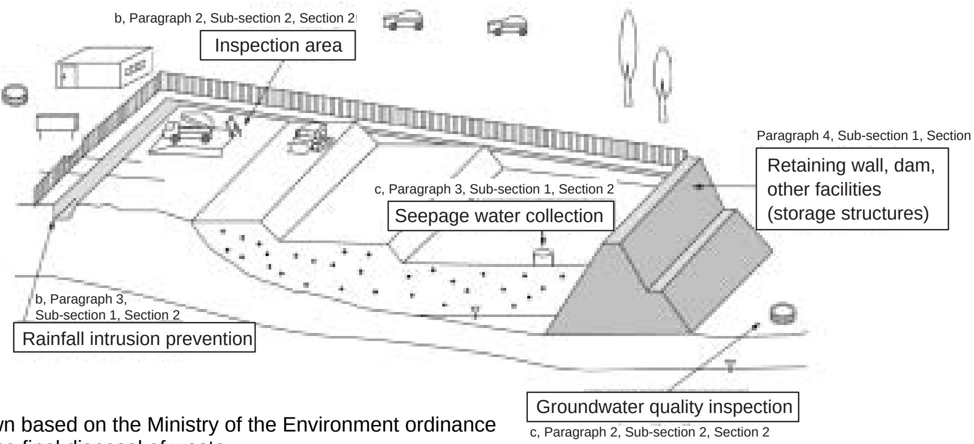


* Drawn based on the Ministry of the Environment ordinance for the final disposal of waste

Source: Japan Environmental Sanitation Center

Least controlled landfill sites receive industrial waste that cannot be decomposed, for example, waste plastic which has no hazardous substance, organic matter, etc. adhered to it, waste metal, waste glass, and rubble. Because industrial waste such as waste plastics contains no water and is not decomposable, it generates no water, no methane gas, etc. and therefore does not contaminate the surrounding environment. Therefore, this type of landfill site does not require seepage control work to isolate the site from the outside world or facilities for collecting, draining and treating seepage water (surface water that permeates into the site) (Fig. 2-12).

Fig. 2-12 Inert controlled landfill site



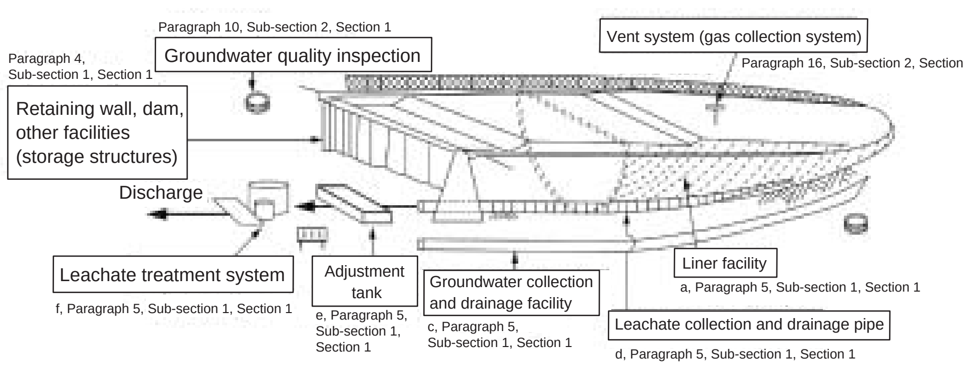
* Drawn based on the Ministry of the Environment ordinance for the final disposal of waste

Source: Japan Environmental Sanitation Center

In controlled landfill sites, industrial waste that can be disposed of only in strictly controlled landfill sites, or industrial waste other than that which can be disposed of in inert controlled landfill sites, is disposed of. According to the decomposition of waste or the elution of metal, retained water (the water held in the waste disposed of or the surface water that permeates into the site) and gas are generated. In order to prevent retained water from contaminating groundwater, the landfill site is isolated from the outside by means of seepage control, such as a liner sheet. The retained water generated in the landfill site is collected in drain pipes to be treated in a treatment facility before being discharged.

For the landfill disposal of general waste, where the residue of incinerated waste is mostly disposed of, in general, landfill sites equivalent to controlled landfill sites are constructed (Fig. 2-13).

Fig. 2-13 Controlled Landfill site



* Drawn based on the Ministry of the Environment ordinance for the final disposal of waste

Source: Japan Environmental Sanitation Center

Example of final disposal site with roof (Takasaki General Waste Final Disposal Site in Miyakonojo-shi)
Source: Research Committee for Closed System Disposal Facilities

Recently, in order to prevent the waste disposed of in landfill sites from contaminating the surrounding environment and thus to improve the reliability of final disposal sites, technical development has progressed actively, such as high-technology seepage control works and storage functions. For example, a final disposal site with a roof can reduce the generation of leachate and prevent the diffusion of odors as well as prevent waste being dispersed. In this way, affecting the surrounding environment can be avoided. In addition, an electric water leakage detection system for liner sheets was developed. This system detects water leaks, should these occur, with electrodes arranged near the liner sheet and provides feedback to the administrative building. With this system, even if the liner sheet should break, any pollution of the surrounding environment, such as groundwater, can be avoided.

Furthermore, technology is now under development that removes waste already disposed of in a final disposal site and segregates and transports it in such a manner as to match the acceptance conditions (for example, grain size, physical properties, etc.) of a resource recovery facility for the purpose of re-securing a space for landfill and reviving the final disposal site.

(5) Technologies for making the waste flow transparent

Various other technologies are also used at waste management sites. Of these, a technology that accurately ascertains and manages the flow of waste and thus makes it transparent is effective for preventing illegal dumping. A representative example of this technology is an electronic manifest.

The manifest system was established so that waste-generating businesses can accurately ascertain and manage conditions throughout the distribution flow of industrial waste. In this system, when a waste-generating business consigns industrial waste to a collecting and transporting business, or when a collecting and transporting business transfers industrial waste to a waste management business, a management form (manifest sheet), in which the type and quantity of industrial waste, the name of the waste-generating business, the name of the collecting and transporting business and the name of the waste management business are recorded, is handed over to the collecting and transporting business and the collecting and transporting business fills in the manifest sheet (with a receipt stamp of the collecting and transporting business, the confirmation of the completion of transport, a receipt stamp of the waste management business, the confirmation of the completion of disposal, etc.) and returns a copy of the manifest sheet to the waste-generating business. Revisions to the Waste Management Law made this system mandatory for industrial waste under special control from April 1993 and for all industrial waste from December 1998, when disposal is consigned.

The 1997 revision of the Waste Management Law introduced an electronic manifest system, in addition to the conventional paper manifest. The electronic manifest system not only contributes to rationalizing information management by waste-generating businesses and waste management businesses but also stores the data on a network, making it impossible for people engaging in illegal dumping to destroy the manifest. There were 7,784 subscribers to the electronic manifest system as at the end of March 2007. Thus, the use of electronic manifests is still low compared to paper manifests, so it is necessary to promote the use thereof.

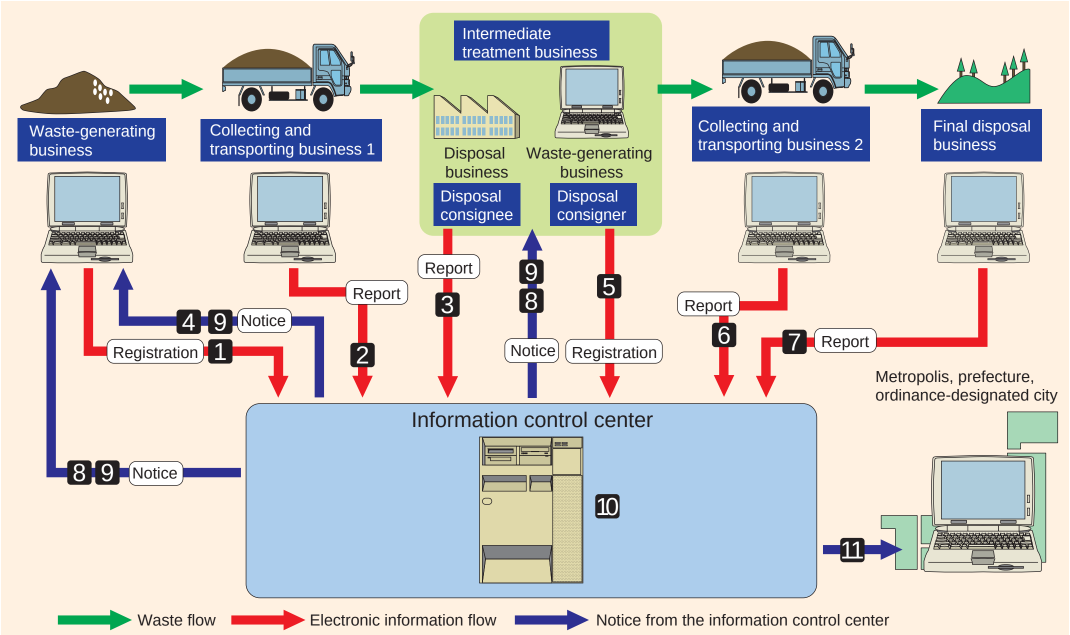
As the target value for spreading the electronic manifest system, 50% was determined in the government's New IT Reform Strategy (in January 2006, by the IT Strategy Headquarters). According to this determination, various activities are being conducted to enlighten waste-generating businesses, waste management businesses and administrative authorities and spread the system (Table 2-1, Fig. 2-14).

Table 2-1 Progress of subscription and registration to the electronic manifest system

FY	The number of Subscribers	Breakdown of subscribers			Cases annually registered to manifest
		Waste-generating business	Collecting and transporting business	Waste management business	
2003	2,001	487	785	729	812,140
2004	2,978	1,019	1,009	950	1,137,785
2005	3,834	1,291	1,327	1,216	1,621,975
2006	7,784	4,083	1,921	1,780	2,388,069

Source: Japan Industrial Waste Technology Center

Fig. 2-14 Electronic manifest system



Source: Japan Industrial Waste Technology Center

In order to prevent illegal dumping of medical waste, a traceability verification test of medical waste is performed by the Tokyo metropolitan government, the Tokyo Medical Association, pharmaceutical industry and industrial waste management businesses, where IC tags are affixed to medical waste containers to check in real time where individual consigned medical waste is and whether or not it has been disposed of. This system records necessary data in an IC tag, reads the data with a card reader and processes it on a personal computer. By interfacing with GPS and the electronic manifest system to effectively process data, it will be possible to ascertain the state of waste within several days, which requires 1 to 2 months with paper manifests.

2 Measures against hazardous substances

If waste contains a hazardous substance, or if a hazardous substance is unintentionally generated in the course of waste management, secondary pollution may result. Therefore, it is necessary to remove hazardous substances contained in waste during disposal and to prevent secondary pollution from occurring in the treatment process. Such measures against hazardous substances require various technologies, adapted to individual hazardous substances.

In Japan, as measures against hazardous substances contained in waste, the Waste Management Law was revised in 1991 to include a new category of waste under special control, which requires stricter management. Waste that is explosive, toxic or infectious or that may be harmful to human health or the living environment is designated as waste under special control. Concretely, parts from home electric appliances that contain PCB, soot and dust generated in municipal waste incinerators and infectious waste generated in medical institutions are designated as general waste under special control. Waste PCB, PCB contaminated matter, waste asbestos and matter containing concentrated hazardous substances, such as mercury, the criteria concentrations of which exceed a certain value, are designated as industrial waste under special control.

In this paragraph, countermeasure technologies against hazardous substances are introduced, taking as examples mercury, PCB and asbestos as representative hazardous substances contained in waste, dioxins as secondary pollutant substances generated in the waste management process, and infectious waste. In addition to these, various technologies are used as countermeasures against exhaust gas in order to control sulfur oxides, nitrogen oxides, etc. that are generated by incineration facilities or to treat drain water from incineration facilities and landfill sites, thus preventing the occurrence of secondary pollution in the waste management system. In order for the site selection for a waste management facility to be accepted by the people living in the area, secondary pollution prevention measures need to be taken.

(1) Mercury

In 1983, a major social problem came to light as a result of a study by the Tokyo Metropolitan Research Institute for Environmental Protection on the risks of environmental pollution caused by mercury through the processes of incinerating or disposing of discarded dry-cell batteries that contain mercury. As measures against this problem, the use of mercury has been banned in manganese batteries since April 1991 and in alkaline batteries since

January 1992. The amount of mercury contained in batteries marketed in Japan today has thus been greatly reduced.

On the other hand, fluorescent bulbs are commonly used for lighting in Japan and the annual production of these amounts to approximately 400 million pieces. The radiation of fluorescent lamps utilizes the discharge phenomenon that takes place when a current flows through mercury vapor, so fluorescent lamps contain small amounts of mercury.

In order to prevent mercury from being dispersed in the environment when waste batteries and fluorescent lamps are disposed of, these are collected for recycling. Many local authorities participated in the Liaison Meeting for the Amalgamated Treatment of Waste Batteries, etc. of the Japan Waste Management Association to cooperate in collecting segregated waste batteries and fluorescent lamps and consigning these to waste management businesses for treatment and disposal (recovery and recycling of mercury). In 2005, 200 kg of mercury was recovered from 5,000 tons of waste fluorescent lamps (see Table 2-2).

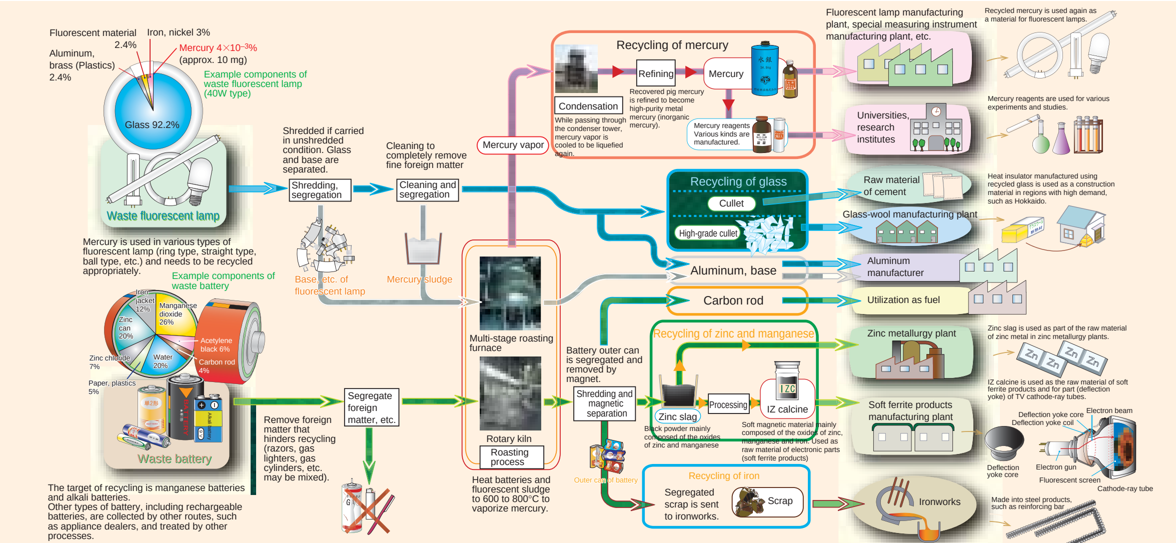
Table 2-2 Trend in the recovered amount of waste fluorescent bulbs and mercury

	2001	2002	2003	2004	2005
Amount recovered (t)	4,300	4,400	4,800	4,600	5,000
Amount disposed of (t)	2,303	2,196	2,555	2,345	2,470
Amount of mercury recovered (kg)	172	176	192	184	200

Source: Compiled by the Ministry of the Environment based on the material of the Japan Waste Management Association

Waste fluorescent bulbs are shredded in the course of their disposal so that mercury will not be dispersed in the environment and are separated into glass, aluminum base parts, fluorescent material and sludge, which contains mercury. Glass and aluminum parts are recycled as valuable resources while the sludge containing mercury is subjected to heat treatment to recover the mercury. Recovered mercury is refined and recycled as metal mercury or a mercury compound for fluorescent lamp material (Fig. 2-15).

Fig. 2-15 management flow of waste batteries and waste fluorescent bulbs for recycling



Source: Nomura Kohsan Co., Ltd.

Column

Reduction and transparency of hazardous substances contained in products

A major objective of waste management is to prevent environmental pollution by removing hazardous substances contained in waste. However, it is preferable to minimize hazardous substances contained in waste that is brought into a waste management facility or to minimize the substances that cause secondary pollution. Namely, to reduce hazardous substances in society as a whole, hazardous substances need to be controlled at the product manufacturing stage.

With this preventive point of view, the EU enforced the RoHS Directive in July 2006. RoHS is an abbreviation for "Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment", which regulates the content of specified hazardous substances in electrical and electronic equipment. The following six hazardous substances are specified: Pb (lead), Cd (cadmium), Cr(VI) (hexavalent chromium), Hg (mercury), PBB (polybromobiphenyl) and PBDE (polybromodiphenyl ether). Excluding exceptional cases, no product whose content of any of the six substances exceeds the criteria value can be sold within the EU's borders.

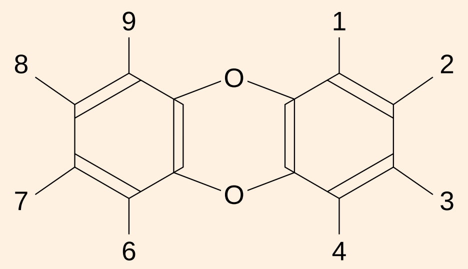
In Japan, too, various activities are conducted to promote proper recycling of products that contain hazardous substances, such as the management of substances that, if contained in products, may degrade the quality of recycled resources or damage the recycling process, and the provision of appropriate information by indication, etc. Specifically, based on the Law for the Promotion of Effective Utilities of Resources, it became mandatory from July 2006 to manage specified chemical substances contained in applicable products and to take measures for providing information, including indication, by a method based on J-Moss (JIS C0950: Marking for the presence of specific chemical substances for electrical and electronic equipment). While the RoHS Directive regulates the sale of products that breach the standard, the Law for the Promotion of Effective Utilities of Resources made it mandatory to indicate the orange mark for specified chemical substances' being contained and to provide information via a website if a product exceeds the criterial value in the content of specified chemical substances (the same substances as the RoHS Directive). In addition, while the RoHS Directive applies basically to all electrical and electronic equipment, the scope of the Law for the Promotion of Effective Utilities of Resources is limited to seven products, including air conditioners and refrigerators.

Mark for specified chemical substances' being contained

(2) Dioxins

Dioxins are by-products that are generated naturally when material is incinerated. Various activities have been conducted to date against dioxins being generated when waste is incinerated (Fig. 2-16).

Fig. 2-16 Chemical Structure of Polychlorinated Dibenzo-p-dioxin



Note: A chlorine atom is bound to the numbered section.

Column

Coexistence of the reduction of dioxins and power generation from waste

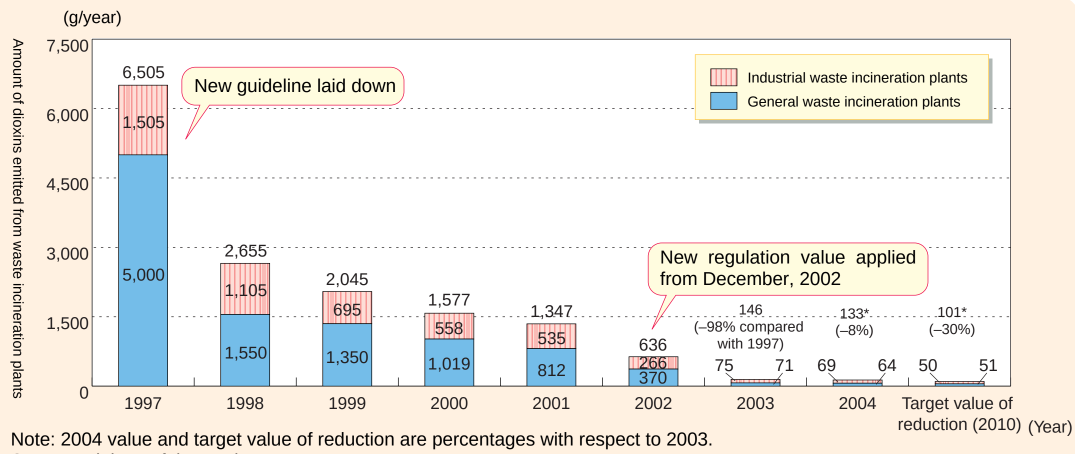
While it is necessary to reduce the amount of dioxins emitted from waste incinerating facilities, it is also necessary to introduce and expand power generation from waste as a way to cut CO2 emissions. Various measures are being taken, including power utilities' purchasing surplus power of waste power generation and the introduction of the RPS system (the Special Measures Law for the Utilization of New Energy, etc. by Electric Power Suppliers).

To prevent dioxins at waste incinerating facilities, rapid cooling to 300°C is needed, in addition to increasing the combustion temperature and securing the retention time. There was concern that the slow cooling of exhaust gas by the boiler, which is necessary for power generation, may cause the re-synthesis of dioxins, but this problem has been solved by spraying activated carbon in the after-flow, installing a catalytic reaction tower, etc. Today, high-efficiency power generation is possible while reducing dioxins.

Thanks to these measures, the amount of dioxins emitted in 2004 from waste incinerating facilities in Japan was reduced by 98% or more, compared with 1997, while the electricity generated from waste increased 2.2 times. These new technologies are the core 3R technologies for waste management in Japan, where municipal waste is mostly incinerated, and are attracting attention worldwide.

As measures against dioxins, in 1990 the Japanese government laid down guidelines for preventing the generation of dioxins related to waste incinerating facilities (the old guidelines), which were revised in 1997 as new guidelines. According to these guidelines, measures have been taken to control waste incinerating facilities. In 1999 the Law concerning Special Measures against Dioxins was enacted and in order to prevent and reduce environmental pollution by dioxins, an environmental quality standard was established as the basis for measures against dioxins, and regulations on exhaust gas and waste water and measures for contaminated soil were stipulated. For example, for dioxins generated in a waste incinerating facility, the emission standard was determined to be 0.1 ng-TEQ/m^3N (for incinerators with a 4 t/h or larger capacity). To meet these regulations, various activities have been conducted and the amount of dioxins emitted in 2003 from waste incinerating facilities has been reduced by approximately 98%, compared to 1997 figures (Fig. 2-17).

Fig. 2-17 Trend in the amount of dioxins emitted from waste incineration plants



Note: 2004 value and target value of reduction are percentages with respect to 2003.
Source: Ministry of the Environment

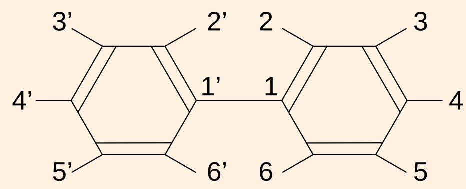
The development and introduction of excellent technology in harmony with institutional reinforcement has greatly reduced the generation of dioxins. Dioxins are thought to be generated when carbon compounds that remain as unburned material react with chlorine in the course of combustion. For their reduction, it is necessary to keep combustion temperatures at 800°C or higher and make combustion as complete as possible.

The aforesaid new guidelines require new furnaces to maintain a combustion temperature of 850°C or higher for two seconds or longer. According to this requirement, the introduction of full continuous type incineration plants, which can maintain high-temperature combustion for a long period of time, have been promoted, in order to reduce the dioxins generated. Because dioxins are generated at a temperature of about 300°C, under the catalytic action of copper, etc. contained in fly ash, a method is applied that quickly cools exhaust gases from 800°C or higher to 200°C or lower and collects dust in a bag filter. In addition, the technology of spraying activated carbon powder in the inlet of bag filters to adsorb dioxins on the surface of the activated carbon and the technology of letting the exhaust gas flow through a tower filled with activated carbon powder after dust collection to adsorb dioxins, have been introduced. Additionally, for soot and dust (fly ash and soot) that are generated in the course of incineration, dioxins criteria (3 ng-TEQ/g or less) have been established. To achieve this, technology has been introduced that heats fly ash from 350 to 450°C in oxygen deficient conditions to pyrolytically decompose dioxins.

(3) PCB

PCB (polychlorinated biphenyl) is an industrially synthesized compound that is less susceptible to thermal decomposition and has other excellent properties, such as high electric insulation and chemical stability. So, it has been used as insulating oil in electric equipment, such as high-voltage transformers, high-voltage capacitors and ballast and as a heating medium in heat exchangers, etc. (Fig. 2-18). However, the Kanemi Oil Poisoning Incident of 1968 brought its toxicity to light and led to a ban on the production, import and use of PCBs in 1974. After that, although the treatment standard by high-temperature incineration was established in 1976, there was no progress in its treatment, except in some areas, due to objections by residents. So, waste PCBs continued to be stored in enterprises for more than 30 years. There was anxiety that waste PCBs, as a negative legacy, could go missing or leak out during long-term storage and cause environmental pollution.

Fig. 2-18 Chemical structure of polychlorinated biphenyl (PCB)



Note: Chlorine atom is bound to the numbered section.

On the other hand, activities against organic pollutants were progressing internationally and the Stockholm Convention on Persistent Organic Pollutants (POPs Convention) took effect in May 2004 (Japan ratified the Convention in August 2002). Concerning PCBs, the Convention requires a ban on their use by 2025 and appropriate treatment of these substances by 2028.

In these circumstances, the Law Concerning Special Measures against PCB Waste (PCB Special Measures Law) was enacted in 2001, requiring enterprises to dispose of their PCB waste by 2016. Therefore, a nationwide PCB waste management system based on regional disposal facilities is now being established, utilizing the Japan Environmental Safety Corporation. As technologies for safely and surely disposing of PCBs, five methods (dechlorination decomposition, hydrothermal oxidation decomposition, reductive thermochemical decomposition, photodecomposition and plasma decomposition) are stipulated, in addition to high-temperature incineration (Table 2-3).

Table 2-3 PCB treatment methods

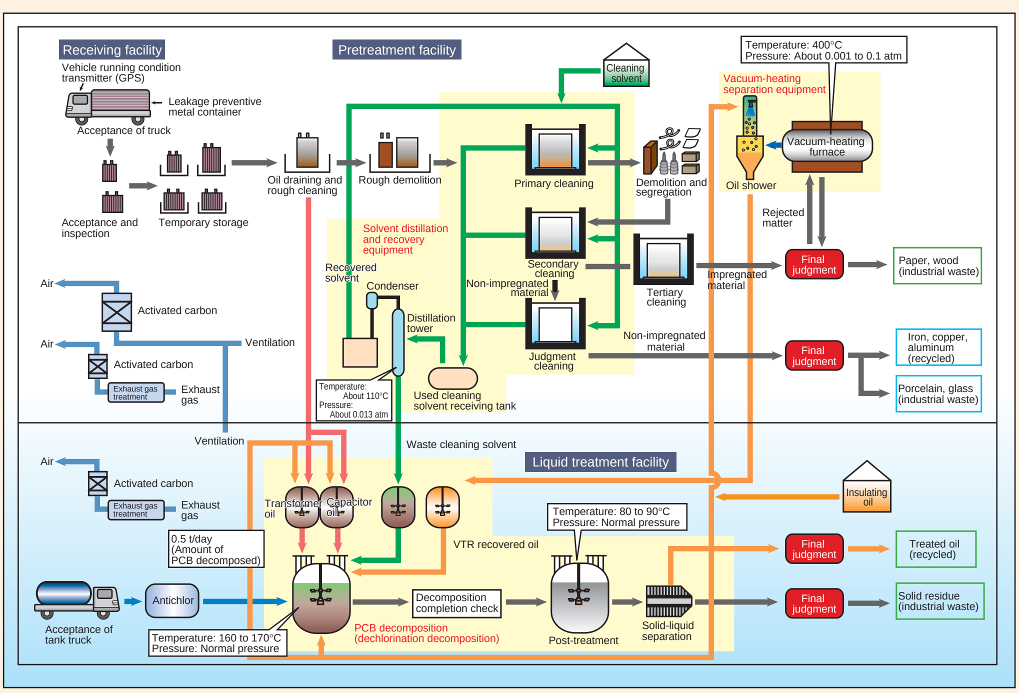
Name	Method	Features
High-temperature incineration	PCB is made into fine droplets to be sprayed in a furnace and incinerated.	Cost-effective method but combustion gas is generated by incineration.
Dechlorination decomposition	Sufficiently mixed with chemicals, etc. to be decomposed by dechlorination reaction.	Main product is dechlorinated treated oil. This method also includes catalytic decomposition.
Hydrothermal oxidation decomposition	Decomposed in high-temperature high-pressure water	Organic matter containing PCB is decomposed into inorganic substances, i.e. carbon dioxide, water and salts. The main product is treated water.
Reductive thermochemical decomposition	Decomposed in a reducing atmosphere	The main product is reducing gas of methane, carbon monoxide, etc.
Photo-decomposition	Decomposed by photochemical reaction	PCB is low-chlorinated by photodecomposition, and the mixture after reaction is treated by dechlorination decomposition or biological decomposition. The main product is treated oil or treated water.
Plasma decomposition	Decomposed by plasma at high temperature	The main products are carbon monoxide, carbon dioxide, hydrogen chloride, hydrogen, etc.

Source: Ministry of the Environment

As a pioneer project in Japan, in the Kitakyushu PCB waste management facility (first phase) of the Japan Environmental Safety Corporation, which started operation in December 2004, the decomposition of PCBs by the dechlorination decomposition method and, as its pretreatment, solvent cleaning and vacuum heating separation for removing PCBs from transformers, etc., have been enacted for electric equipment, such as high-voltage transformers and high-voltage capacitors, which have been installed to the west of Okayama. For these facilities, sufficient safety measures are taken, such as measures for environmental preservation during operation, appropriate responses to abnormalities and the monitoring of the surrounding environment (Fig. 2-19, Table 2-4, Fig. 2-20).

Recently it was found that a large amount of electric equipment is being used in transformers, which were said to contain no PCBs, and so insulating oil is contaminated with a small amount of PCB. So, it has become important to establish a system for safely disposing of these substances. In these circumstances, incineration verification tests have been performed since March 2006, in existing industrial waste management facilities that are capable of high-temperature incineration, in order to prove that such equipment can safely and securely be disposed of.

Fig. 2-19 Treatment process diagram of Kitakyushu PCB waste management facility of the Japan Environmental Safety Corporation



Source: Japan Environmental Safety Corporation

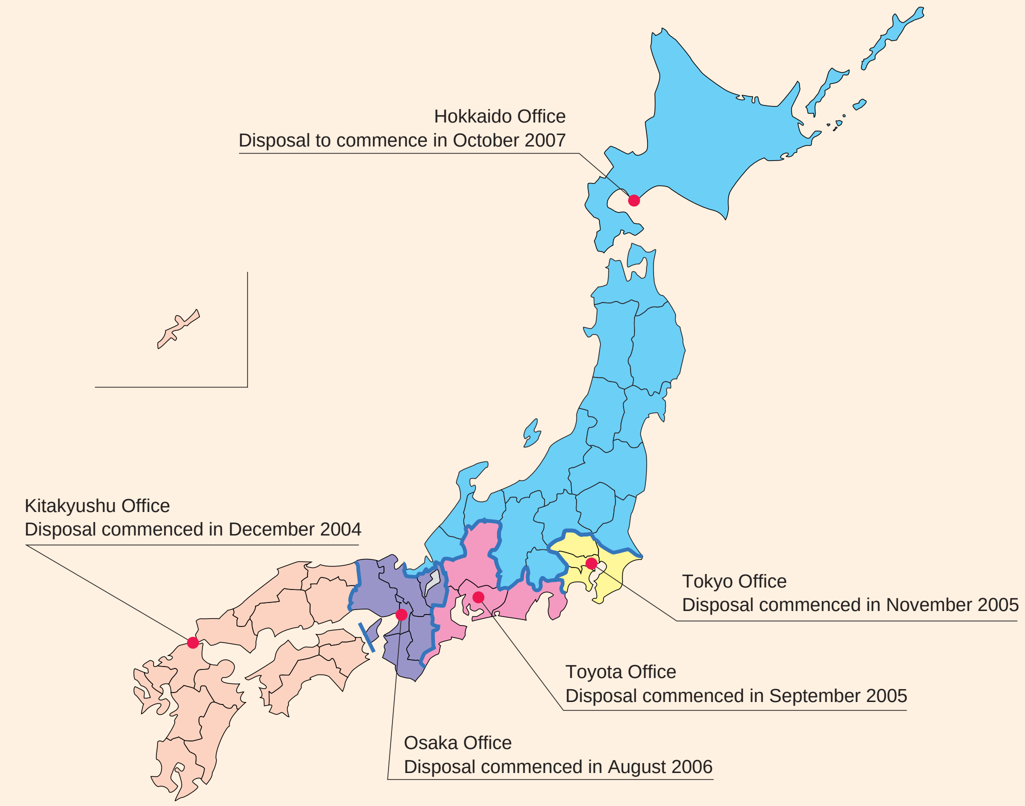
SECTION 2

Table 2-4 PCB waste management plan

Office name	Kitakyushu	Osaka	Toyota	Tokyo	Hokkaido
Location of office	Wakamatsu-ku, Kitakyushu-shi	Konohana-ku, Osaka-shi	Toyota-shi, Aichi-ken	Koto-ku, Tokyo	Muroran-shi, Hokkaido
Districts covered	Okinawa, Kyushu, Chugoku, Shikoku (17 prefectures)	Kinki (6 prefectures)	Tokai (4 prefectures)	Minami-Kanto (1 metropolis and 3 prefectures)	Hokkaido, Tohoku, Koshinetsu, Kita-Kanto, Hokuriku (Hokkaido and 15 prefectures)
Target of disposal	High-voltage transformer, waste PCB, etc.	High-voltage transformer, waste PCB, etc.	High-voltage transformer, waste PCB, etc.	Waste transformer, waste capacitor, waste ballast, waste PCB	High-voltage transformer, waste PCB, etc.
Amount of PCB decomposed	0.5 t/d (1st phase) About 1.3 t/d (2nd phase)	2.0 t/d	1.6 t/d	2.0 t/d	1.8 t/d
Treatment method	Chemical treatment (dechlorination decomposition)	Chemical treatment (dechlorination decomposition)	Chemical treatment (dechlorination decomposition)	Chemical treatment (hydrothermal oxidation decomposition)	Chemical treatment (dechlorination decomposition)
Contractor	Nippon Steel Corp., etc.	Mitsui Engineering & Shipbuilding Co., Ltd., etc.	Kubota Corp., etc.	Mitsubishi Heavy Industries, Ltd., etc.	Nippon Steel Corp., etc.
Disposal commencement	December 2004 (1st phase)	October 2006	September 2005	November 2005	October 2007
Project completion	March 2016	March 2016	March 2016	March 2016	March 2016

Source: Ministry of the Environment

Fig. 2-20 Map of regional PCB disposal facilities



Source: Ministry of the Environment

(4) Asbestos

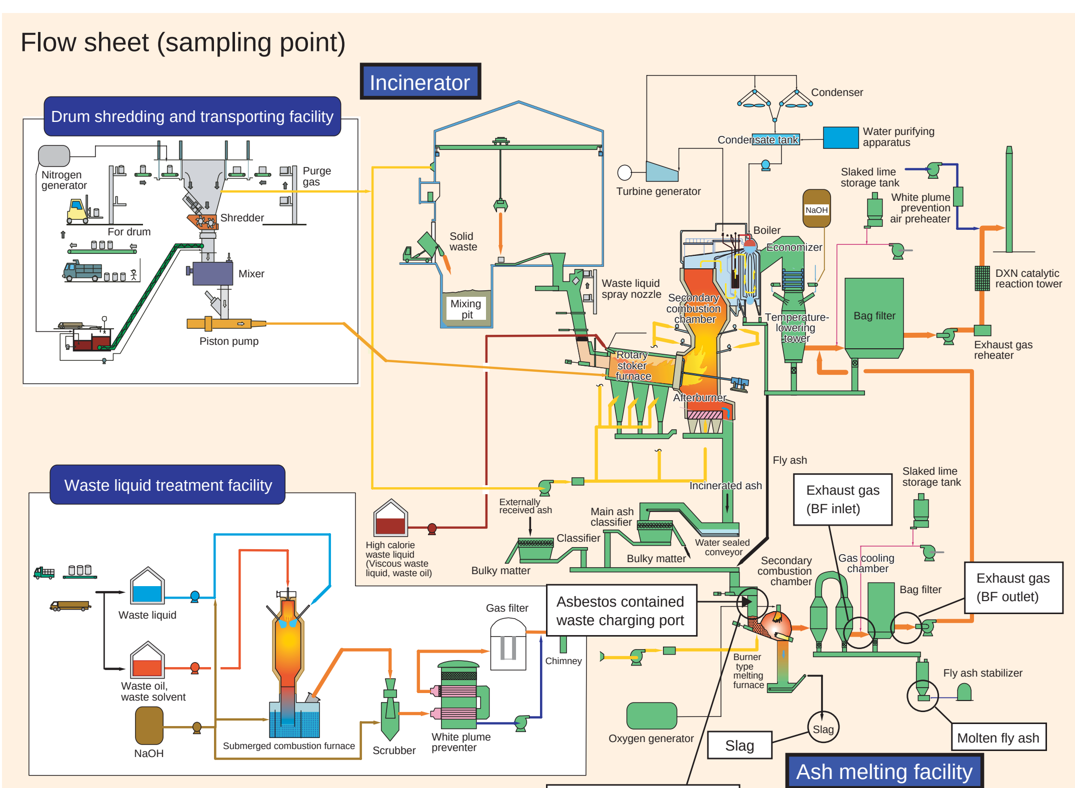
Because of its excellent heat resistance, etc., asbestos has been used in many products, including construction materials. But it is now regarded as a cause of pneumoconiosis, lung cancer, mesothelioma, etc., so the production, use, etc. of asbestos and products containing it have been prohibited. The Waste Management Law designates waste asbestos, i.e. substances that represent a danger of asbestos being dispersed in the air, such as structural members sprayed with asbestos and heat insulating materials made of asbestos, as industrial waste under special control. Waste asbestos-molding panels, such as waste asbestos slate, are classified into non-scattering waste asbestos, but there is a danger that asbestos will disperse when such waste is destroyed or broken in the course of disposal. Accordingly, a technical guideline for appropriate disposal was published in March 2005.

In February 2006, the Law for Revising Part of the Air Pollution Control Law, etc. to Prevent Damage to Health, etc. due to Asbestos was promulgated and the Waste Management Law was partly revised. Specifically, in order to promote safe and rapid disposal of waste containing asbestos, a new system (detoxifying treatment qualification system) was established. In this system, an enterprise that executes detoxifying treatment using high technology, such as melting, requires no approval by the metropolitan or prefectural governor for industrial waste management business or the installation of an industrial waste management facility when approved by the Minister of the Environment.

There are two methods available for the final disposal of scattering waste asbestos: one is disposal in a controlled landfill site after scattering-preventive treatment, such as packing or solidifying with concrete, etc., and the other is disposal in a controlled landfill site or a inert controlled landfill site as general industrial waste, after melting the waste and thus removing its property as industrial waste under special control.

Today, non-scattering waste asbestos is mostly subject to landfill disposal. But it is expected that a large quantity of non-scattering waste asbestos will be generated as the number of buildings to be demolished increases in the future. Therefore, studies are progressing on the utilization of existing industrial waste melting facilities or on treatment using production facilities, such as a cement kiln (Fig. 2-21).

Fig. 2-21 Flow of asbestos treatment facility



Source: Kamtecs, Inc.

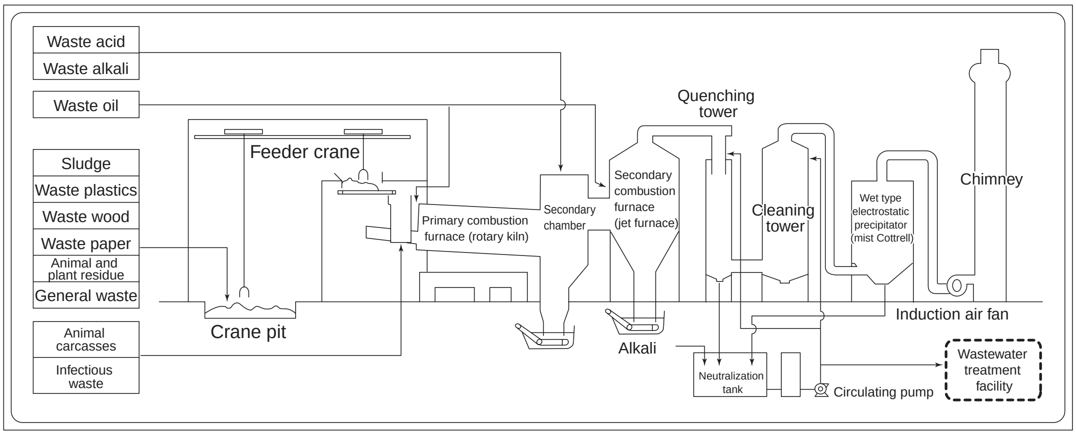
(5) Infectious waste

In order to prevent infection, hypodermic needles, scalpels and specimen containers that are used in medical institutions, etc. must be disposed of properly when they become waste. The Waste Management Law designates infectious waste (waste containing infectious pathogens or to which an infectious pathogen is adhered, or waste having such probability) generated in medical institutions, etc., as waste under special control (industrial waste under special control or general waste under special control).

For infectious waste, the disposal standard is stipulated in the Infectious waste management Manual that was published in March 2004, whereby it is required to remove infectiousness with an incinerator, melting facility, etc. It is also mandatory to use an incinerator or a melting facility that can completely incinerate or melt waste and to prevent the living environment from being polluted by the exhaust gases of such facility.

In order to appropriately treat infectious waste, various technologies have been introduced. For example, a rotary kiln type incinerator is used, in which infectious waste is burned together with other industrial waste that plays the role of combustion improver, etc. to destroy infectious bacteria, to detoxify infectious waste, and to reduce its volume (Fig. 2-22).

Fig. 2-22 Incineration treatment flow



Source: Kureha Ecology Management Co., Ltd.

3 Technologies for the 3Rs

To construct a sound material-cycle society, it is necessary to implement the 3Rs: reducing (controlling the production of wastes), reuse, and recycling. Specifically it is necessary to first limit as much as possible the production of waste and at the same time, reuse, recycle, and thermal-recycle wastes produced, as much as possible, in this order of priority, i.e., use them cyclically to ensure that improper disposal or treatment of them is prevented and their environmental loads are reduced. The implementation of the 3Rs is also based on related technologies. This section discusses waste-reducing technologies, waste-reusing technologies, designs for recycling, material-recycling technologies, and thermal-recycling technologies.

(1) Material-reducing or reusing technologies

Efforts to reduce waste include making more efficient use of materials and extending the lives of products. An example of using materials more efficiently includes making the walls of PET bottles thinner. That structural improvement has so far made the 10 to 40% lighter containers.

For containers and packagings for soap and detergent, the use of plastic materials has been reduced by concentrating the soap or detergent to make it smaller and by developing and selling refilled bottle products and replacement bottle products. According to a survey by the Environment Committee of the Japan Soap and Detergent Association, the shipments of refilled bottle products and replacement bottle products have increased fivefold in the past nine years. The quantity of plastic materials used in 2004 was 52,500 tons, half of the 113,000 tons that is assumed to be the case if the products had not been made more compact.

For home appliances, products have been made lighter by reducing the numbers of their parts and making them as units. For automobiles, the body has been made lighter by using much more aluminum, high-tension steel plates, and so on.

Efforts to extend product life include making longer lasting liquid-crystal backlight, hard disk, and so on for personal computers, for example. For automobiles, the specified times for replacing engine oil, engine coolant, and so on have been extended.

Reuse has priority over recycling because the former uses less additional energy and causes less environmental contamination than the latter. Efforts to reuse products include reusing copy machine parts. Internal parts such as the drive device and exposure devices have been reused for some time; but more recently external parts are increasingly becoming the focus for reuse because technology for scraping stains off the surface by blasting grains at high speeds has been developed.

For the slot game machine, a structure by which it can be separated into the upper component (rotating component) and the lower component (housing) has been adopted. For new models using this structure, only the upper component is replaced while the lower component is reused, thus reducing the resources used to produce the new model.

Furthermore, for automobiles, components taken from end-of-life vehicles are used as a base and reassembled with new parts to replace worn and deteriorated parts, and checked for quality to recover their original function.

Column
Reusing technology

According to a recent report, the reusing technology where a special toner is used with which the printed faces of paper sheets used with office equipment can be erased so that the sheets can be reused has been developed. That technology makes it possible to reuse a paper sheet five to ten times. It is reported that it has reduced the amount of paper used.

Erasable toner

Copying machine for erasable toner

Erasing device for erasable toner

Source: Toshiba Corporation

(2) Product design for recycling

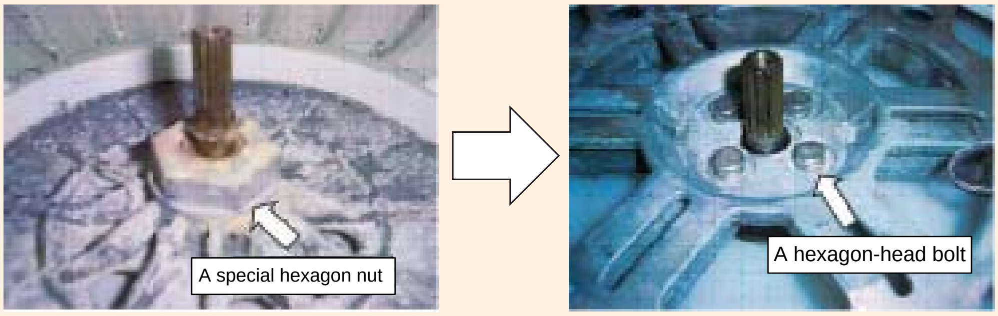
Techniques in the design stage to improve the ease of decomposition of products and the possibility of making them into resources again in the recycling stage have been developed. Such technologies are called “environmentally conscious design”, which are combined with waste-reducing and waste-reusing technologies.

Of such techniques, the ease of decomposition reduces the labor and time for decomposing used products and contributes to their reuse and recycling.

Such designs for containers or packagings involve changing composite materials to a single material, using shrink labels with a perforated line for easier removal, using recycled materials, and introducing biodegradable materials.

For home appliances, an example of techniques implemented is the introduction of product assessment where the producer researches a product to predict its safety, resources used and environmental effect in the stages of production, distribution, usage, disposal, recycling/processing, and final disposal, and in the stage of design before it is put into the production. There are cases of ease of decomposition design where parts that could only be decomposed by means of special tools have been made decomposable using common tools and where parts are labeled to indicate their materials so that those of the same material can be treated accordingly when they are decomposed. (Fig. 2-23)

Fig. 2-23 Environmentally conscious design of a washing machine



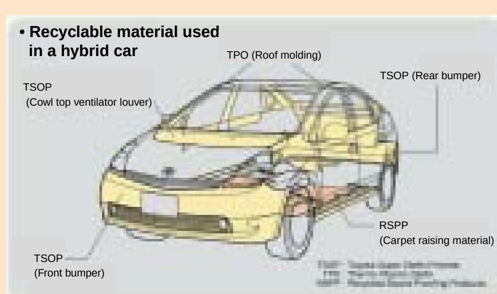
For disassembly, it was necessary to prepare a tool with a special size.

With this bolt, this can be disassembled with a common tool.

Source: Mitsubishi Electric Corporation

For the production of automobiles, there are cases where recycled materials or recyclable resources are used for recycling and where components of the body are structured for easier disassembly to improve recyclability in the design stage. For example, in order to dismantle end-of-life vehicles, the suction hole of a fuel-removing device has been made larger in the diameter to shorten the work time for removing the fuel of them and an air saw capable of quickly cutting windshield glass has been developed that reduces work time by 45%. Furthermore, in order to design easy to dismantle automobiles, a technique that makes it possible to simulate the status of pulling resin parts off an automobile on a computer has been developed. Thus, the status of breaking down an automobile can be known without testing on real vehicles. (Fig. 2-24)

Fig. 2-24 Environment-conscious design of a hybrid car



Examples of adopting structures using a recycled material or a recyclable resource that are easy to dismantle for body parts or has a better-for-dismantlement mark attached.

Source: Toyota Motor Corporation

(3) Wastes to resources: material recycling technologies

Material recycling recycles waste into usable material. This section discusses the recycling of waste containers and packagings, end-of-life vehicles, discarded home appliances, construction waste, paper, and so on as typical types of material recycling introducing technology that recycles waste into resources.

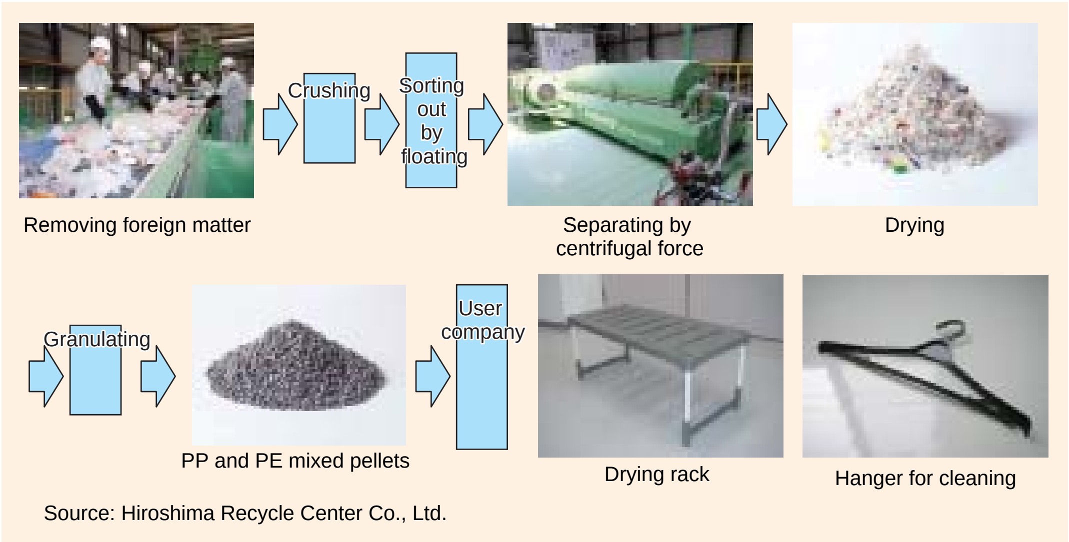
a) Recycling of waste containers and packagings

The Law for the Promotion of Sorted Collection and Recycling of Containers and Packaging (hereinafter referred to as "the Container and Packaging Recycling Law") defines containers and packagings as "containers and packagings for commercial goods (including such container or packaging for which money is charged) that are unwanted when the goods have been consumed or when they are separated from the goods." "Containers", which include glass containers, PET (Polyethylene Terephthalate) bottles, paper containers, plastic bottles (including styrene foam trays for foods and food bags), and "packagings", which include package paper and wrapping, that households dispose of are to be made once again into commercial goods. Such containers and packagings account for about 60% by bulk and about 20% by weight of total household garbage. Of those containers and packagings, this section addresses waste plastic and PET bottles and discusses technologies for recycling them. Although there are many kinds of waste plastics, only PET bottles and foam styrene food trays are collected as separate categories.

The technologies for recycling waste plastics are categorized into material recycling that uses the materials in their original plastic form and chemical recycling that chemically treats the material for use as a chemical material.

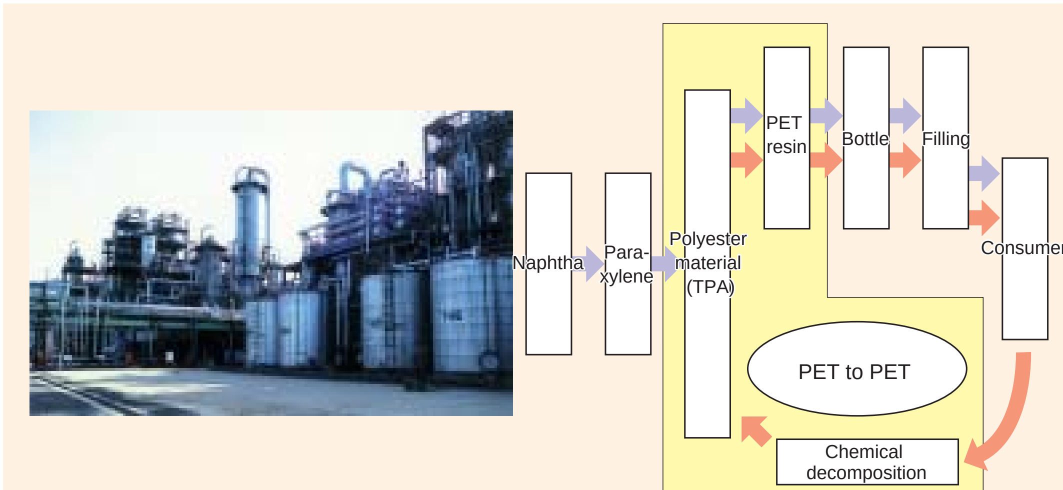
In material recycling, collected waste plastics are made into materials for plastics in the form of flakes, fluffs, and pellets through the processes such as removal of foreign matter, sorting, and cleaning. They may then be mixed with new materials for necessary component adjustment to make them into materials such as pellets. (Fig. 2-25)

Fig. 2-25 Material recycling of waste plastics



On the other hand, waste containers and packagings and waste PET bottles are recycled into textile products such as working clothes and carpet, sheet products, such as egg packs, and containers for cup noodles, hangers, and planters. A technology to make PET bottles from waste PET bottles has also been put into practical use, with about 12,000 tons of PET bottles manufactured in this way in 2005. (Fig. 2-26)

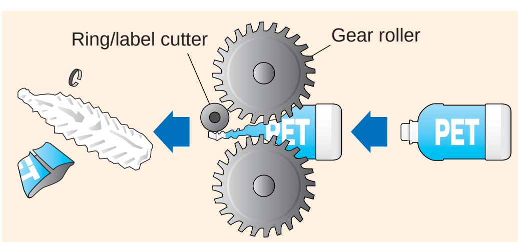
Fig. 2-26 Bottle-to-bottle recycling process



Source: Teijin Fibers Co., Ltd

For PET bottles, a technology to separate the body from the cap and the ring (i.e., the thing left on the main body when the cap is screwed off) has also been put into practical use. This technology involves flattening a PET bottle with gears and cutting it in a longitudinal direction so that it is easy to separate the body from the cap and ring manually. (Fig. 2-27)

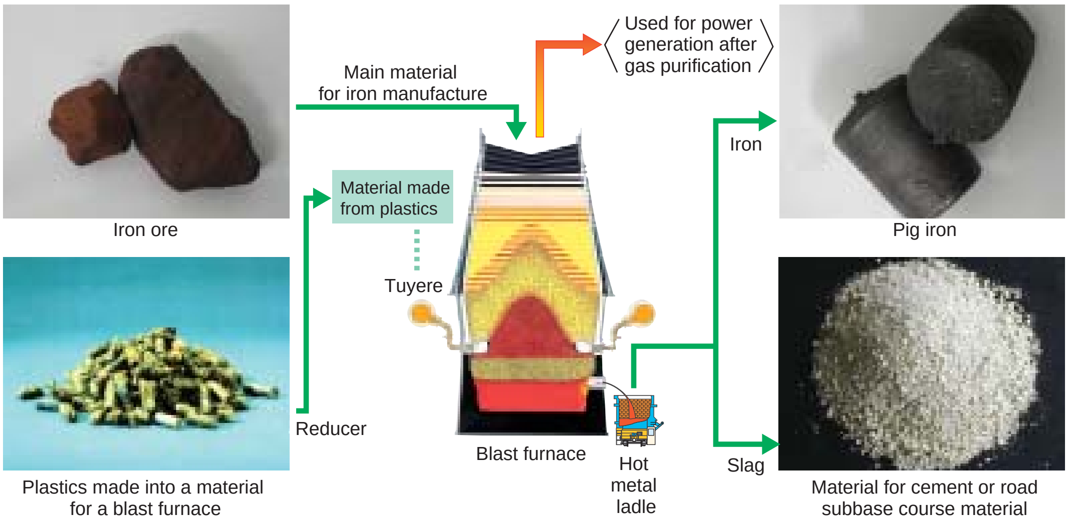
Fig. 2-27 PET-bottle bulk reducer



Source: Meiwa Kousakusyo Corporation

Chemical recycling has been implemented particularly in the fields of steel manufacturing and chemicals. In steel manufacturing, coke is used to reduce iron ore to iron in a blast furnace, and waste plastics can be substituted for coke after they are processed into grains. This is because carbon and hydrogen contained in plastics can function as a reducer. Plastics blown into a blast furnace decompose into hydrogen and carbon monoxide at high temperatures of about 2000°C and react with iron oxide as the main component of iron ore to reduce it to pig iron. The residual hydrogen and carbon monoxide after the reduction reaction are recovered as blast furnace gases and used as a fuel for power generation. (Fig. 2-28)

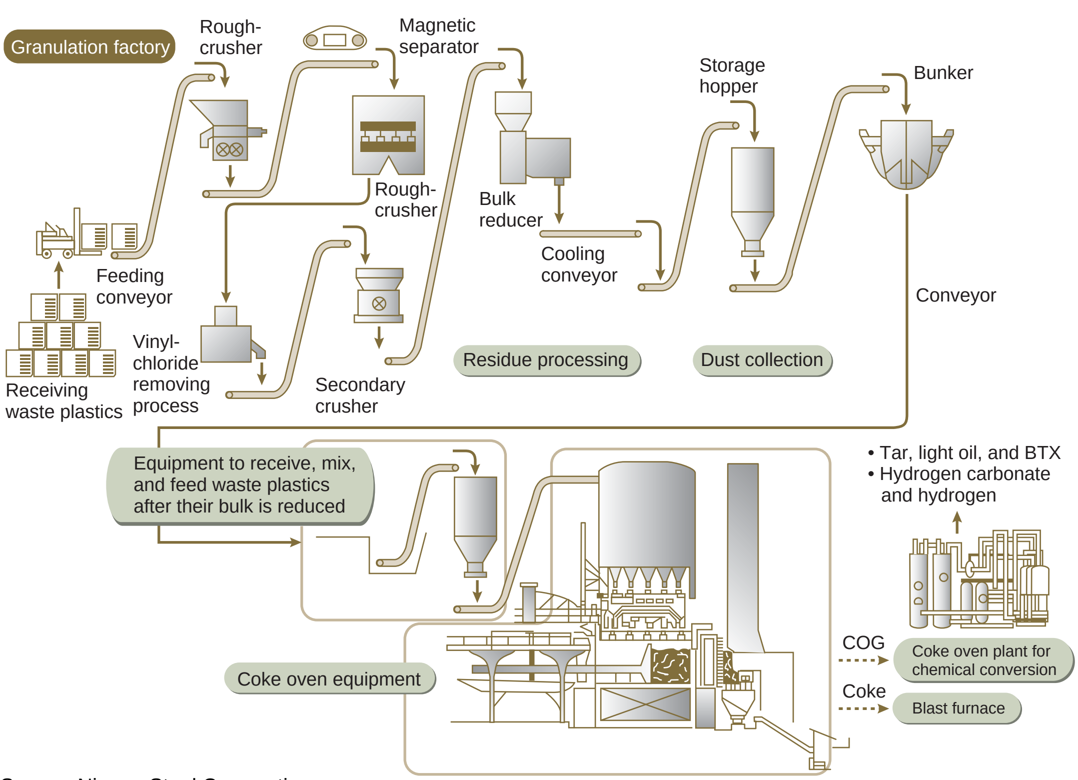
Fig. 2-28 Waste plastics recycling by a blast furnace



Source: JFE Steel Corporation

For a coke furnace, there is also technology to thermally decompose waste plastics and reuse them as resources. This technology involves heating waste plastics in a closed chamber, called a carbonizing chamber, in a coke furnace without oxygen at about 1,200°C, thus generating hydrocarbon oils (light oils and tar) and coke furnace gases (hydrogen, methane, etc.) from the hot gases produced in the heating and recovering coke as the residue. The hydrocarbon oils are used as chemical materials in chemical plants, and the coke furnace gases as fuel gases to power steel plant generators. (Fig. 2-29)

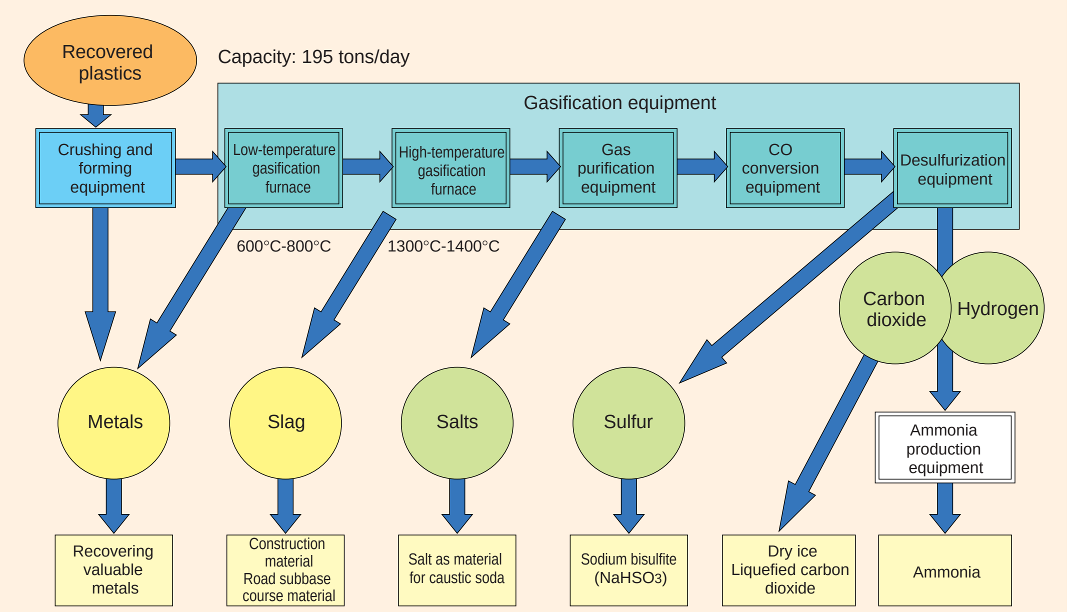
Fig. 2-29 Waste plastics recycling by a Coke oven



Source: Nippon Steel Corporation

In the chemical industry, a technology to thermally decompose waste plastics into gases for materials contributes to the saving of fossil fuels such as coal and oil. Specifically, in a waste-plastic gasification process, waste plastics are processed into intermediate formed products in a pretreatment process. The products are then put into a pressurizing two-stage gasification furnace (EUP system) involving the low and high temperature stages where they are thermally decomposed into hydrogen gas and carbon monoxide gas. The gases generated as a result are put into ammonia production equipment where they are synthesized with nitrogen in the air to make ammonia. With this technology, waste plastics can be recycled into ammonia of the same quality as the conventional product produced from naphtha and other substances used for such materials as nylon. (Fig. 2-30)

Fig. 2-30 Process of producing ammonia from waste plastics



Source: Showa Denko K.K.

A technology to make oils from waste plastics has also been put into practical use. Specifically, waste plastics are separated from foreign matter in a pretreatment process and then put in a recycled oil production apparatus where the plastics go through a demineralization process, a thermal decomposition process, and a oil production process into hydrocarbon oils (heavy, middle-weight, and light oils) as recycled commercial goods. For the uses of those hydrocarbon oils, light oils are accepted by oil refineries as petrochemical materials, and middle-weight and heavy oils are used as fuels for power generation.

Introducing these technologies required solving a number of difficult technical issues, such as the removal of chloride in waste plastics and forming processes.

b) Recycling end-of-life vehicles

The automobile industry, which is also called a comprehensive industry, produces automobiles using various materials such as metals, glass, and plastics. End-of-life vehicles have conventionally been recycled or disposed of by companies specializing in dismantling or crushing. Nowadays they are recycled under the Law for the Recycling of End-of-Life Vehicles (End-of-Life Vehicle Recycling Law) with specified targets for reusing resources from shredder dust at 70% or higher, and airbags at 85% or higher by 2015.

An example of technologies to recycle end-of-life vehicles is collecting aluminum wheels for melting down and converting into suspension parts. This technology enables an automobile company to establish an intra-company recycling process where it collects used products of its own, melts them down, and makes them into new parts in its parts production factory. (Fig. 2-31)

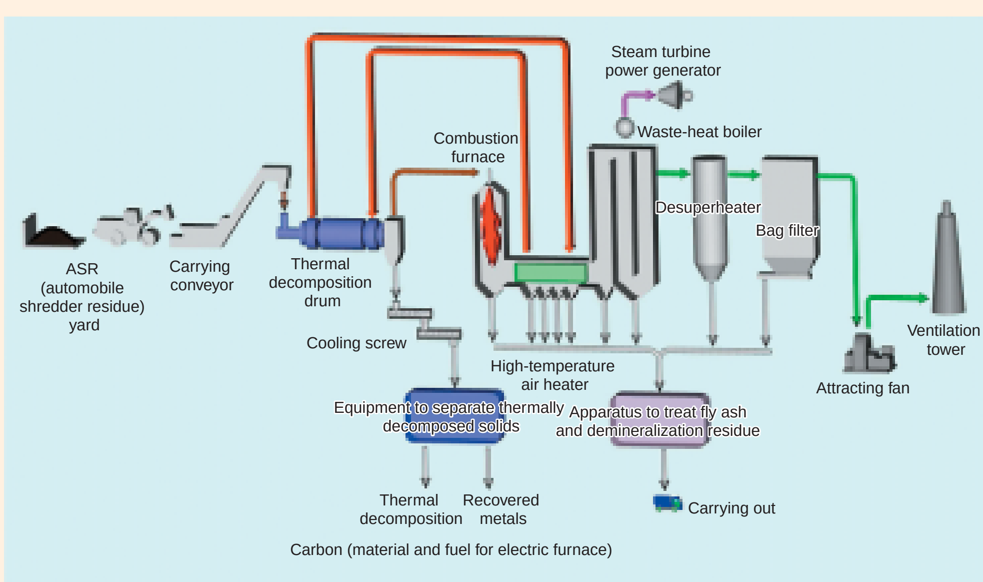
Fig. 2-31 Recycling aluminum wheels

Recovering aluminum wheels　　Melting　　Suspension parts

Source: Nissan Motor Co., Ltd.

End-of-life vehicles after all reused or recyclable parts are collected are crushed and shredded into shredder dust. Until now, shredder dust has been buried, but is now being treated by means of recycling technologies because a target rate for reusing it as a resource has been set. For example, shredder dust is put into an indirectly heating rotary kiln shielded from the air and thermally decomposed at 450oC for one to two hours to obtain carbides (thermally decomposed carbon) that are used as materials and fuel for electric furnaces. This process also recovers valuable metals. (Fig. 2-32)

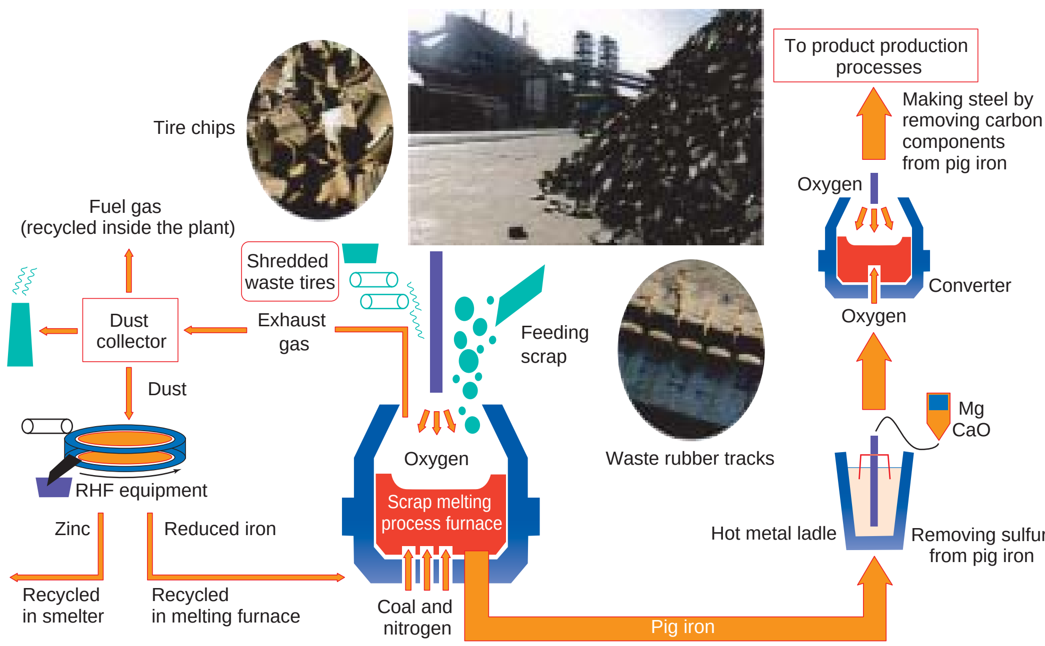
Fig. 2-32 Technology for carbonizing automobile shredder residue



Source: Mitsui Engineering & Shipbuilding Co., Ltd.

About 100 million tires, or one million by weight, are discarded every year. Typical examples of waste tire recycling include using them as a firing fuel in cement production, as a material for cement, and as a source of thermal energy. In addition, in steel plants, technology to convert them into a resource has been introduced. Specifically, pieces of cut up waste tires are put in a scrap melting process furnace, where the carbon components of the rubber are used as materials and fuel for the production of pig iron, while the steel cords (the iron in string form that forms the skeleton of a tire to maintain its shape) are used as a source of iron. Another technology put into practice involves thermally decomposing waste tires in an externally heating rotary kiln to separate and produce gases, oils, and carbons by means of dry distillation and iron wires for use as materials and energy sources. Each of these technologies used in steel manufacturing processes has converted waste tires into resources at 60,000 tons annually. (Fig. 2-33)

Fig. 2-33 Flow of processing waste tires

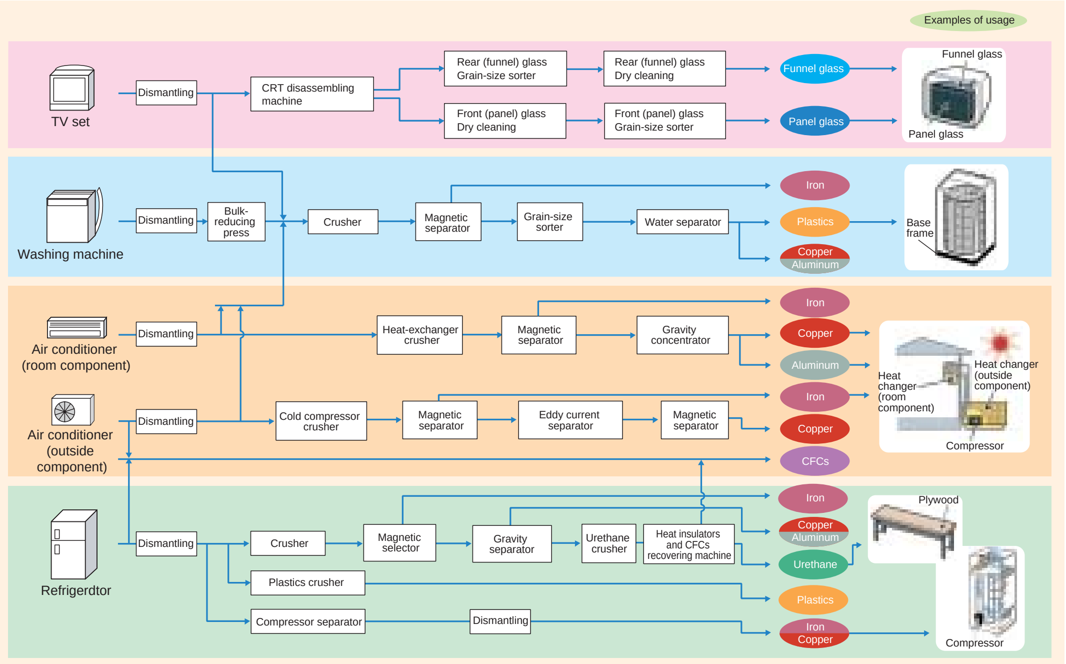


Source: Nippon Steel Corporation

c) Recycling of discarded home appliances

Since the Law for the Recycling of Specified Kinds of Home Appliances (the Home Appliance Recycling Law) became effective, home appliance producers are required to recycle four specified appliances into commercial goods at a rate (excluding thermal recycling) of at least 60% for home air conditioners, at least 55% for television sets, at least 50% for refrigerators and freezers, and at least 50% for washing machines. The steps for recycling home appliance products are shown in Fig. 2-34, where various technologies are used to ultimately recover metals, glass, and plastics. As an enhanced effort for recycling plastics, waste plastics recovered from used home appliance products are used again as components for new products. Recycling that substitutes and reduces the input of virgin materials has a higher value added (closed recycling). Such recycling has been made possible by meticulously separating the collection of waste plastic from used home appliances by means of manual dismantling and by developing technologies to make the properties and service lives of recycled plastics meet the requirements of the home appliance products to which they will be applied. (Fig. 2-35)

Fig. 2-34 Flow of recycling home appliances



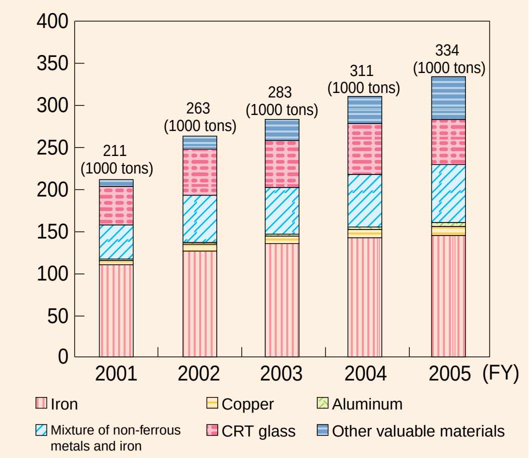
Source: Matsushita Eco Technology Center

Fig. 2-35 Case of closed recycling

Source: Sharp Corporation

Changes in the rates of recycling the four specified products in the Home Appliance Recycling Law into commercial goods according to their materials are shown in Fig. 2-36. As shown there, the recycling of non-metal materials such as plastics and glass has increased since the Law became effective.

Fig. 2-36 Change in volume for four specified materials recycled for reuse as a product



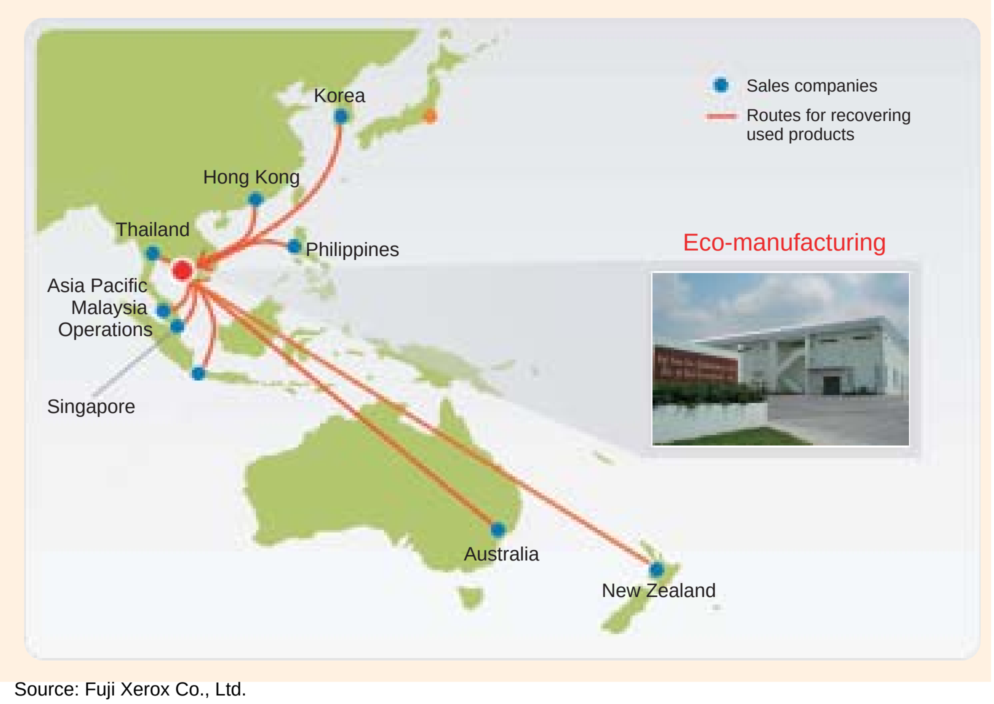
Source: Environmental Council Planning Committee on Sound Material Cycle Society

Column

International resource cycle of used copying machines

A system is in operation for collecting used products such as copying machines, printers and related products, including cartridges, in nine countries and regions in the Asia Pacific region. The used products are delivered to a recycling factory in Thailand, where they are dismantled and sorted and then recycled into a useable resource. In constructing this international resource-cycle system, four principles were established: (1) preventing unlawful disposal of such machines, (2) producing no environmental impact on the import country, (3) importing no waste, and (4) returning some benefits to the import country. Collected used products are sent from each sales location to the plant together with a list of weights, where they are dismantled and sorted out into 68 categories. In 2005, about 20,000 units of used copiers and printers were collected, of which 99.2% were converted back into resources.

Areas covered by recycling system and routes for recovering used products



Source: Fuji Xerox Co., Ltd.

d) Recycling of wastes from construction sites

Wastes coming out of construction sites include not only concrete and asphalt waste and sludge, but also mixed construction wastes. Mixed construction waste may include not only waste produced in the construction, remodeling, and dismantling of buildings, but also fractional pieces of construction materials, packing materials, and waste materials from provisional structures, which may be mixtures of waste plastic, wood, paper, metal, and so on. According to a survey on the state of by-products from construction by the Ministry of Land, Infrastructure and Transport of Japan, the quantity of construction waste produced in 2005 is about 77 million tons in weight, which represents a decrease from about 83 million tons reported by a similar survey in 2002.

In order to encourage the recycling of construction waste, the Construction Material Recycling Law was established in 2000. This law requires that those who have construction contracts under specific conditions dismantle and separate construction waste and convert them back into resources. It also provides that the rates of concrete blocks, wood products used in construction, and asphalt and concrete blocks recycled into resources will be increased to 95% by 2010.

To enable the recycling and making into resources of mixed construction waste, it is necessary to make them into products with stable properties and qualities. Technologies to sort such mixed construction waste involves sorting it by means of a sieve composed of a combination of rotary gears, removing oils attached on their surfaces with water, washing gravels and sand with water, which is crushed into recycled washed sand. The remaining silt and clay is dehydrated and dried and the material is then burned into recycled artificial aggregate.

Roller screen unit Source: TAKEEI CO., LTD.

Gravity separator Source: Takatoshi Co., Ltd.

Subbase course material Source: Daiko Group

Washed recycled sand
Source: Mud Recycling Association

Column

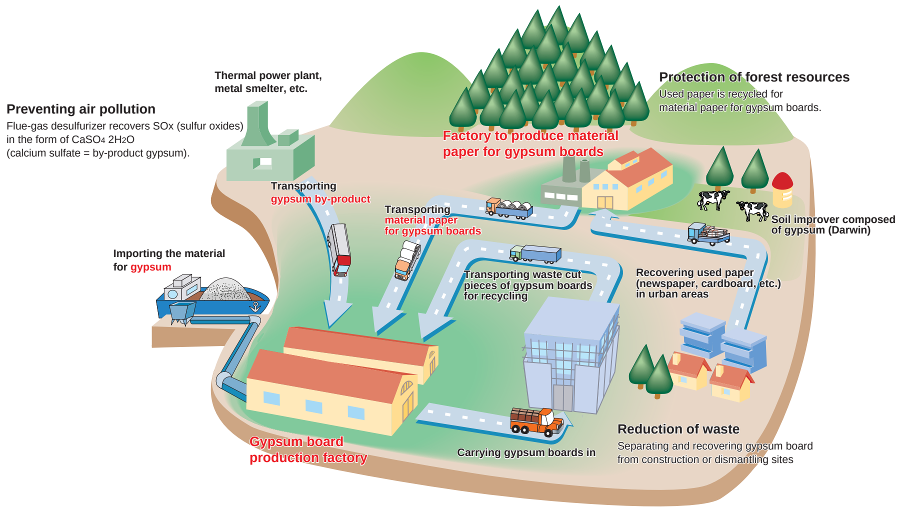
History of recycling gypsum

Sulfur dioxide (SO_2) discharged in the burning of coal or oil is removed by a desulfurization device. A large-scale boiler, for example in a thermal power plant, is based on limestone slurry absorption desulfurization technology. This technology involves using limestone ($CaCO_3$) or slacked lime ($Ca(OH)_2$) to absorb SO_2 to make the limestone or lime into gypsum (calcium sulfate: $CaSO_4$) or calcium sulfate ($CaSO_3$). Gypsum produced in this process has been recycled into gypsum boards for use as a building material for interior walls and ceiling substrates.

In October 1999, however, there occurred an accident at a final stable disposal site in Fukuoka Prefecture where a worker died of suspected hydrogen-sulfide poison. Other similar cases occurred around the country. It was discovered that buried waste gypsum boards can be metabolized by sulfate-reducing microorganisms living in groundwater at the disposal site thus producing hydrogen sulfide.

In view of the above-mentioned fact, the involved parties have made efforts to recycle waste gypsum boards and reduce the quantity of such waste. A technology to recycle waste gypsum boards into boards has now been developed.

Recycling gypsum board



Source: Yoshino Gypsum Co., Ltd.

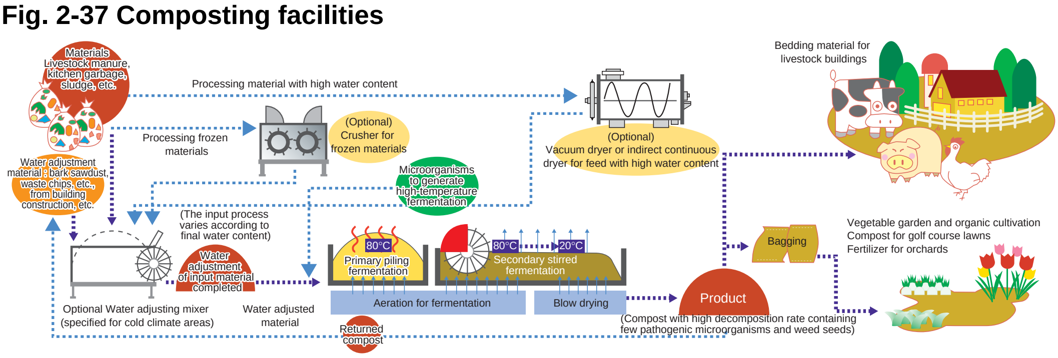
e) Recycling food waste

Food waste is the residues derived from animals or plants leftover during the processes of production, distribution, and consumption. Specifically they are processing residues produced in the food production process, unsold and disposed food products, food leftover after consumption, and cooking garbage. The food waste produced by the food production industry is relatively easy to recycle because it is easier to acquire the quantity of waste required for recycling and because the composition of a food waste is uniform. Such waste is made into compost or fertilizers or oils or fats are extracted from them. As a result, 78% of the food waste produced in the food production industry is recycled. Food waste produced during distribution and at restaurants is also made into compost or fertilizers or oils or fats are extracted from them. As a result, 24% of them are recycled.

Composting technology involves putting food waste into a rotary-kiln fermentation tank and rotating it for two or three days while supplying air to accelerate fermentation. The fermentation tank heats to nearly 60oC because sugars and cellulose (fibers) in the food waste is oxidative-decomposed by microorganisms. Pathogenic bacteria and eggs of parasitic worms are killed so that sanitary compost is produced.

Technology for producing eco-feeds from food waste involves collecting separated food residues suitable for making livestock feed and putting them into a heating and drying process, a fermentation process (drying, liquefying, etc.), a dehydration process by means of deep-frying and depressurizing (a tempura process), or a liquefaction process for making feed, in order to produce livestock feed. (Fig. 2-37)

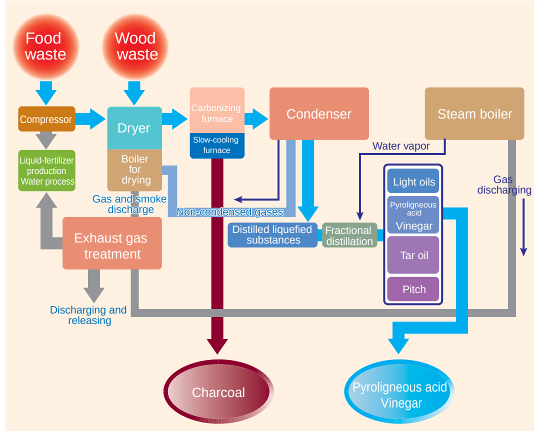
Fig. 2-37 Composting facilities



Source: JFE Environmental Solutions Corporation

Recently technology to make kitchen garbage or wood waste (residues in the agricultural process) into resources, such as fuels, by carbonizing, liquefying, and distilling has been put into practical use. (Fig. 2-38)

Fig. 2-38 Food and wood waste recycling project



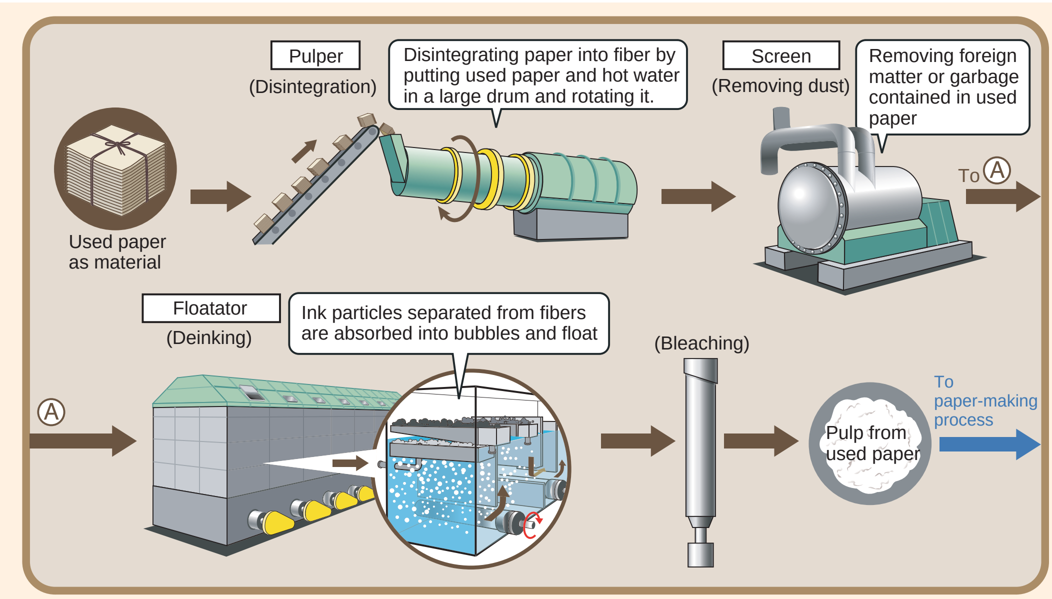
Source: Kansai Saishigen Network Co., Ltd

f) Recycling paper

In recent years used paper has been used in the paper-manufacturing industry at record-breaking rates. The quantity of used paper used in 2005 was about 18.59 million tons. The major area of use for used paper is board papers such as cardboards. In that area the ratio of used paper as materials has reached 90%. On the other hand, in the area of paper in paper manufacturing, the ratio of used paper as a material is less than 40%. For newspaper or sanitary paper products, the ratio has already reached more than 50%. While used paper is used as a material for paper manufacturing on the basis of its advantage in formability, it is also now being used to create other paper products.

The technology for producing used paper pulp for use as recycled paper involves (1) decomposing used paper into fiber in a mixer called a pulper, (2) screening out foreign matter such as sand and plastics, and (3) bleaching the fiber by means of a flotator (bubble-producing device) to make the ink attach to and float with bubbles. (See Fig. 2-39)

Fig. 2-39 Paper-recycled pulp production process

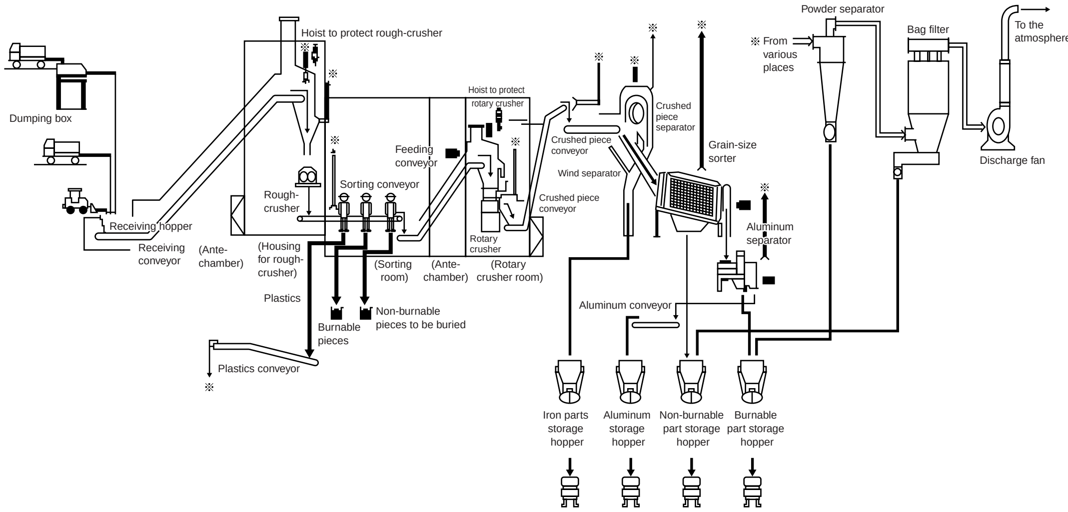


Source: Oji Paper Co., Ltd.

g) Technologies to recycle non-burnable waste and large-size discarded articles

In 2006, the quantity of non-industrial non-burnable waste reached about 2.76 million tons and that the quantity of large-size discarded articles about 800,000 tons. Technology to crush and sort the waste and efficiently convert the valuable portions into resources has been introduced. The technology involves crushing waste and articles with a crushing machine first roughly and then finely into pieces of sizes and shapes that enable efficient sorting by sorting equipment, selecting crushed iron pieces by means of a magnetic separator, sorting crushed grains by means of rotary sieves on the basis of the different grain distributions according to substances to separate non-burnable components efficiently, and further separating non-ferrous components by means of a ferromagnetic drum rotating at high speed. The final residues are burnable. (Fig. 2-40)

Fig. 2-40 Facility for crushing and sorting large-size discarded articles



Source: Kubota Corporation

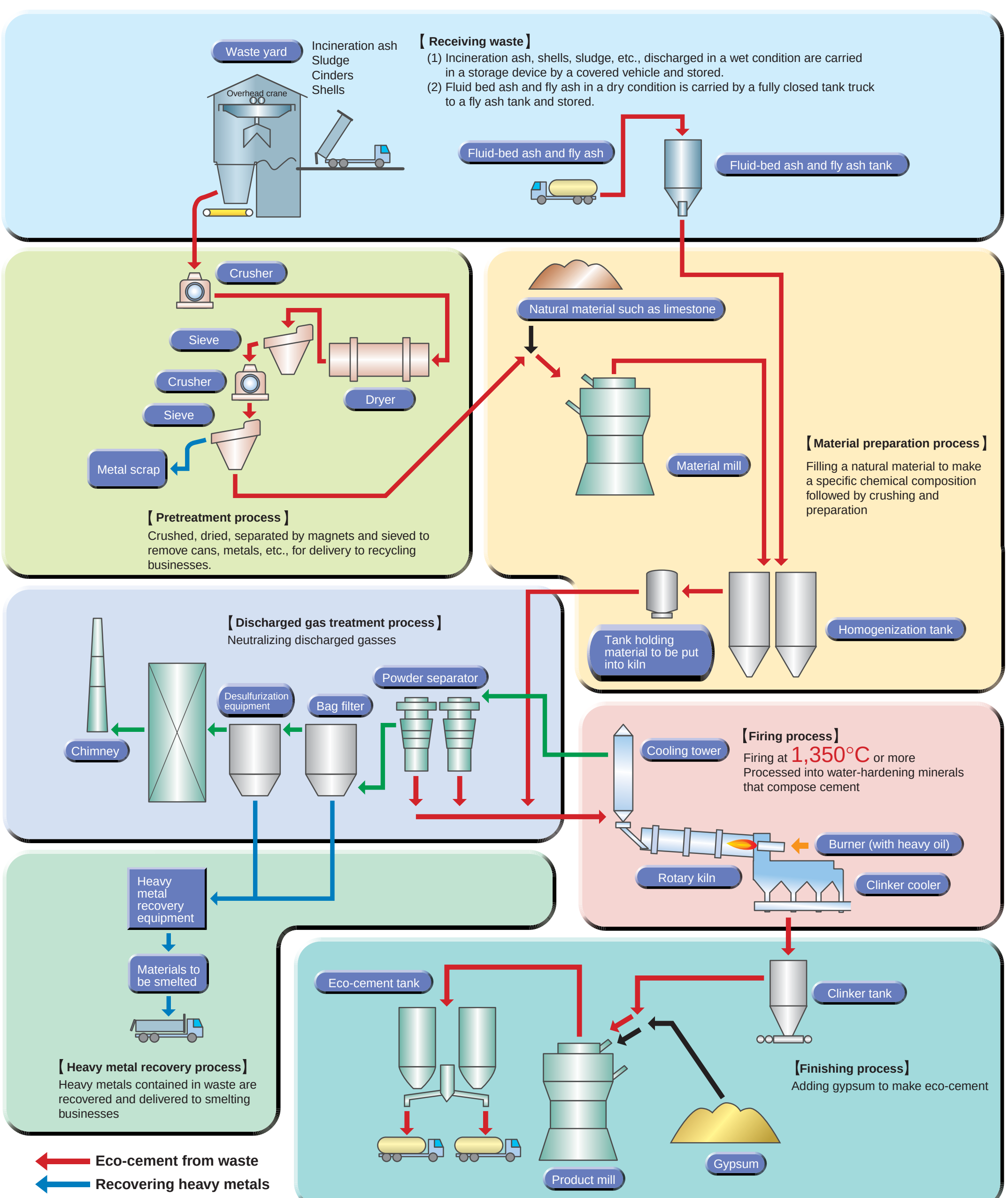
h) Recycling incineration ash

Various waste such as garbage incineration ash or sewage sludge in urban areas are used as a main material (about 50% of the materials) in the production of eco-cement. Eco-cement was included in the Japan Industrial Standards (JIS) in July 2002. Materials for ordinary cement include limestone, clay, silica, and iron materials. In the case of eco-cement, garbage incineration ash, sludge, and so on produced in urban areas is used instead of limestone, clay, and silica. Garbage incineration ash contains all the components necessary for the production of cement and is effectively used as eco-cement. In the process of the production of eco-cement, some heavy metals contained in such ash are separated and recovered.

In the Tama area of the Tokyo Metropolitan Area, an eco-cement production plant that processes and recycles incineration residues and melting fly ash produced in municipal garbage incineration plants into eco-cement is in operation. (Fig. 2-41)

A picture of an eco-cement plant
Source: the homepage of the Tokyo
Tama Extended-area Resource Cycle Cooperative

Fig. 2-41 Eco-cement flow sheet



Source: Ichihara Ecocement Corporation

(4) Waste into energy

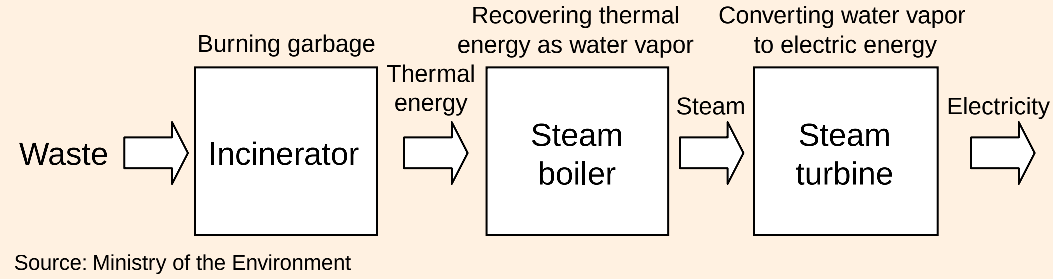
When it is difficult to recycle waste into materials it must be processed by other means such as incineration. Thermal energy produced in such a process can be recovered in the form of power energy or water vapor, a process called thermal recycling. Technology to convert biomass waste such as food waste, livestock manure, and wood waste from construction into methane for use as energy is also being used with increasing frequency.

Today, the reduction of emission of greenhouse-effect gases such as CO_2 is an important issue related to controlling global warning. Thermal recycling converts thermal energy produced by waste incineration into electric power and other forms of energy. Since it replaces fossil fuels it reduces CO_2 emissions. In addition, in view of the fact that biomass contains CO_2 that is fixed from the atmosphere, the CO_2 produced by burning biomass is considered as reintroducing CO_2 that originally existed in the air (the carbon neutral concept). Accordingly, these CO_2 emissions are not included with artificial CO_2 emissions, and substituting biomass for fossil fuel results in a reduction of CO_2 emissions.

a) Waste power generation

Waste power generation involves recovering high-temperature thermal energy produced by incinerating waste by means of a boiler and using the water vapor thus generate to rotate a power generation turbine. It is an effective means of using the heat produced by incinerating plants. The first waste power generation plant in Japan was probably the Nishiyodo Plant of Osaka City established in 1965. Since then, the national government has encouraged waste power generation, by, for example, granting subsidies to construct new incineration plants and equipment for the use of extra heat added to existing incineration plants. As a result, many waste power generation facilities have been constructed around the country. As of the end of fiscal 2004, of the waste incineration plants in operation or under construction, 281 plants are generating or will generate electric power. These power generation plants have a total capacity of 1,491 MW and account for about 20% of all waste incineration plants. (Fig. 2-42)

Fig. 2-42 Outline of waste power generation



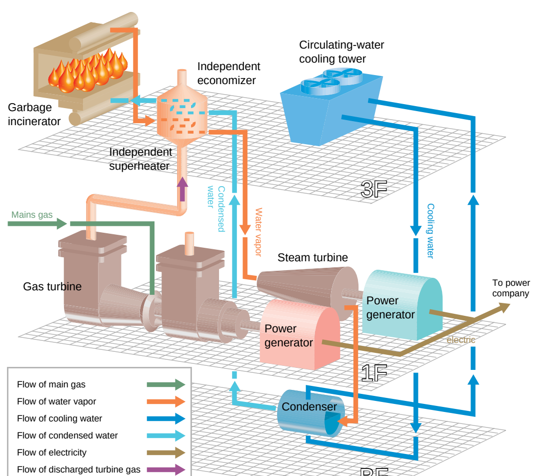
Source: Ministry of the Environment

Waste may contain plastics or vinyl chloride, which produce hydrogen chloride when incinerated. Along with hydrogen chloride, iron chloride and alkali iron sulfate is produced on the surface of metals, which decomposes with dust on the surface. The metal surfaces subsequently rapidly corrode when the surface temperature rise to 350°C-400°C. As a result, waste incineration plants in Japan are designed so that the temperature of water vapor does not exceed 300°C. As a result, the power generation efficiency of waste power generation plants is 10%-15% at the most. More recent plants, however, have an efficiency exceeding 15%. Nevertheless, this rate is low compared to the 40% efficiency of thermal power plants.

“Super waste power generation” is a technique for improving the efficiency of waste power generation. This is a system where natural gas-turbine power generation equipment is constructed in a waste incineration plant. Water vapor produced in the waste incineration boiler is heated to high temperatures with the heat discharged from the gas turbine and used by a vapor turbine for power generation. This system improves power generation efficacy by 20%-25%.

Additionally, the use of gasification and melting furnaces are being increasingly used as incineration equipment. These furnaces thermally decompose waste to produce combustible gases and carbides, and burns them at high temperatures of 1200°C and higher. The heat discharged is used for power generation. (Fig. 2-43)

Fig. 2-43 Example of super waste power generation



Source: Kitakyushu City

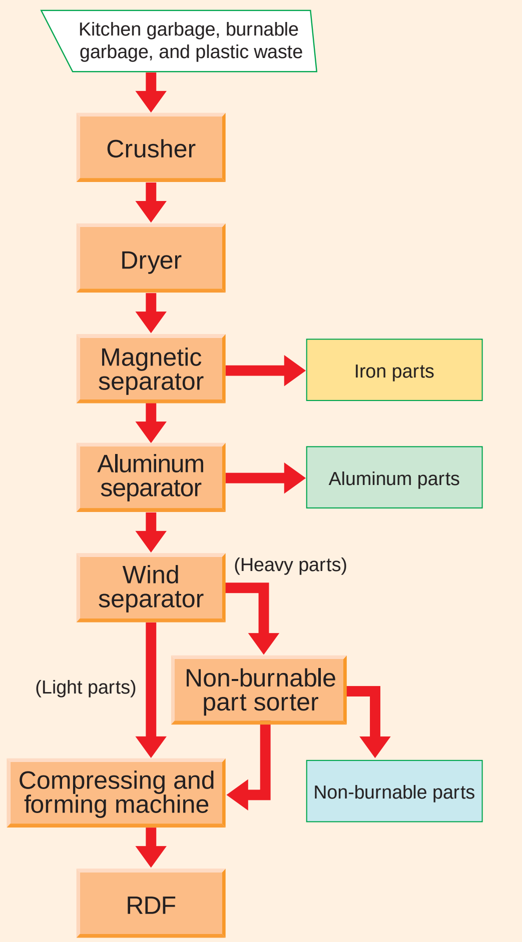
b) Biomass power generation

Power generation using biomass such as wood chips or bagasse (residual pulp of sugar cane after the juice is extracted), among industrial wastes, has also been introduced. The biomass of such industrial waste can be acquired in large homogenous quantities. This type of power generation involves burning wood chips or bagasse in a stoker furnace or a fluidized bed furnace, absorbing burning heat in a boiler, and using it to power a steam turbine. It can supply heat at the same time. The issue of treating chlorine contained in biomass when water vapor is in a high temperature, high pressure state, and the issue of optimizing a series of processes including storage, pretreatment, transportation, supply, and burning of biomass to ensure stable power generation, had to be solved in order to put this technology into practical use.

c) RDF (refuse derived fuel)

Small-scale garbage incineration plants cannot economically implement heat recovery individually. Thus, some small-scale garbage treatment plants process garbage into burnable solid fuel, and the fuel is collected at a dedicated power generation plant. This solid fuel is called RDF (refuse derived fuel). It is produced by crushing and drying burnable garbage, removing the non-burnable, iron, and aluminum portion, adding a preservative to it, and then compressing and forming it. (Fig. 2-44)

Fig. 2-44 Flow of RPF production



Source: Takuma Co., Ltd.

RDF has a heat capacity of about 4,000-5,000 kcal per kg, twice that of ordinary non-industrial waste. Moreover, harmful substances can be extracted in the processing stage, so discharge gases are easy to treat. Furthermore, it is easy to handle because it is a solid and can be transported by ordinary trucks. Additionally, this fuel is easy to make odor free and store because it is dry.

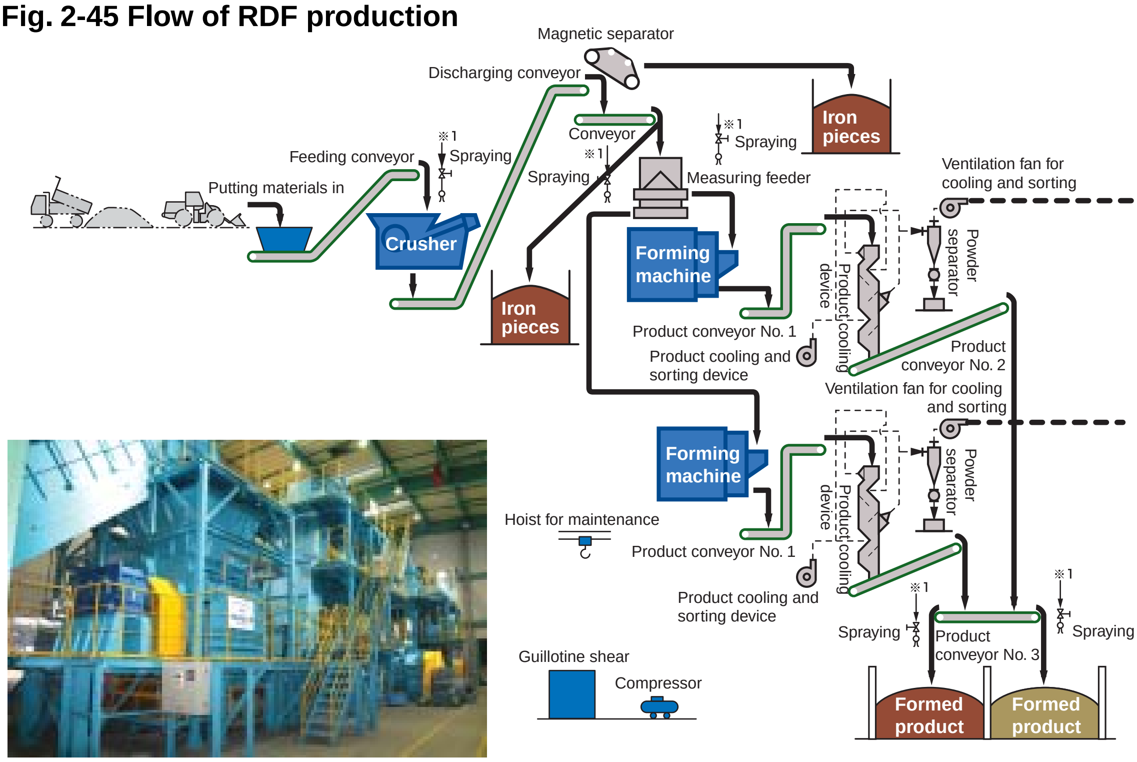
In August 2003, a storage tank exploded at an RDF power generation plant in Mie Prefecture. It was assumed that the RDF may have ignited due to heat generated by fermentation, or that the storage tank might have produced combustible gas. As a result, in December 2003 the Ministry of the Environment (MOE) reviewed RDF production, storage, and property control methods and developed guidelines for the safe production and use of RDF. In September 2004, the MOE revised the Regulations for Enforcement of the Wastes Disposal and Public Cleansing Law in terms of the safe production and use of RDF based on those guidelines in order to reinforce the regulation.

The Fire and Disaster Management Agency, Ministry of Internal Affairs and Communications, studied the actual state of RDF facilities, conducted demonstration tests for possible accidents, and developed safety measures in December 2003. Based on those measures, the Agency revised the Fire Services Law in June 2004, and revised the ordinances to add recycled resource fuels including RDF to the specified combustibles materials in July 2004. These measures went into effect in December 2005. With those revisions, municipal governments added standards for the location of storage and handling of recycled resource fuel, as well as technical standards for the structure and equipment for such storage or handling, to their own fire prevention ordinances in order to ensure safety.

d) RPF (refuse paper & plastic fuel)

Difficult to recycle used paper and waste plastic (excluding vinyl chloride) found mainly among industrial wastes are crushed and then compression-formed after iron pieces are removed. Such formed products are called refuse paper & plastic fuel (RPF). RPF is made from industrial waste, which has an easily known history of being produced as an RDF material in comparison to combustibles derived from non-industrial wastes. Since this does not require a drying process, the production process of RPF is simpler. RPF can have a heat capacity of about 5,000-10,000 kcal per kg by adjusting the mixture ratio of used paper to waste plastic and is used in substitution for fossil fuels such as coal or coke by paper manufacturers and steel manufacturers. (Fig. 2-45)

Fig. 2-45 Flow of RDF production



A general view of RPF production line

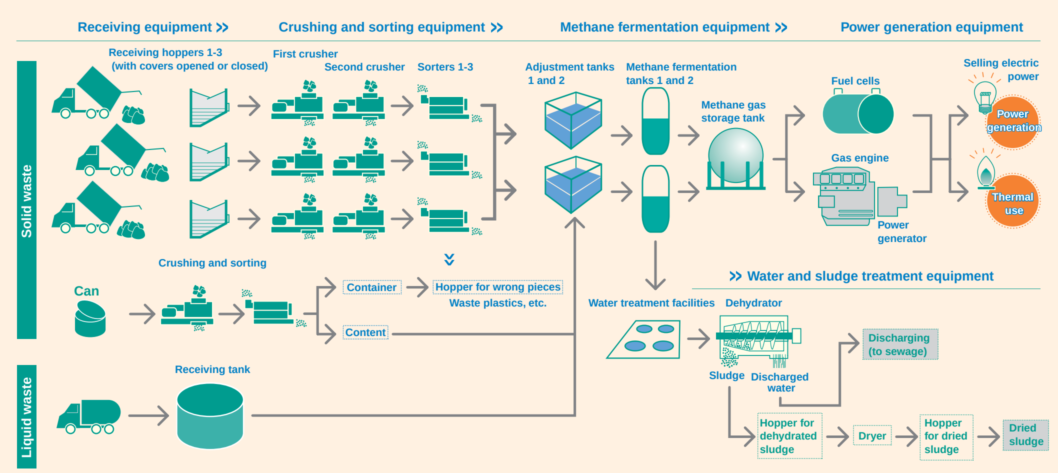
Source: Japan RPF Association Inc.

e) Methane fermentation

Methane fermentation acquires methane from organic substances by an anaerobic fermentation process. It is suitable for biomass waste such as kitchen garbage and animal feces, which have high water content. The methane gas obtained is used as a fuel for power generation.

Residues of methane fermentation can be used as compost and liquid fertilizer. There are also cases where kitchen garbage and sewage sludge are mixed with each other, made soluble, acid-fermented, and then methane-fermented, in order to stabilize the content of the methane fermentation tank and also treat discharged water in the existing facilities of a sewage treatment plant. (Fig. 2-46)

Fig. 2-46 Example of methane fermentation



Source: Bio-Energy Co., Ltd.

Column

Chicken feces power generation plant

In Miyazaki Prefecture, where livestock farming is a major industry, the first chicken feces power generation plant in Japan was constructed in fiscal 2001 and has been in operation since April 2002.

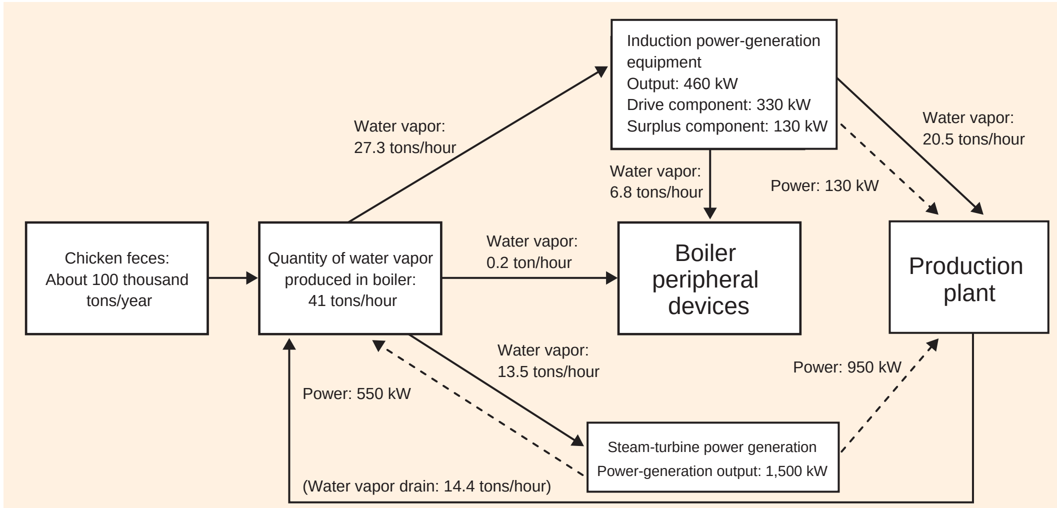
About 50% (100,000 tons annually) of the chicken feces produced all over the prefecture is collected and incinerated at the plant. Water vapor produced in the boiler is used as a heat source in fertilizer production processes as well as for power generation. Incineration ash is granulated into fertilizer.

Outline of project

Number of beneficiary households	Poultry farming households in the prefecture: 232 with 11,914 thousand chickens
	Broiler-farming households among the above: 203 with 8,841 thousand chickens
	Layer-farming households among the above: 29 with 3,073 thousand chickens
Processing plan	Chicken feces: 100,000 tons/year
	Broiler feces among the above: 91,000 tons/year
	Layer feces among the above: 9,000 tons/year
Quantity of incineration ash produced	10,664 tons (to be granulated and sold as fertilizer)

Source: NANGOKUKOSAN Co., Ltd.

Diagram of chicken feces boiler



Source: NANGOKUKOSAN Co., Ltd.

f) Biodiesel fuel

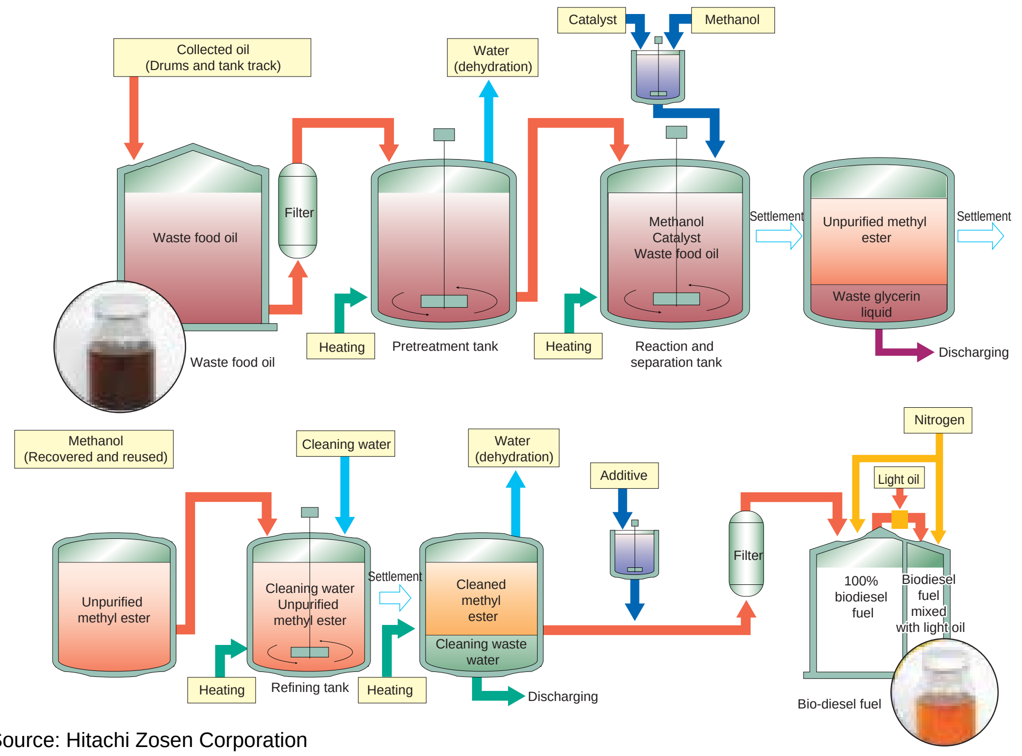
Biodiesel fuel (BDF) can be substituted for light oil and used in automobile diesel engines. It is made from biomass materials such as waste food oil. BDF has low sulfur oxide content, so the exhaust contains low concentrations of sulfur oxides. Since it is an oxygen-containing fuel it promotes engine combustion, making it a clean fuel characterized by low carbon monoxide and dark smoke emissions.

The process of producing biodiesel fuel involves first causing fats (triglycerides) in waste food oil to react with methanol (transesterification) to produce fatty acid methyl esters. Glycerin and other byproducts produced at the same time are separated out from the obtained reaction oil. The remaining oil is then refined into biodiesel fuel.

Kyoto City collects about 125 kiloliters of waste food oil annually at about 1,000 collection sites in the city in cooperation with members of unit communities. The collected oil is made into biodiesel fuel at a dedicated plant with a capacity of 5,000 liters per day. The fuel is used in garbage trucks (equivalent to 210 trucks) and city buses. (Fig. 2-47)

Source: Homepage of Kyoto city

Fig. 2-47 Production of bio-diesel fuel

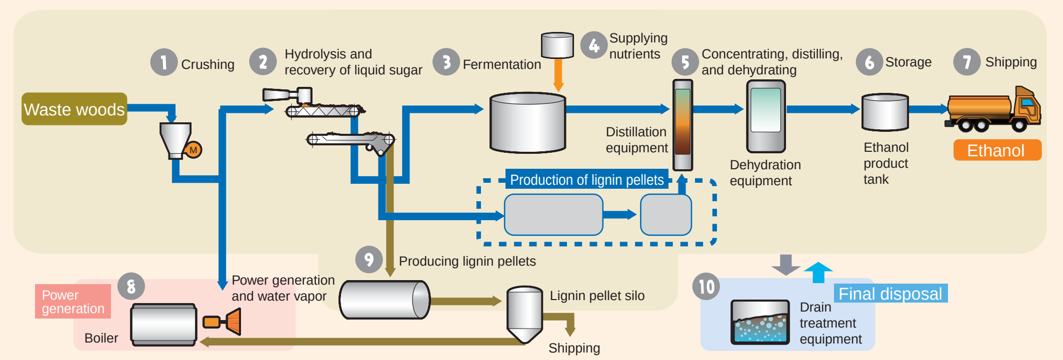


Source: Hitachi Zosen Corporation

g) Bioethanol

Fuel ethanol is produced using construction waste wood as the main material along with paper trash and food residue (tofu refuse, etc.) by means of saccharification by diluted sulfuric acid, two kinds of genetically modified microorganism (KO11), and yeast. (Fig. 2-48)

Fig. 2-48 Production of bio ethanol from waste wood materials



* The technology for producing ethanol used in this plant was provided by Marubeni Corporation and Tsukishima Kikai Co., Ltd.
Source: Bio Ethanol Japan

4 Technologies for metal circulations

Every economic and social activity has a material basis. Metals ? in the form of home appliances, automobiles, and buildings ? are especially important to supporting life in modern society. This section discusses a sound material-cycle society from the perspective of metals, explaining the cyclic use of major metals such as iron, copper and aluminum, as well as and rare metals, and the technologies that enable cyclical use.

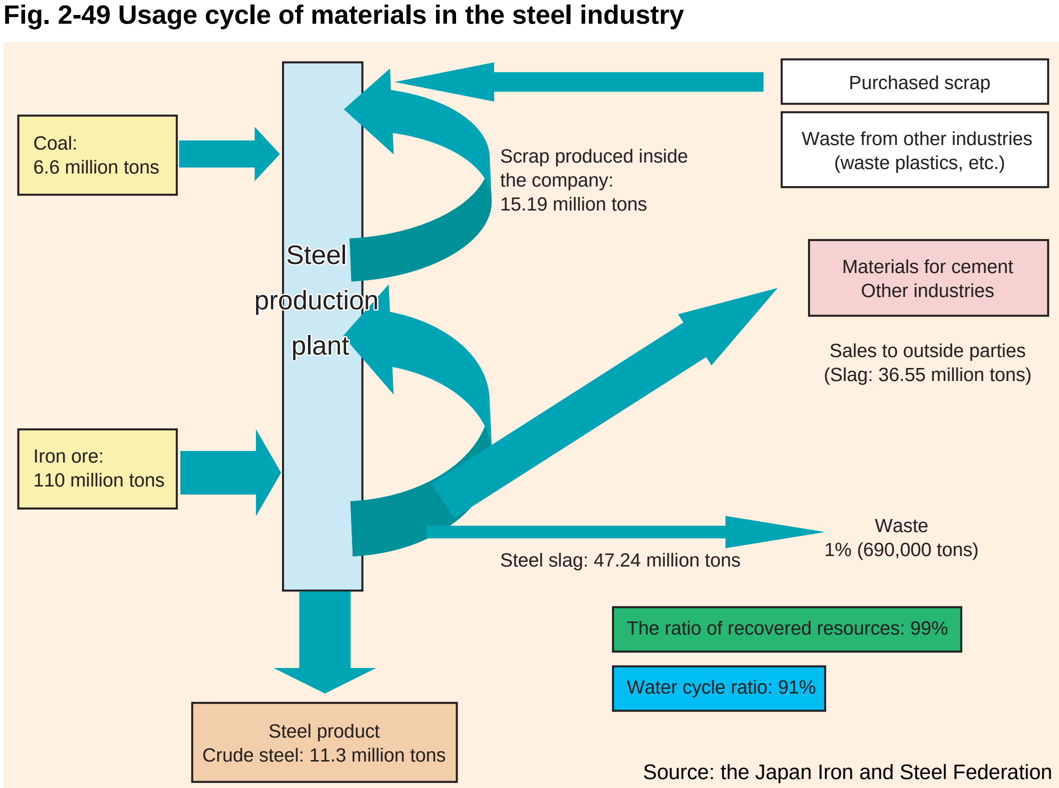
(1) Iron, copper and aluminum

By-products and waste should be recycled and reused or properly disposed whenever recycling and reuse is difficult. The highest priority, however, is to avoid discharging waste. The material industry in Japan is working to reuse and recycle by-products and waste produced in manufacturing processes within a plant as a way to minimize the waste discharged by the production system. The industry also smelts and refines scrap metal collected in town for use in production.

Iron is the most common metal to man. The quantity of crude steel produced in Japan is about 110 million tons annually. The steel industry recycles internally produced scrap and scrap collected in town as a production resource. Every year about 48 million tons of scrap iron is used in electric furnace processes where the scrap is melted by electricity for use in steel production or by blast furnaces where scrap iron is used in the converter step of steel manufacturing in which iron ore and coal are used as materials.

To produce one ton of pig iron, about 1.5 tons of iron ore, about 0.8 tons of coal, and about 0.2 tons limestone are consumed in the production process. Components other than the iron in iron ore melted in a blast furnace to produce pig iron are separated and recovered in the form of blast-furnace slag, including limestone and the ash component of coke, as auxiliary materials. Blast-furnace slag is produced at a ratio of about 290 kg to one ton of pig iron. In the production process with a converter and an electric furnace, about 110 kg of steel-production slag is produced for every ton of pig iron. In the overall steel industry, about 47 million tons of steel-production slag is produced annually, of which 99% is used as materials for cement or road subbase course materials. (Fig. 2-49)

Fig. 2-49 Usage cycle of materials in the steel industry



Column

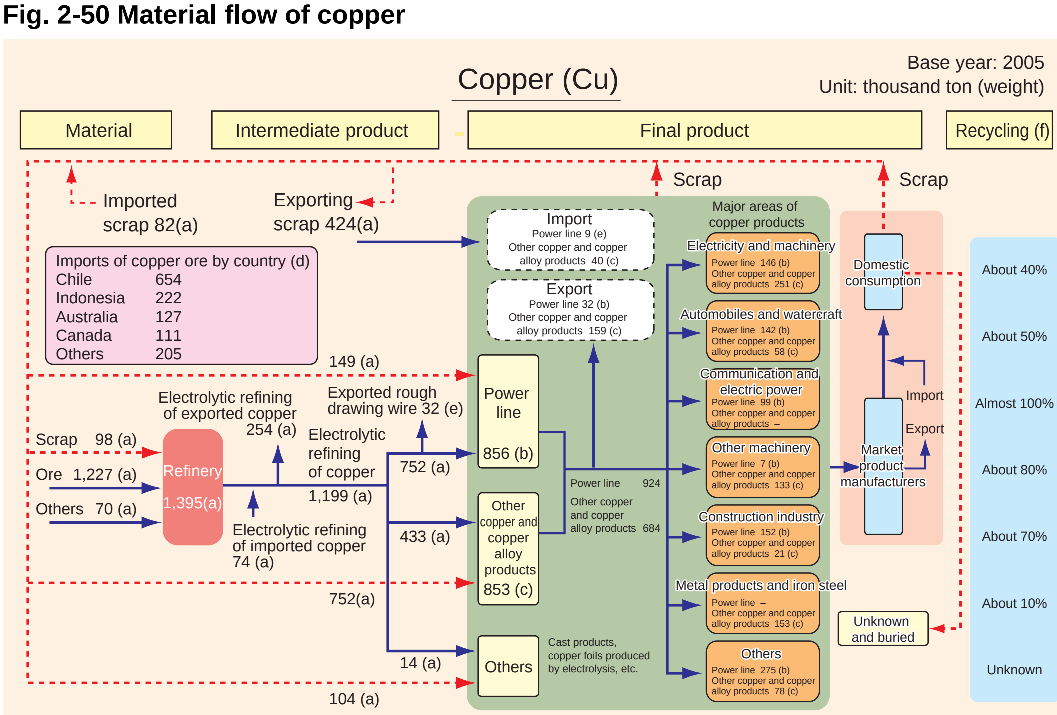
Recycling of waste wood into material for iron production

Some steelworks use technology that uses waste wood, such as packing wood plates and pallets, as an auxiliary material to adjust the carbon component of steel. This technology recovers iron from oxidized iron, such as iron ore, by means of a reducing reaction with the carbon component of wastes wood and also reuses CO gases produced as a byproduct as fuel. As a result, the process contributes to reducing CO_2 emissions during the steel manufacturing process.

Source: Sumitomo Metal Industries, Ltd.

Copper is used as a material for power lines, and copper and copper alloy products such as plates, pipes, and rods, due to its excellent workability and conductivity. In Japan about 1.38 million tons of copper refined by means of electrolysis (copper ingots) was produced in 2004. Copper and copper alloy scrapped after use in products is returned to smelters and copper/copper alloy factories according to the type, quality, and form of the scrap and melted and reused. (Fig. 2-50)

Fig. 2-50 Material flow of copper

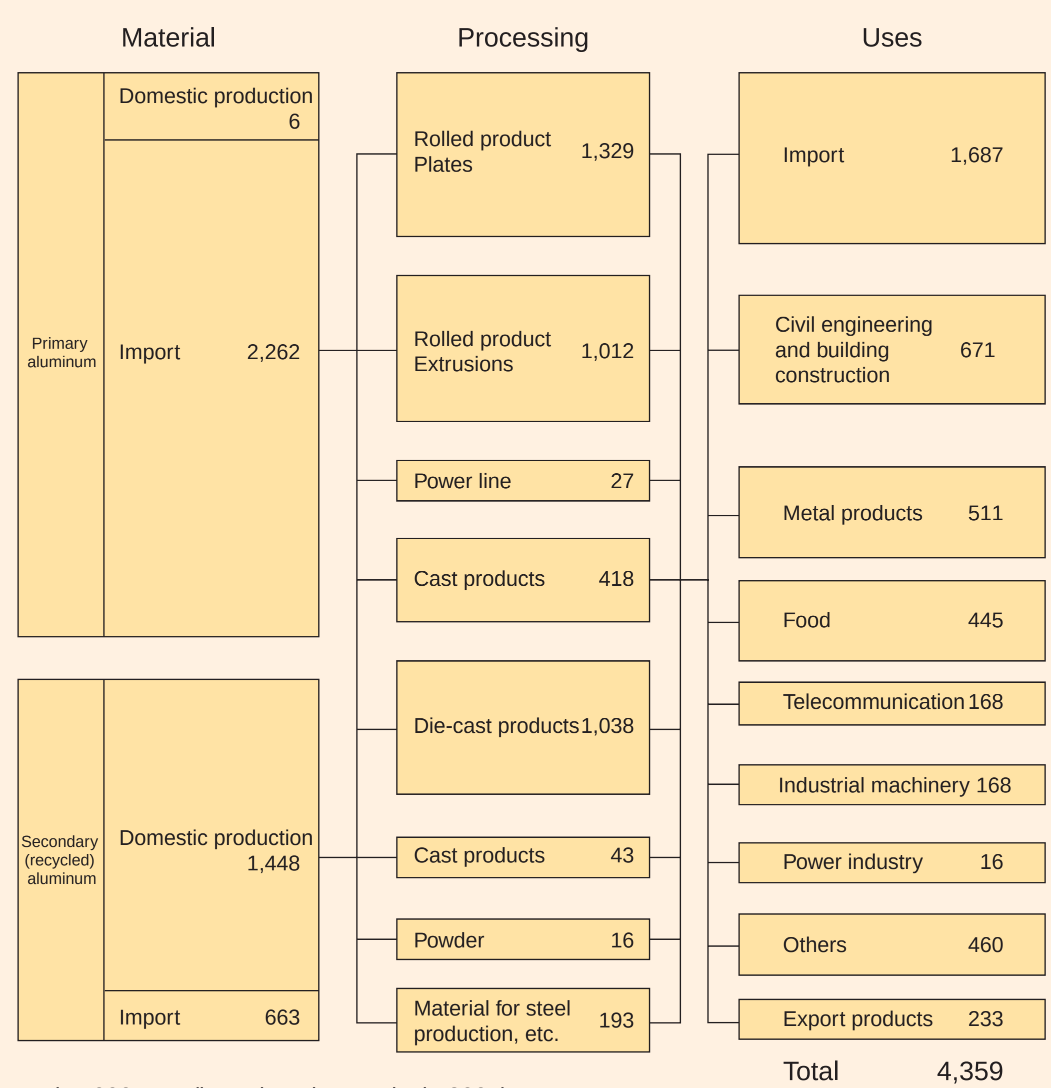


Upstream and downstream (final product) data are not consistent with each other because they are taken from different sources and involve various processes, inventories, and yields.

Sources:(a) "Statistics of Steel, Non-ferrous, and Metal Products" by Ministry of Economy, Trade and Industry (METI)
(b) The Japanese Electric Wire & Cable Maker' Association
(c) Japan Copper and Brass Association
(d) "The Status of Import of Major Non-ferrous Metals according to Countries and Forms" by METI
(e) Trade of Japan
(f) Estimates by Metal Economics Research Institute, Japan

Aluminum is used in transportation equipment, building structures, and food containers due to its lightness and high strength. Because the process of producing aluminum from ore (bauxite) requires an enormous quantity of electricity in the bauxite smelting phase, little aluminum is produced by that process in Japan. Instead new aluminum ingots imported from overseas and recycled aluminum ingots produced from domestic aluminum scrap are used as aluminum materials. In 2004, about 2.5 million tons of new ingots and about 1.96 million tons of recycled ingots were used. As a result, recycled ingots account for about 40% of total demand. (Fig. 2-51)

Fig. 2-51 The Aluminum industry of Japan (structure and import of material)



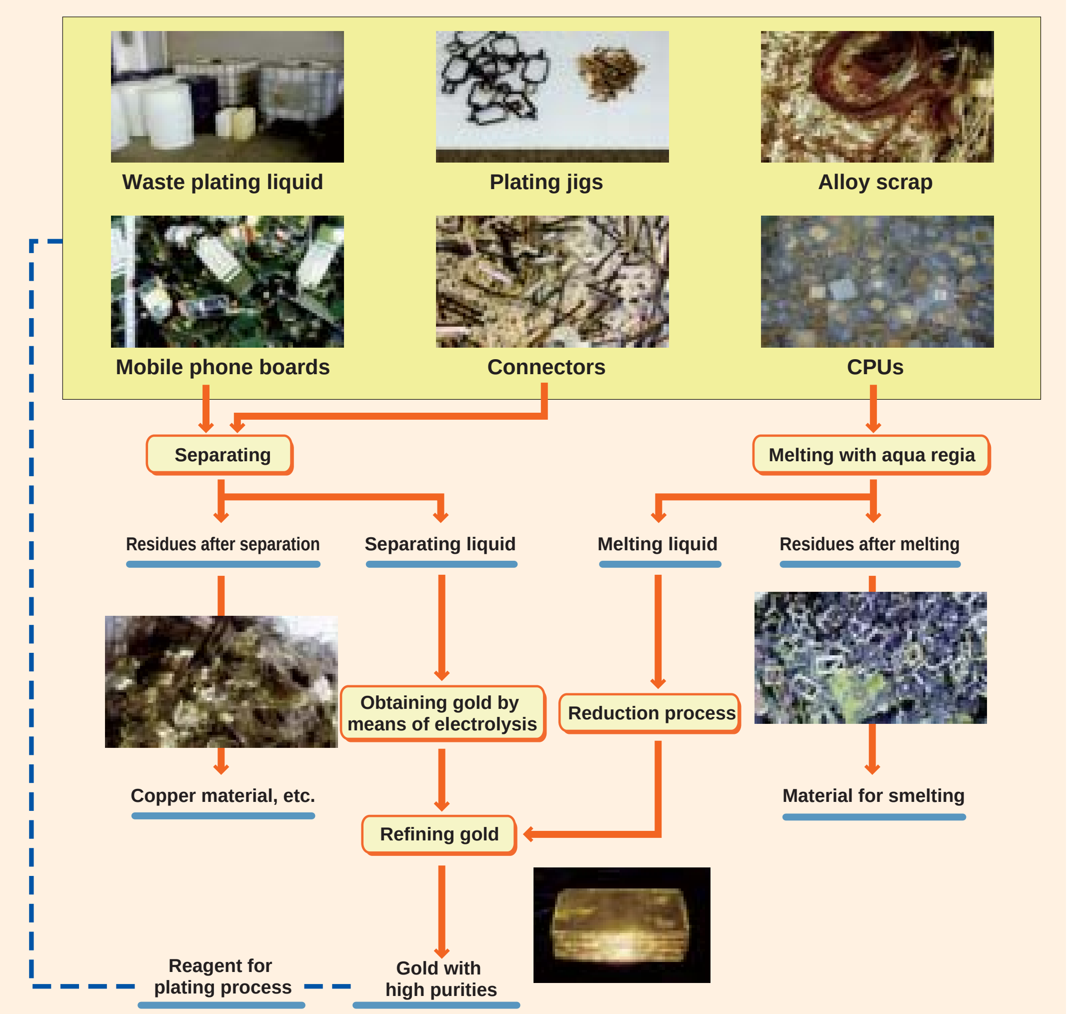
Unit: 1000 tons (based on the results in 2005)

Source: Japan Aluminum Association

(2) Rare metals and heavy metals

While gold and silver have traditionally been used as ornaments, rare metals such as platinum and indium are used in the fields of cutting-edge technologies. For example, platinum is used as a purification catalyst for automobile exhausts; molybdenum and vanadium are industrial catalysts for oil refineries and the production of petrochemicals; and indium is used in transparent electrodes for liquid-crystal panels. Since heavy metals such as lead and cadmium are harmful when discharged into the environment, it is necessary to ensure their recovery from discarded home appliances. Japan has technologies to recover and recycle rare metals and heavy metals from waste as an extension of the metal smelting and refining technologies that it has been developing and acquiring for decades. Specifically, non-ferrous metal smelters and refineries take advantage of enhanced smelting and refining technologies to recover and recycle precious metals such as gold and silver and heavy metals such as lead contained in discarded home appliances, platinum contained in automobile catalysts, and indium contained in intra-process scrap in the production of liquid-crystal panels. (Fig. 2-52)

Fig. 2-52 Example of flow of metal recycling in a smelter



Source: DOWA Eco-System Co., Ltd.

Factory that recovers rare metals and heavy metals from shredding dust

Naoshima Smelter of Mitsubishi Material
Source: Homepage of the Prefecture of Kagawa

There are also technologies where shredder dust produced from automobiles and discarded home appliances and copper-containing sludge are incinerated and melted. After melting the burnable pieces and substances as well as chlorine are removed. Water vapor produced in the recycling process is used as energy, at the same time that copper, lead, and zinc are recovered by copper smelting and refining equipment. Metals are also recovered from melted fly ash produced in non-industrial wastes incinerators by means of similar smelting and refining after the fly ash has been washed with water and chlorine and removed.

Column

Project for collecting and recovering resources from used mobile phones

In cooperation with the Basel Convention secretariat and the Asian countries of Singapore, Malaysia, and Thailand, Japanese companies have established a network on a trial basis to collect used phone mobiles from those countries and transport them to Japan where their resources are recovered. This is the first project that Japanese private enterprises have launched in cooperation with the Basel Convention secretariat.

The project will first research and evaluate schemes to collect used mobile phones in those countries followed by the implementing of a pilot project for transporting mobile phones to Japan for resource recovery. The project period covers the two years of 2006 and 2007. Depending upon the results, expanding the areas covered and items collected will be considered.

Source: Ministry of the Environment

Section 3
POLICIES AND MEASURES TO PROMOTE THE DEVELOPMENT AND INTRODUCTION OF TECHNOLOGIES

Section 2 explained various technologies that support a sound material-cycle society (SMS). The development and introduction of these technologies advanced due to related legal systems and regulations, tax schemes and other economic incentives, and due to independent efforts of enterprises. Section 3 will explain the policies, regulations and the like that promote the development and introduction of technologies supporting a SMS.

1 Legal systems

(1) The Basic Law for Establishing a Sound material - cycle Society

The Basic Law for Establishing the Sound material - cycle Society is a basic legal framework to promote the formation of a SMS. To promote science and technology, it stipulates that the "State shall promote the development of science and technology on the establishment of a SMS, including methods for evaluating the degree of environmental load resulting from the recycling and disposal of recyclable resources, and technologies for restraining products, etc. from becoming wastes, etc. or for appropriate recycling and disposal of recyclable resources." As specific technologies that should be promoted, the law mentions technologies to improve the efficiency of using raw materials when products are made, technologies for the reuse or regeneration of used products, technologies to remove hazardous substances generated with the incineration of waste, and others.

The same law also stipulates that the "State shall take necessary measures, including improvement of research systems, promotion of research and development activities, dissemination of its results, and training of researchers, to promote the development of science and technology on the establishment of sound material-cycle society."

Furthermore, the Basic Plan for Establishing the Sound material - cycle Society, which was established on the basis of this law, requires the state to promote Sound material - cycle society business. These include, for example: (1) the promotion of a green industry, including improvements in product design and production systems to restrict the generation of waste, etc. in the production process of products or to accelerate the recycling of recovered waste, etc., as well as the development of materials with a low impact on the environment, and (2) the collection, organization and provision of technical information, product information such as lifecycle assessment and other information for the development and dissemination of technology. To achieve this, the plan stipulates that proper measures should be taken with the collaboration of industry, academia and the government. Examples include the establishment of an organization for testing and research, the promotion of R&D in line with the needs of industry and the dissemination of results, the establishment of a system for third-party evaluation of the environmental conservation effect, etc. of environmental technology, the training of researchers and engineers to secure human resources that are highly specialized in environmental technologies on a broad basis, or the provision of technical guidance to enterprises, including small and medium-sized companies. As efforts of the state to realize secure and safe recycling and disposal of waste, etc., the plan also defines research on the impact of recycling and disposal of waste, etc. on the environment, including evaluation of the hazardousness of waste, etc., as well as the development and dissemination of technologies for proper treatment.

In line with the rules of this law and basic plan, various measures have been taken to support the development of technology contributing to the establishment of a SMS as mentioned below.

(2) Reinforcement, etc. of the responsibility of waste-emitting enterprises

The Waste management and Public Cleansing Law and its related laws and ordinances have been accelerating the development and introduction of technologies related to the proper treatment of waste by defining standards for the installation of treatment facilities for general waste and industrial waste to ensure proper treatment. In light of the various problems occurring with respect to waste, for example, that the quantity of waste emissions is fluctuating at a high level, that final landfill sites are almost full, that waste incineration generates dioxins, or that illegal dumping is on the increase, the law underwent a number of revisions that led to the development and introduction of new technologies.

The following mentions a few concrete examples: the revision in 1991 imposed the restriction of waste emissions as a purpose of this law, and separation and recycling, etc. as ways for waste management. This accelerated the development and introduction of technologies that contribute to these points. Further, the classification of waste that may inflict harm on human health or the living environment due to hazardous characteristics such as explosiveness, toxicity, infectiousness, etc. as special management waste promoted the development and introduction of technologies for the proper treatment of special management waste.

In the revision of 1997, an exemption scheme was created for the regeneration of certain waste that allows the conduct of treatment business and the installation of facilities without requiring permission provided that an accreditation by the (then) Health and Welfare Minister was obtained. This regulation encouraged the development and introduction of recycling technology. As of present, 122 accreditations (65 for general waste, 57 for industrial waste) have been given on the basis of this regulation, promoting the regeneration of waste rubber tires, waste plastics, waste meat and bone powder, etc. in cement kilns and others. The scope of application of the manifest system for industrial waste was further expanded to all industrial waste, and it is now permitted to use electronic information processing organizations instead of the manifest slips. This has accelerated the development and introduction of technologies to make the flow of industrial waste transparent.

In order to prepare a system for the proper treatment of waste and to prevent improper treatment, the revision of 2000 stipulated, among others, (1) a review of the manifest system for industrial waste to secure proper treatment of industrial waste, (2) reinforcement of the scheme to order remedies such as rehabilitation to the original state in case of illegal dumping and (3) the prohibition of any incineration of waste other than incineration according to the waste management standards. Furthermore, the revision made it obligatory for enterprises with business sites that generate large quantities of industrial waste to draw up a plan for reducing the waste and other treatment. In this way, the revision increased the responsibility of waste-emitting enterprises. Waste-emitting enterprises now have to pay the costs for the proper treatment and recycling of their waste, and this has encouraged the development and introduction of technologies related to proper treatment and recycling of waste.

In the revision of 2003, a wide-area treatment approval scheme was newly created on the basis of the concept of Extended Producer Responsibility (EPR). In this scheme, manufacturers who perform recycling, etc. of waste by conducting waste management in a wide area need not obtain permission for the treatment business if they obtain approval from the Minister of the Environment. Up to now, 169 approvals have been given (65 for general waste and 104 for industrial waste).

The law was revised several more times, promoting the development and introduction of related technologies in a corresponding form.

There are also examples where the rules of the waste management and Public Cleansing Law function in connection with another law. Under the Law for the Promotion of Effective Utilization of Resources, manufacturers conduct voluntary collection and material recycling of designated material recycling products such as personal computers or small rechargeable batteries on the basis of "judgment standards" defined by the Minister of Economy, Trade and Industry. In relation with this, manufacturers do not need permission for the collection, transport and disposal of waste designated material recycling products in a wide area if they fulfill certain conditions and are designated by the Minister of the Environment through the wide-area treatment approval scheme under the waste management and Public Cleansing Law. This helps promote material recycling.

(3) Development of various recycling schemes on the basis of Extended Producer Responsibility (EPR)

Extended Producer Responsibility (EPR) is the concept that a producer bears a certain physical and financial responsibility for the proper recycling and disposal of products even after manufactured products have been used and disposed of. It gives incentives to the producers to develop and introduce technologies to develop and produce products that are not easily disposed of, or that are easy to reuse or recycle. Japan played a central role in the discussions on EPR at the OECD (Organization for Economic Co-operation and Development), and now this concept is internationally standardized.

The Basic Law for Establishing the Sound material - cycle Society clearly demands EPR, ruling that enterprises that manufacture and sell products or containers, etc. must control the generation of waste by improving their durability or enhancing the organization for repairs, and that manufacturers must collect and recycle. Apart from this, Japan has set up recycling schemes according to individual product characteristics, such as containers and packaging, home appliances, food, construction material or cars.

(4) Law for the Promotion of Effective Utilization of Resources

The Law for the Promotion of Effective Utilization of Resources came into force in April 2001. It requires enterprises to 1) design eco-friendly products (design lightweight products or products that are easy to dismantle) and 2) reduce and recycle by-products generated in the manufacturing process and independently collect and recycle used products, further accelerating efforts.

Specifically, enterprises that fall under a designated resource-saving industry type (an industry type that should control the generation of by-products and conduct material recycling) must promote the control of the generation of by-products and material recycling according to the "judgment standards" defined by the competent minister. For example, for the automobile manufacturing industry, which is one of the designated resource-saving industry types, the Minister of Economy, Trade and Industry, who is the competent minister, defined "judgment standards" stipulating that manufacturers must systematically prepare equipment necessary to control the generation of scrap metal, etc. and work to improve the following technologies:

- Enhancement of manufacturing methods to improve the manufacturing yield for metal parts and to control the generation of scrap metal in other ways
- Improvement of technology to use molding sand for a long period of time by enhancing methods to use waste molding sand
- Development of new applications for the use of waste molding sand, for example, as material for civil engineering or soil improvement

In this way, concrete measures are defined to improve technologies related to promoting the control of the generation of by-products and used products, etc. and the use of regenerated resources or regenerated components, and this leads to the development and introduction of related technologies.

(5) Laws and ordinances related to pollution

To treat waste properly, it is necessary to prevent secondary pollution from waste management facilities. The treatment of waste must therefore comply with the emission standards and waste water standards, etc. defined in the Air Pollution Control Law or the Water Pollution Control Law. Specifically, the Air Pollution Control Law defines emission standards, etc. for air polluting substances emitted from fixed sources by substance type and by type and volume of the emitting facility. Waste incinerators (with a fire grate area of 2 m^2 or more or an incineration capacity of 200 kg/hour or more) also must, as facilities which emit soot and smoke, comply with the emission standards related to dust, nitrogen oxide and others.

Meanwhile, the Water Pollution Control Law specifies a part of incineration facilities for general waste or treatment facilities for industrial waste as designated facilities, putting them under the obligation to comply with the waste water standards. To comply with these pollution regulations, the development and introduction of various technologies for preventing pollution in waste management facilities was accelerated.
With the enforcement of the "Law Concerning Special Measures Against Dioxins" in January

2000, Cabinet orders and ministerial ordinances of the waste management and Public Cleansing Law were revised, and the dust and combustion residue, etc. emitted from waste incineration facilities, which are designated facilities, as well as leachate, etc. from final landfill sites became subject to the regulations related to dioxins. As a result, the development and introduction of technology for controlling dioxin emissions also advanced.

Column

Implementation status of the Basel Convention

To address the problem of environmental pollution, etc. caused by hazardous waste crossing country borders, the "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal" came into force in 1992 and was ratified in Japan in 1993. In recent years, the international movement to recycle resources has grown, backed by rising demand for resources due to rapid economic growth in Asian countries, for example. In fiscal 2005, there was no export from Japan to developing countries, but import of nickel-cadmium battery scrap, electronic component scrap, waste fluorescent light bulbs and others was conducted mainly from Asian countries for regeneration, such as recovering the metal or regenerating the glass.

Exports and imports on the basis of the Basel Convention (Fiscal 2005)

Figures in brackets represent FY2004.

Exports from Japan			Imports into Japan		
Reports to the partner country	9 (11)	19,980t (18,822)	Reports to the partner country	25 (16)	9,625t (9,253)
Export approvals	11 (5)	25,220t (10,502)	Import approvals	19 (19)	6,844t (8,562)
Issuance of export movement documents	109 (37)	14,057t (6,510)	Issuance of import movement documents	77 (71)	3,971t (4,812)
Partner country	South Korea, Belgium, United States of America, Canada		Partner country	Philippines, Singapore, Indonesia, Thailand, Malaysia, China, South Korea	
Articles	Lead scrap, solder scrap, lead ash, lead slag, waste potassium nitrate		Articles	Copper sludge, silver sludge, glass cullets (scrapped Brown tubes), electronic component scrap, nickel-cadmium battery scrap, etc.	

Source: Ministry of the Environment

(6) Law Concerning the Promotion of Procurement of Eco-Friendly Goods and Services

If the demand for recycled products, etc. is secured, this will boost supply and provide an incentive for the development and introduction of recycling-related technology. The purpose of the Law Concerning the Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities (Law on Promoting Green Purchasing) is to aim for a shift in demand by promoting the procurement of eco-friendly goods and services by public sections of the state, etc. and by promoting the provision of information related to eco-friendly goods and services. In line with the "Basic Policy Concerning the Promotion of Procurement of Eco-Friendly Goods and Services" (Basic Policy), the various institutions of the state, etc. publicize their procurement policies and procure according to these policies. The judgment standards for the designated procured goods and services defined in the Basic Policy stipulate, for example, that copier paper must have a ratio of pulp from recycled paper of 100% and a whiteness degree of 70% or less, and that uniforms or work wear containing polyester fiber must contain polyester obtained from recycled PET resin (made by regenerating PET bottles or fiber products, etc. as raw material) accounting for at least 10% of the entire product. To make products that satisfy these judgment standards, relevant technologies will be developed and introduced.

2 Economic incentives

For the introduction of technology for the proper treatment of waste or the promotion of 3R, there are also economic incentives, including preferential tax treatment or low interest rates. Specifically, the Special Taxation Measures Law, the Local Taxation Law and other laws define preferential measures such as special depreciation or tax exemptions with a predetermined time limit and financing by government-related financial institutions as schemes to support the development of treatment facilities for industrial waste and others. For example, there is preferential tax treatment for the following industrial waste management equipment: high-temperature incineration equipment, smoke and soot treatment equipment, equipment to treat items polluted with PCB, etc., and equipment for detoxification treatment of waste containing asbestos.

Further, there are the following economic measures for the introduction of equipment that contributes to 3R and fulfills certain conditions.
* Low-interest financing by the Development Bank of Japan, the Okinawa Development Finance Corporation, the Japan Finance Corporation for Small and Medium Enterprise and the National Life Finance Corporation
* Special depreciation and reduced fixed asset tax for the introduction of equipment that contributes to 3R
* Interest subsidies, loan guarantees and other support measures if approval according to the "Law on Temporary Measures to Promote Business Activities for the Rational Use of Energy and the Utilization of Recycled Resources" was obtained for the introduction of facilities contributing to 3R, or for the development of technology related to recycling
As regards low-interest financing, the Development Bank of Japan provided financing in 6 cases (2,620 million yen), the Japan Finance Corporation for Small and Medium Enterprise in 73 cases (6,340 million yen), and the National Life Finance Corporation in 106 cases (1,438 million yen) in fiscal 2005.

3 Standards

The objective of standardization is, for objects or matters that would become diversified, complicated and chaotic if they remain uncontrolled, to "unify" them on a national basis by establishing "standards" as national-level technical documents in view of the following aspects: securing convenience in economic and social activities (securing compatibility, etc.), improving the efficiency of production (mass production through a reduction in the number of articles, etc.), securing fairness (securing profit for the consumer, simplification of transactions, etc.), promoting technological progress (support for the creation of new knowledge and the development and dissemination of new technologies, etc.), maintaining safety and health, preserving the environment, and others. Industrial standardization is standardization in the field of industry. In Japan, the Japanese Industrial Standards (JIS) are established as industrial standards defined by the state. Standards for product performance or testing methods, etc. accelerate the use and dissemination of the applicable technology to a wide scope of industrial activities, etc. and thus contribute to the development of technology since unnecessary overlaps with similar technology development will be avoided, productivity will be improved and labor resources will be focused on making further technology improvements.

In an effort to prepare the Environmental JIS, the Japanese Industrial Standards Committee (JISC), which is the standardization institute of Japan, established an "Action Program for the Promotion of the Establishment of Environmental JIS" in April 2002. The program contains an "Environmental JIS Mid-Term Plan", which is revised every year. The "Environmental JIS" are Japanese Industrial Standards related to the environment and to the recycling of resources. They indicate standards that are useful for the promotion of 3R and others.

As examples of this kind of standards, (1) molten slag aggregate for concrete (JISA5031) and (2) molten slag for road construction (JISA5032) were standardized as JIS in July 2006. These JIS define standards for the elution and content of hazardous substances. In combination with the chemical testing method for slag (JISK0058), they provide a method to evaluate environmental safety for the use of molten slag.

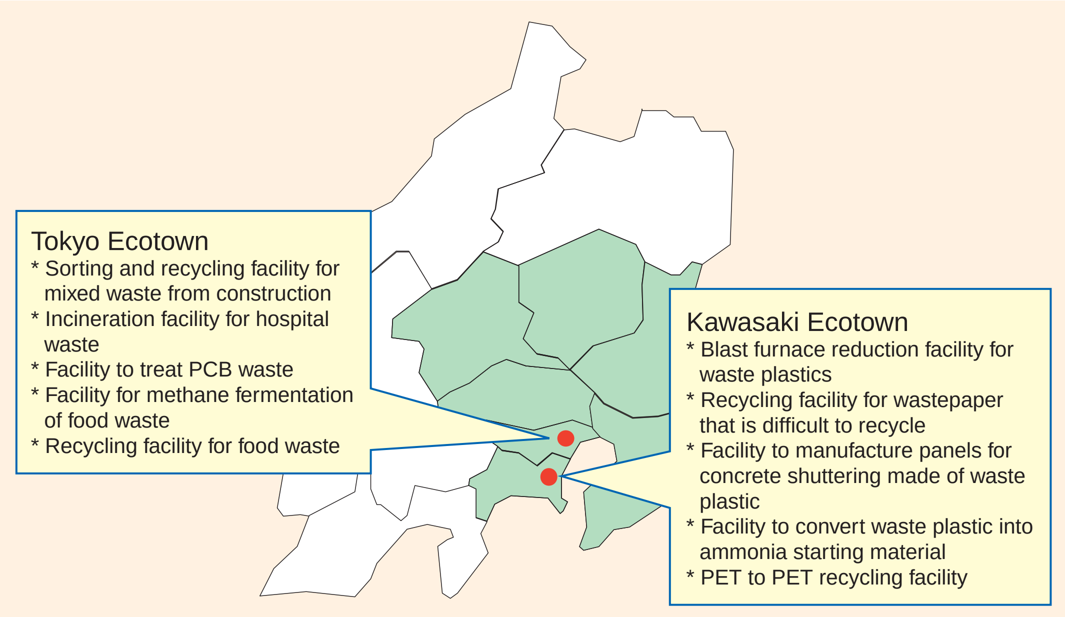
Molten slag Source: Okayama City

4 Ecotowns, etc.

Ecotown projects are a scheme that was created in 1997. The scheme positions the "zero-emissions concept" (which aims to use all wastes generated by an industry as raw material in another field to reduce waste to zero) as the basic concept to form a regional environmentally-friendly economy and society and aims to promote this concept as a cornerstone of regional development to promote an advanced environmentally-friendly town development.
Specifically, if a plan prepared by the prefecture or Cabinet-order designated city (if prepared by a city, town or village, including some administrational service associations, the plan is jointly

signed with the prefecture, etc.) corresponding to the characteristics of the specific region was approved by both the Ministry of the Environment and the Ministry of Economy, Trade and Industry, then comprehensive and multi-faceted support is provided to local governments and private-sector organizations for projects implemented on the basis of this plan. Zero-emission efforts on a regional basis enable the collaboration among different industry types and promise the introduction of even more advanced technology (Fig. 3-1).

Fig. 3-1 Tokyo Super Ecotown / Kawasaki Ecotown



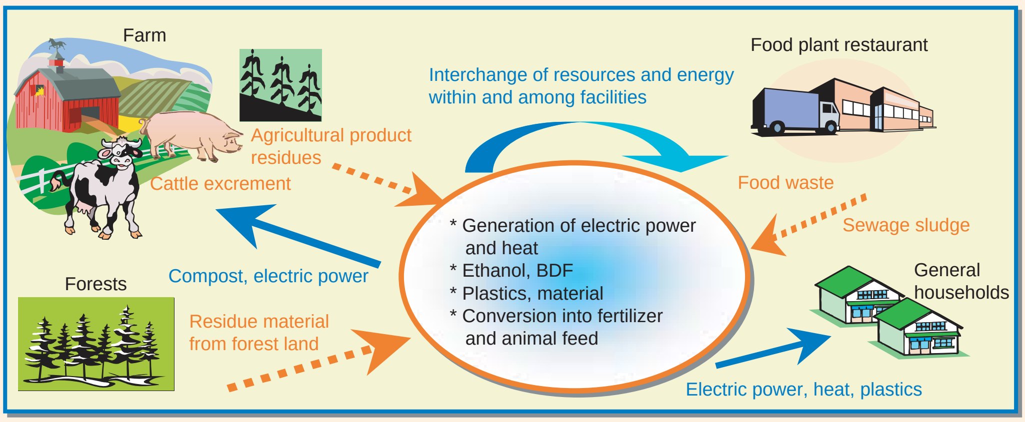
Source: Ministry of the Environment

At the first ecotown, Kitakyushu Ecotown, various recycling businesses for PET bottles, office equipment, cars, home appliances and other items use advanced technology to produce recycled components and recycled raw material, etc. in an effort to become a zero-emissions environmental industry complex through mutual collaboration. Moreover, the recycling residue, shredder dust and other material generated in the town is properly treated in the direct melting furnace of the complex core facility. The molten material is recycled into concrete blocks, etc., and the heat generated is recovered and used to generate electric power, which is then supplied to each recycling plant.

Kitakyushu Eco-Town Source: Kitakyushu City

With cities, towns and villages playing a central role, an overall plan for using regional biomass, the “Biomass Town Concept”, is being developed. As of March 31, 2007, 90 cities, town and villages have announced this concept. In these biomass towns, resources from cattle excrement or food waste, etc. are converted into energy at biomass conversion facilities such as power generation facilities or composting facilities to ensure that biomass is effectively used inside and outside of the regions (Fig. 3-2).

Fig. 3-2 Biomass towns

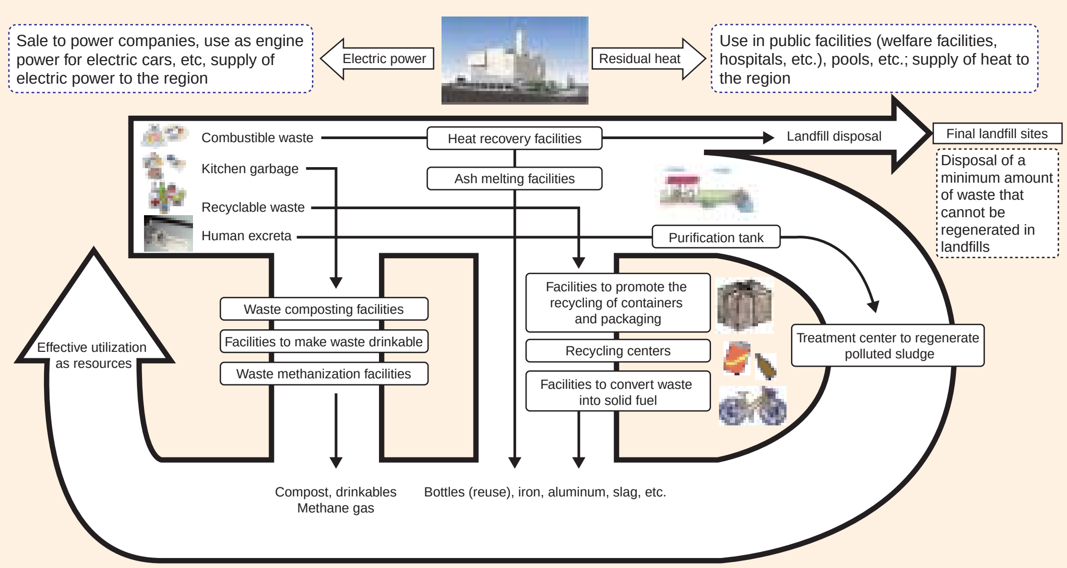


Source: Ministry of Agriculture, Forestry and Fisheries

5 Financial support for establishing a SMS

To date, the state has been promoting measures to deal with the dioxins generated by waste incineration, as well as heat recovery and the recycling of molten slag of general waste through subsidies, etc. for the preparation of general waste management facilities. To develop this further, and adopting the new concept of promoting the establishment of a SMS on a regional basis, the state started, in fiscal 2005, to actively cooperate with cities, towns and villages to create wide-area, comprehensive systems for the efficient recovery of resources and energy from waste with the development of general waste management facilities while utilizing the self-initiative and ingenuity of the cities, towns and villages and using subsidies for establishing a SMS. Under this system, the cities, towns and villages establish a regional plan covering about 5 years (regional plan for the establishment of a SMS) to comprehensively promote 3R, including measures to restrict the generation of waste, to establish an organization for waste separation in the region, to develop recycling facilities for collecting resources and energy from waste, and others. In these regional plans, the cities, towns and villages identify 3R objectives, such as to restrict waste generation, to promote recycling, to recover energy, to reduce waste disposed of in final landfill sites, and so forth. The state works with the prefectures to cooperate in the efforts of the cities, towns and villages from the conceptual phase of these regional plans, and provides subsidies for the cost of developing the facilities on the basis of these regional plans (Fig. 3-3).

Fig. 3-3 Main facilities eligible for financial support for establishing SMS



Source: Ministry of the Environment

The establishment of these regional plans for creating a SMS and subsidies for the cost of developing facilities help to accelerate the introduction of technology to promote 3R.

6 Support for technology development

To accelerate the development of 3R and waste management technologies, various forms of support have been provided. Details will be given in the next section, since this is also related to the future trends in the development of these technologies.

7 Establishment of independent action plans by companies

Japanese industry is working through appeals by Nippon Keidanren to promote recycling and restrict waste emissions. In 1997, an environmental independent action plan was established, and alongside it, an independent action plan for anti-waste measures was created. As of March 31, 2007, 40 types of industry are participating in the anti-waste measures field of the independent action plan, and each industry has identified numerical objectives such as for the recycling ratio or the quantity of waste disposed of in final landfill sites, and has set forth specific measures to achieve these objectives.

For example, the electric power industry defined the objective of making the waste material-recycling ratio in 2010 at least 90%, and to achieve this, stated it would actively work to open up fields where coal can be stably used in large quantities, and to conduct research and development on technologies for effective utilization. These independent efforts of enterprises will accelerate the development and introduction of technologies necessary for the proper treatment of waste and the promotion of 3R.

As described, the development and introduction of various technologies have been accelerated by incentives based on various schemes. On the other hand, the schemes started to function and produce positive effects because of the actual development and introduction of technology. When designing schemes to build a SMS in the future, it is necessary to monitor the development and introduction of related technologies.

Further, the individual technologies identified in Section 2 do not function by themselves, but only function as a system. This is another point that needs to be considered. For example, when conducting methane fermentation using biomass waste, an effective collection and stable supply of suitable waste is required, and there needs to be a user of the resulting methane gas located in the vicinity. When designing a scheme, it is important to consider this kind of technology introduction as a system.

Section 4
DEVELOPMENT OF 3R AND WASTE MANAGEMENT FACILITIES AND INTERNATIONAL CONTRIBUTIONS IN THE FUTURE

The previous sections examined the various technologies for forming a SMS and the policies that accelerated their development and introduction. This section will give an overview of research and development for improving 3R and waste management technology, and the state of technology development. It will also describe international contributions on the basis of Japan's excellent 3R and waste management technologies, as well as Japan's role in using these technologies as a summary of this document.

SECTION 4

1 Research and development for improving 3R and waste management technology

In the "Promotion Strategies by Field", which were decided in the Council for Science and Technology Policy in March 2006 under the Third Science and Technology Basic Plan, which was decided by the Cabinet in March 2006, the area of 3R technology research was selected as a high-priority research area in the next five years in the environment field. This is a research area to achieve the "effective utilization of resources and reduction of waste using 3R or resource-saving alternative technologies", which is one of the individual policy objectives in the environment field. By promoting such research, the strategy aims to ensure the effective and circulating use of resources and proper waste management in a way that meets people's demands for security and safety using new substance control methods. As specific research and development issues, three programs are listed: "technology for the design, evaluation and support of systems for resource-recycling production and consumption", "technology to manage the usability and hazardousness of recycling resources", and "technology for recycling and proper treatment or disposal of waste". For each program, priority issues for research and development were established.

Further, the Central Environment Council compiled a report on "Promotion Strategies for Environmental Research and Environmental Technology Development" in March 2006, and the "area of building a sound material-cycle society" was established as a focus area for research and technology development also in this report. The focus issues listed include "research on systems for the proper management of waste in the Asian region on the basis of 3R technology and the social system", "research on economic techniques and other policies and techniques to promote reform towards a sound material-cycle society", "sophistication and practical application of recycling technologies and systems related to recycled resources", "research on the standardization of recycled articles and regenerated products" and "research and technology for the proper management and utilization of old final landfill sites".

Various research and technology development is being conducted in line with this direction. The subsidies for scientific research on waste management, etc. are used to promote research projects on establishing the SMS and solving various problems involving waste, technology development projects, and others. The following three projects use these subsidies: the "research project on waste management measures", the "project to develop the technical foundation for next-generation waste management technology" and the "project to promote research on waste measures." In particular, a special budget for 3R incentives was created in fiscal 2006 in the subsidies for scientific research on waste management, etc., targeting research and technology development related to international 3R. These research projects use the top-down method and have the theme "constructing a system for international recycling of resources and proper waste management optimized for the environment of the Asian region". The research conducted during the three-year research term is shown in Table 4-1.

Table 4-1 3R technology research

No	Representative research institute	Research issue
1	Kyoto University, Environment Preservation Center	Analysis of residual chemical substances in household waste products and 3R scenarios
2	National Institute for Environmental Studies, Research Center for Material Cycles and Waste Management	Lifestyle comparison techniques for scenarios including overseas recycling, and application to waste plastics
3	National Institute for Environmental Studies, Research Center for Material Cycles and Waste Management	Analysis of the resource recycling system of waste electric and electronic components and waste plastic in the Asian region
4	Sophia University, Graduate School of Global Environmental Studies	Comparative research on recycling systems in various Asian countries
5	Tohoku University, Graduate School of International Cultural Studies	Analysis of extended producer responsibility schemes in Japan and South Korea, and research on forging partnerships
6	JETRO, Institute of Developing Economies	State of recycling in the Asian region and international resource recycling management/3R policies
7	Kumamoto University, Faculty of Law	Comparative research on car recycling systems in the Asian region

Source: Ministry of the Environment

Further, the "Strategic Technology Roadmap 2007", established by the Ministry of Economy, Trade and Industry in April 2007, lists 3R as one of the points in the environmental and energy field, and for 3R-related technology for reducing waste disposed of in final landfill sites and for effectively using resources, the roadmap sets policy objectives to be achieved by fiscal 2010 and a technology strategy roadmap for the next 30 years. Specifically, the following items were selected as key issues: "reduction of waste disposed of in final landfill sites", "construction stock (construction waste)", "3R for metal resources" and "3R eco-design and regeneration production technology". The technologies necessary to solve these issues are detailed in the roadmap. Further, several relevant policies for technology development and practical application as technology development strategies were bundled in a package as the "3R program" for a systematic approach to research and development as well as technologies for practical application contributing to the promotion of 3R. The policies in the package are mainly in the technology development fields listed in the "Technology Strategy Map" that the state should get involved in. Specific efforts in fiscal 2006 included, for example, the development of technologies for removing substances hindering recycling in the design and manufacturing phase of a product, maintenance technologies that prolong the life of buildings and architectural structures, technologies to reinforce construction material, and technologies to improve and facilitate the recycling of steel sheets for cars.

Further, projects to subsidize practical application in order to disseminate and promote 3R technology were carried out (projects based on public invitation for proposals).

In the research and development term from April 2005 through March 2009, a project for encouraging advanced technologies for recycling sewage sludge (LOTUS Project) is in progress. The project targets the sludge generated in sewage works, with the goal of cutting costs to promote the recycling of sewage sludge. The project aims to develop a "zero sludge discharge" technology (technology that enables recycling more cheaply than disposing of sewage sludge) and "green sludge energy" technology (technology that uses the biomass energy of sewage sludge, etc. for producing electric energy at the same or lower cost than commercial electric power rates). The technology developed to date includes technology to combine biomass and sewage sludge, digest it, increase the quantity of digestion gas generated and use it to generate electric power.

In addition, technologies in the field of agriculture were developed when the potential quantity of biomass in the region became clear. These include, for example, technologies for systemization in order to recycle animal feed and fertilizers or industrial raw materials, etc. as resources, technology to reduce the odor of cattle excrement, etc. and recycle them, and technology for recycling organic waste such as food processing remainder and waste from facilities in the agricultural, forestry and fishery industries.

Column

Research network on 3R waste management in the Asia-Pacific region

In November 2006, the 2nd Expert Meeting on Solid Waste Management in Asia-Pacific Islands was held in Kitakyushu city, with 14 experts attending from 10 countries and 2 regions, including China, South Korea, Thailand and the Philippines.

2nd expert meeting on solid waste management in Asia-Pacific Islands

This meeting aims to form an expert network in the Asian-Pacific region to improve waste management and promote 3R by sharing experiences. Another objective is to promote international research cooperation by sharing knowledge on waste management.

As a result of this meeting, the Society of Solid Waste Management Experts in Asia & Pacific Islands: SWAPI (preliminary name) was set up to promote cooperation in the field of waste management, including 3R.

2 International contributions on the basis of 3R and waste management technology

As shown in Section 1, the movement of recycled resources, including waste, is not limited to Japan, but extends beyond country borders. Further, resources and energy are becoming increasingly tight on a global scale, and the international community must make concerted efforts to address global environmental problems, particularly global warming. Therefore, the establishment of a SMS that restricts the consumption of natural resources and eases the burden on the environment through 3R must be promoted not only in Japan, but also on an international basis. Japan must play a leading role in promoting international efforts to build a SMS, and disseminating the 3R and waste management technology owned by Japan on an international scale will be the core of such cooperation. International contributions on the technical side using Japan's strengths will create a virtuous circle of the environment and the economy. The technologies for 3R and waste management also include some that can help reduce greenhouse gas emissions as clean development mechanisms (CDM) projects under the Kyoto Protocol.

The international development of 3R and waste management technology will advance on a broader and deeper level by focusing on the following two points. The first is that technology transfer requires identifying the economic and social situation in each country in advance while protecting intellectual property rights. In a country with an economic development level and a productivity that is largely different from Japan, the most advanced technology is not necessarily required, but rather a technology that matches the environment and economy and that is accepted by society.
Active bilateral and multilateral policy talks and information exchanges are needed to grasp the technical needs of these countries.

The second point is that technology only functions if it is incorporated into a suitable system. This system includes the human resources that actually operate the technology, as well as schemes, etc. to accelerate the introduction of that technology. In other words, to transfer technology, it is crucial to also transfer experience and know-how related to its operation, and to train human resources in the local country. As shown in Section 3, the development and introduction of technologies requires schemes providing backup and incentives in many cases. For example, if waste-emitting enterprises are not made fully responsible, then they will probably select cheap but inferior treatment instead of paying the cost necessary for proper treatment or recycling of the waste. Thus, the role of technology within the entire system must be considered when rolled out on an international basis.

3 Our role in using technology

The 3R and waste management technologies, the policies and schemes to accelerate their development and introduction, and efforts and collaboration of the respective entities operating them described in this document, are the "Japanese model for a sound material-cycle society". Particularly, technology for 3R and waste management is a valuable asset of Japan. The development and introduction of these technologies are backed by solid efforts of countless engineers and experts to resolve various technical issues, as well as Japanese culture that does not tolerate waste and strives to use the true worth of things.

To promote our 3R efforts, including the development and introduction of these technologies, the "3R Promotion Forum" (Chairperson: Hiroshi Komiyama, Ph.D., President of Tokyo University) was established in Japan to engage in various activities.
With the shrinking population and changing attitudes to life, Japan will become a more mature

country. In the future, it will be important to develop and introduce more efficient and effective 3R and waste management technologies befitting a mature country, and to create frameworks for these technologies. Even more important in such a society is to use technology appropriately without allowing technology to dominate. In other words, not everything can be solved with technology. Instead, we all need to lead a sustainable lifestyle ourselves. For example, to use recycling technology more effectively, the recycling resources delivered to a recycling facility should be of stable quality. To achieve this, we must separate waste properly in the emission phase. The utilization of technologies related to "reduce" and "reuse", which have a high priority among the 3Rs, also depends on reforming our economic and social activities. This reform of our lifestyles will extract even more of the intrinsic value of technologies, sending out more excellent technologies into the world.

About 6 years have passed since the first white paper on the sound material-cycle society was published on the basis of the Basic Law for Establishing the Sound material - cycle Society in June 2001. The introduction of this first white paper on the sound material-cycle society closes with the remark "For a truly affluent 21st century, for a second millennium that enables a striking development of humankind, we must first fundamentally revise our one-way economic and social structure of mass production, mass consumption and mass disposal, and make concerted efforts to build a SMS with a proper division of roles for any entity in our society."

Examining the developments of the last six years from this starting point, can we say that the construction of a SMS has made progress? Certainly, the numbers for the three indicators for the Basic Plan for Establishing the Sound material - cycle Society (resource productivity, recycling ratio and quantity of waste disposed of in final landfills) are improving, and certain progress can be seen. But looking at the emissions of industrial waste, the emissions of 2004 (417 million tons) are about 2% below the emissions at the peak in 1996 (426 million tons), but compared to the emissions of 2001 (400 tons) there is an increase of about 4%. This means that the restriction of waste generation (reduce), which has the highest priority among the 3Rs, is not sufficient, and further efforts are needed. Further, regarding efforts for "reuse", the use of returnable bottles such as beer bottles used to be normal, but as people's lifestyles have changed, the number of returnable bottles used has been declining. The efforts for "reuse" require each person to be aware of the value of things. People need to review their lifestyle and step up their reuse of things.

As this document has shown, technologies to support the SMS already exist. To extract the intrinsic value of these technologies and attain the SMS, we need to review our social and economic activities and our lifestyles, and to make continuous efforts in our everyday lives.

Stop Global Warming

Team minus 6%

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