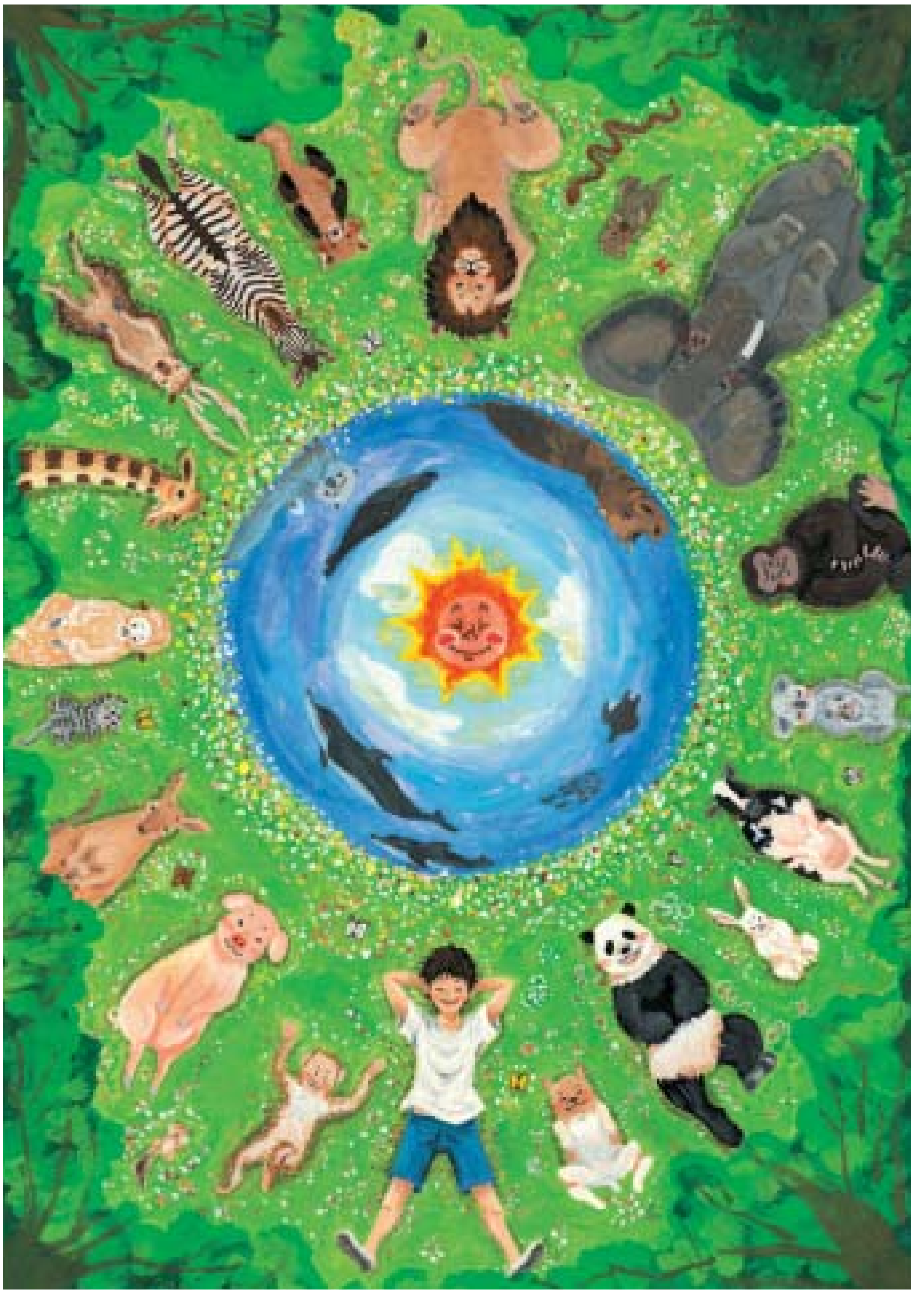
Abridged and Illustrated for Easy Understanding

Annual Report on the Environment and the Sound Material-Cycle Society in Japan 2007

Overview 1:
Accelerating Global Warming and Countermeasure Technologies

Overview 2:
Technologies to Support a Sound Material-Cycle Society
—Development of 3R and Waste Management Technologies—



Ministry of the Environment

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Part 1

Overview

Overview 1

Accelerating Global Warming and Countermeasure Technologies

Chapter 1

Accelerating Global Warming

Global warming has been accelerating. The term "global warming" is now widely recognized, but in reality expectable outcomes and its impacts on our lives are not thoroughly understood by people.

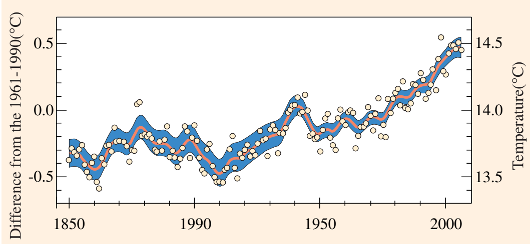
1. We are Currently Facing Accelerating Global Warming

The Intergovernmental Panel on Climate Change (IPCC), which is a framework to estimate the climate change caused by greenhouse gases (GHG), to assess its potential impact on nature, society and the economy and to assess options for mitigation. It is currently finalizing its Fourth Assessment Report (AR4).

According to the report issued by the IPPC's Working Group I (WG1), which presents the physical basis of Climate Change, the global atmospheric concentration of carbon dioxide has increased 1.4 times from a pre-industrial value of about 280 ppm to 379 ppm in 2005. The report also explains that the updated 100-year linear trend (1906 to 2005) of global mean surface temperatures is 0.74°C [0.56°C to 0.92°C]. In addition, the linear warming trend over the last 50 years (0.13°C [0.10°C to 0.16°C] per decade) is nearly twice that for the last 100 year.

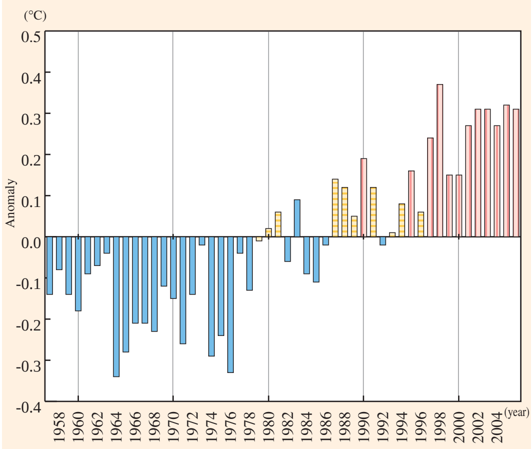
The AR4 WG1 report (the IPPC report issued by its Working Group I for the Fourth Assessment Report) says that eleven of the last twelve years (1995–2006, excluding 1996) rank among the 12 warmest years in the instrumental record of global surface temperature (the average of near-surface air temperature over land and sea surface temperature) since 1850 (Figure 1-3). The IPPC's Third Assessment Report issued

Figure 1-2: Changing global average temperature



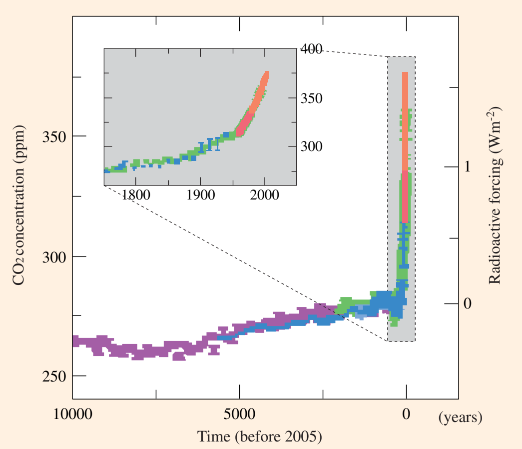
Source: *IPCC AR4 WG1 Report*

Figure 1-3: Annual Anomalies of Surface Temperature Anomalies for the past fifty years



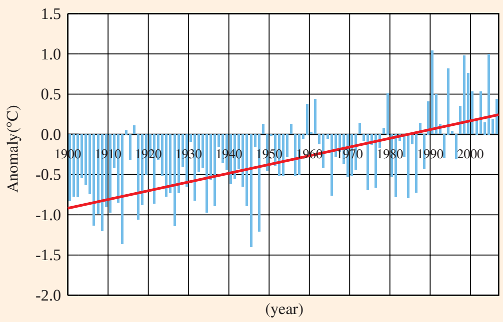
Note 1: Red bars indicate the warmest twelve years since 1850.
Note 2: Anomalies are deviations from normal (1971 - 2000 average).
Source: Compiled by the Ministry of the Environment based on the Japan Meteorological Agency data.

Figure 1-1: Changing CO_2 concentration from ice core and modern data



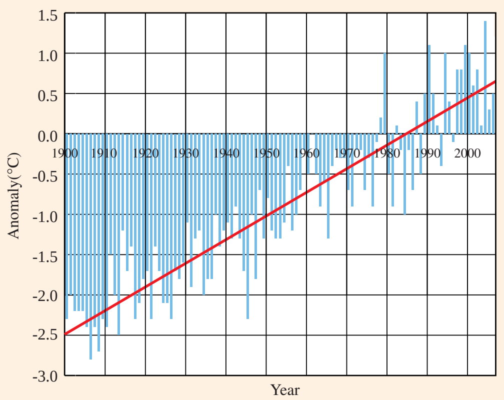
Source: *IPCC AR4 WG1 Report*

Figure 1-4: Yearly mean temperature anomalies in Japan



Note 1: The data is based on the past observation records of monthly mean temperatures in Abashiri, Nemuro, Suttsu, Yamagata, Ishinomaki, Fushiki (Takaoka City), Nagano, Mito, Iida, Choshi, Sakai, Hamada, Hikone, Miyazaki, Tadotsu, Naze and Ishigakijima .
Note 2: The bars indicate anomalies against normal (for thirty years from 1971 – 2000 average of the 17 stations).
Note 3: The red line indicates a long-term linear trend.
Source: Compiled by the Ministry of the Environment based on the Japan Meteorological Agency data.

Figure 1-5: Annual Average Temperature Anomalies in Tokyo



Note 1: The bars indicate anomalies against normal (for thirty years from 1971 to 2000).
Note 2: The red line indicates a long-term linear trend.
Source: Compiled from the Japan Meteorological Agency data by the Ministry of the Environment.

in 2001 explains globally it is very likely that the 1990s was the warmest decade in the instrumental record (1861–2000), but annual global mean temperatures on record since 2000 exhibit an trend that exceed the 1990s pace.

Japan also experiences a long-term upward tendency as to annual average surface temperatures, at a rate of 1.07°C per 100 years. Especially in and after the 1990s, we have had many warmer-than-normal years (Figure 1-4).

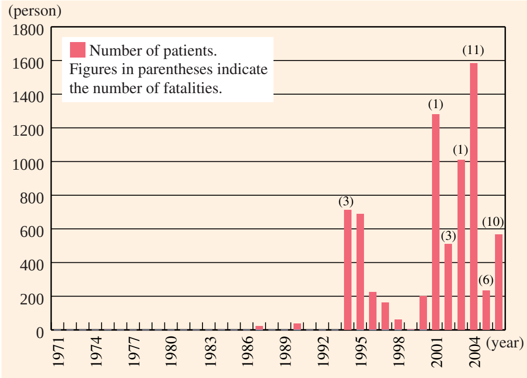
The data in Figure 1-4 is based on the past observation records of monthly mean temperatures in seventeen geographically scattered non-urbanized locations nationwide, selected from those that have a meteorological observatory and a history of continuous weather observation since 1898. In urban areas, due to the heat-island phenomenon and other urbanization impacts, the upward trend is more prominent (Figure 1-5).

Such changes, estimated to be caused by increasing atmospheric CO_2 concentration and rising temperature, have been emerging here and there in various places in the world.

a. Extreme hot weather

In the summer of 2003, the central and western areas of Europe suffered a heat wave of unprecedented magnitude. More than 10,000 people died in France, and throughout Europe, the death toll exceeded 50,000 people. In Zurich, Switzerland, the monthly mean temperature in June was 6.9°C higher than in a normal year. From the end of 2006 to the beginning of 2007, almost all areas in the Northern hemisphere experienced a warm winter. Global monthly mean temperatures in December 2006 and January 2007 registered record highs respectively since 1891. It is estimated that such extreme phenomena are attributed to global warming as a result of increasing GHGs.

Figure 1-6: Changes over time of the number of heat-illness victims in Japan



Source: Compiled from the Japan Meteorological Agency data by the Ministry of the Environment.

Column : Introduction of “Extreme Heat Day”

The Japan Meteorological Agency establishes definitions for temperature-indicating meteorological terms used in weather reports. For example, a “frost day” is a day with a daily minimum temperature below 0°C and a “tropical night” is a night without cooling down below 25°C. For terms indicating hot weather, a “summer day” and a “heat day” are days with daily maximum temperatures of 25°C or higher and 30°C or higher, respectively. From April 2007, the Agency introduced a new summer term, an “extreme heat day”, to define a day with a high of 35°C or higher. This reflects the frequently broken records of highs mainly in urban areas.

In 2004, Tokyo (Otemachi) had as many as seventy heat days, registering a record high. A heat day is defined as a day that marked a high of 30°C or higher. (The average number of tropical days per year from 1971 to 2001 was forty-six.) According to the Tokyo Fire Department, a total of 793 people were rushed by ambulance to hospitals within Tokyo due to heat illness during the period between May 1 and September 30 in 2004. (The mean value from 1996 to 2005 is 472 people.) If such extreme hot weather happens more frequently due to global warming in the future, heat-illness victims will probably increase further.

b. Formation of high-intensity tropical cyclone and increasing frequency of heavy rain

There is observational evidence for an increase in intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures, and the frequency of heavy precipitation events has increased over most land areas (IPCC AR4 WG1 report).

In August 2005, Hurricane Katrina, which hit the Southeastern part of the United States, was a Category 5 hurricane, the highest level under the Saffir-Simpson Hurricane Scale. Katrina caused catastrophe, claiming the lives of more than 1,300 people. According to the ISDR (International Strategy for Disaster Reduction), the damage caused by Katrina within the United States is estimated to be 125 billion dollars (or about 14.4 trillion yen). The NOAA (National Oceanic & Atmospheric Administration of the U.S. Department of Commerce) reported that in 2005 a total of twenty-eight tropical storms formed (tropical storms are defined as tropical cyclone that have a maximum wind speed of 17.2m/s or faster) in the zone stretching from the Northern Atlantic Ocean to the Caribbean Sea, far exceeding the norm in this zone (19), and that fourteen of them developed into hurricanes (defined to be tropical cyclone that have a maximum wind speed of 32.7m/s or faster). If global warming further raises sea-surface temperatures in the tropics in the future, the frequency of high-intensity tropical cyclone is likely to increase.

In Japan, it is also reported that heavy rains are occurring more frequently than ever. According to the "Report on Climate Change 2005" issued by the Japan Metrological Agency, the number of days that have a daily precipitation of 100mm or greater and 200mm or greater respectively increased 1.19 times and 1.46 times, from the 1901-1930 period to the 1975-2004 period.

According to a global warming projection conducted by the Metrological Research Institute, an affiliate of the Japan Meteorological Agency, it is likely under a future warmer climate that the northward progression of the North Pacific High slows down to prolong the rainy season (Baiu) gradually, possibly until as late as August.

Hurricane Katrina Photo: courtesy of NOAA

With a minimum central pressure of 902hPa, Katrina marked the central pressure of 920hPa when it made its landfall.

c. Sea level rise

According to the IPCC AR4 WG1 report, the total 20th-century rise is estimated to be 0.17 [0.12 to 0.22] m. The report says that warming causes the thermal expansion of seawater and ice sheet melting contributing to sea level rise.

Southern Pacific nations are already suffering coastal erosion and the danger of land submergence in many shores. One of them is a small, 26-square-kilometer island nation, Tuvalu, which has a total population of about 10,000 people. Tuvalu is consists of nine atolls, scattered ranging from lat.5 to 10 degrees south, and a half of its habitants is living in its capital, Funafuti. Fogafale Island, where Funafuti is located, is less than 1.5 meters above sea level on average, and has recently started to suffer frequent flooding especially during the period from January to March when the tide level is relatively high. Some of the palm trees on the shore are already unable to stand up, and have fallen into the ocean. We could

Funafuti atoll suffering coastal erosion (in Tuvalu)
Photo: courtery of Shuichi Endo (NGO Tuvalu Overview)

assume that such scene indicates accelerating coastal erosion. There are also reports on salt damage due to the seawater that enters into fields, damaging crops.

On one hand, such salt damage can be attributed to the nation's societal change; increasing population has led to the expansion of residential areas and farming lands into flood-susceptible areas. However, it is estimated that the acceleration of global warming will further exacerbate the said damage.

d. Changes in the habitat conditions of plants and animals

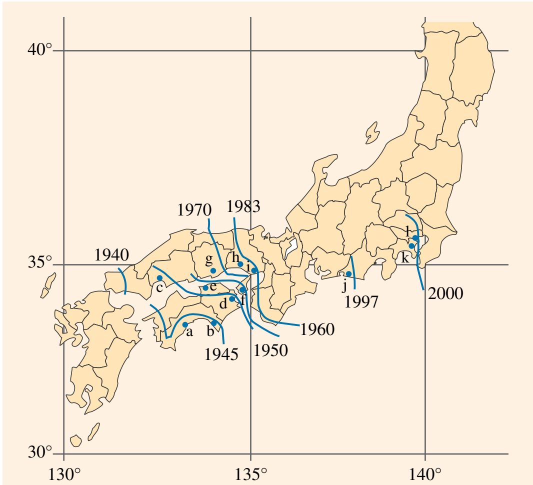
Animals and plants, who are constituents of ecosystems, are sensitively reacting to global warming. There are many reports from all over the world on various changes in their habitat that are attributable to global warming.

The Arctic Circle, which is considered as the area most vulnerable to global warming in the world, facing the peril of the extinction of polar bears. Polar bears depend on seals for food. They hunt seals by capturing them, sneaking up through an ice hole to breathe. Fat from seal meat stored in the body makes it possible for bears to survive. Loss of sea ice as a result of global warming would endanger polar bears because they will not be able to hunt seals easily. Actually, the results of a survey on the average weight of polar bears living in Hudson Bay, Canada, show that they have lost weight in the last few decades, from an average weight of only 230 kg as of 2004, compared to 295 kg in 1980. The weight of 230 kilograms is considered to be close to the minimum level that allows polar bears to maintain the reproductive ability. There have also been reports of polar bear deaths attributable to melting ice. The bears had been forced to swim for long distances and have died due to exhaustion. In 2006, the World Conservation Union (IUNC) classified polar bears into the Red List of Threatened Species as "Vulnerable (VU)."

Coral near Akajima Island of the Kerama Islands, Okinawa Prefecture
Photo: courtesy of by Akajima Marine Science Laboratory

Another example is coral-reef bleaching. Reports of coral bleaching (coral bleaching is the whitening of coral colonies due to the loss of symbiotic zooxanthellae from the tissues of polyps) have been frequently heard from various places around the world. The ecological significance of coral reefs is remarkable, as they serve not only as habitats and egg-laying sites for around 4000 species of fish, but also as natural breakwaters that protect people's homes in coastal areas. Among various factors known to be responsible for coral bleaching, one of the most serious ones recently reported is a stress caused by rising seawater temperature. It has been discovered that during the 1998 El Nino event, which was the severest one in history, as much as 16% of the global coral reefs died or were seriously damaged. Scientists predict that the combined effects of global warming and El Nino, causing further rise of seawater temperatures, could result in coral bleaching which will become much more common. In addition, there is a report warning that accelerating ocean acidification caused by the increase in CO_2 uptake will make it difficult for corals to form a hard protective skeleton of calcium carbonate, and will possibly hamper the growth of corals. The IPCC AR4 WG1 report estimates that projections based on SRES scenarios give reductions in average global surface ocean pH16 of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times.

Figure 1-7 Northward expansion of habitats of Papilio memnon Linnaeus



Note: Figures indicate calendar years. Small letters from "a" to "l" indicate twelve cities and locations where temperature analysis was conducted.
Source: "Correlation between the expanding habitats for Papilio memnon Linnaeus and global warming" written by Masahiko Kitahara et al and published through the journal "Butterflies and Moths" issued by the Lepidopterists' Society (52, 2001).

Global warming also causes changes in flora/fauna habitat locations. In Japan, stakeholders are paying close attention to the recent phenomenon of the northward expansion of habitats of butterflies of southern species such as Papilio memnon Linnaeus (Figure 1-7). Also in recent years, deer habitats have been expanding into mountain areas, causing serious damage to agricultural and forestry businesses. Deer are compelled to migrate in order to avoid heavy snows at the onset of winter, and the said trend of changing deer habitats is considered to correlate with increasing warm areas and global warming.

2. Projections of Global Warming

According to the IPCC AR4 WG1 report, best estimates and likely ranges for global average surface air warming for six SRES emissions marker scenarios are given in this assessment and are shown in figure 1-8. For example, the best estimate for the low scenario (B1) is 1.8°C (likely range is 1.1°C to 2.9°C), and the best estimate for the high scenario (A1FI) is 4.0°C (likely range is 2.4°C to 6.4°C).

The IPCC AR4 WG2 report suggests that approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C

Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease.

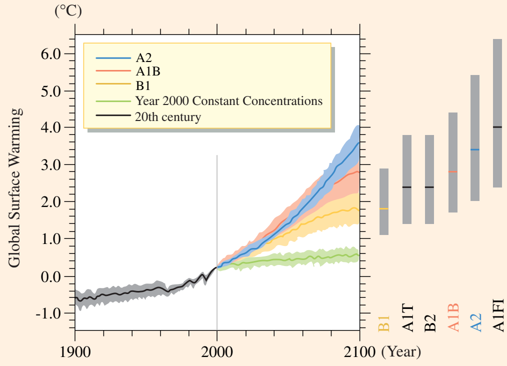
Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and widespread mortality. With higher temperatures, hundreds of million people are projected to be exposed to water stress.

Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change (See paragraph 5, Section 3 of Chapter 2).

Thus, increases in global mean temperature of less than 1-3°C above 1990 levels, some impacts are projected to produce benefits in some places and some sectors, and produce costs in other places and other sectors. It is very likely that all regions will experience either declines in net benefits or increases in net costs for increases in temperature greater than about 2-3°C.

If the human society continues to emit GHG at the current pace, the said increase level could be exceeded. It can be said that "global warming doomsday clock" is ticking. In order for us to stop this clock from striking catastrophe, it is urgently required to accelerate our efforts to fight against global warming.

Figure 1-8: Projections of the IPCC Special Report on (SRES)



Note: The Emission Scenarios of the IPCC Special Report on Emission Scenarios (SRES)

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.
Source: *IPCC AR4 WG1 report*

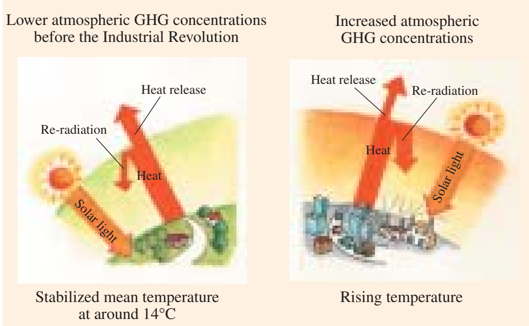
3. Mechanism of Global Warming and Necessity of Immediate Actions

The Earth's temperature depends mainly on the balance of incoming solar energy and outgoing terrestrial radiation.

The Earth is heated by solar light. Then, the Earth radiates infrared, which is absorbed by atmospheric greenhouse gases including carbon dioxide, and the heat is returned to the Earth's surface (re-radiation). Through this process, the Earth's surface temperature is maintained at an average of about 14°C, providing an optimal condition for living creatures.

However, since the Industrial Revolution, the human society has come to consume a large amount of fossil fuels by combusting them, resulting in enormous GHG emissions such as carbon dioxide into the air. This led to the hike in GHG concentrations in the air, which has increased the atmospheric uptake of radiated heat from the Earth's surface. This has induced higher temperatures throughout the Earth, and that's the mechanism of global warming. Annual fossil carbon dioxide emissions per year in 2001-2005 are estimated to be about 7 billion tons (carbon equivalent; hereinafter referred to as tC. Seven billion tC is equivalent to about 26 billion tons in terms of the amount of carbon dioxide), and this value is expected to further increase in the future. In the meanwhile, the maximum amount of carbon dioxide that can be absorbed yearly by nature is estimated to be about 3 billion tC (or about 11 billion tons in terms of the amount of carbon dioxide). In this light, it is necessary to maintain the GHG balance between emissions and uptake in order to stabilize climate and prevent the expansion of adverse impacts.

Figure 1-9: Mechanism of global warming



Source: Ministry of the Environment

A few scientists strongly doubt this theory that the increase in human-caused CO_2 emissions is the major cause of global warming. However, when we study the trend after the Industrial Revolution and during the latter half of the 20th century in particular, we cannot explain the hike in CO_2 level and temperature without consideration on the human-caused CO_2 emission increase.

Those scientists who doubt the fatal contribution of human-caused carbon dioxide to global warming point out that the current amount of human-caused CO_2 emissions of about 7 billion tC is far below the amount of carbon exchanged among the atmosphere, ocean, and terrestrial biosphere, which is estimated to be 90 billion tC. However, the value "7 billion tC" represents the annual emissions, and the accumulated amount of CO_2 emissions caused by human activities is estimated to be 350 billion tC. This is equivalent to 60% to 70% of the amount of CO_2 remaining in the atmosphere before the Industrial Revolution, and apparently exceeds the CO_2 uptake potential in nature.

There is another theory supported by a few scientists, arguing that the increased CO_2 concentration is not responsible for global warming and that, instead, the rise of temperature is responsible for the increase in CO_2 concentration. This theory alleges that increased sea-surface temperature induces CO_2 release into the air from the ocean, causing the increase in atmospheric CO_2 concentration. However, suppose this alleged mechanism exists, it cannot theoretically explain the fact that CO_2 concentration has rapidly risen for the past few decades, and the cause of the recent temperature hike either.

Recently, science academics of the G8 nations jointly announced the statement (in 2005) that claims urgent actions to be taken by G8 governments over the issue of global warming, on the grounds that most of the warming in recent decades can be attributed to the human-caused increases in CO_2 emissions . The IPCC AR4 WG1 report also supports most of the observed increase in global average temperatures since the mid-20th century is very likely (probability of occurrence is more than 90%) due to the observed increase in anthropogenic greenhouse gas concentrations. Thus, the mechanism that global warming is attributed to human-caused GHG increase in the atmosphere, including carbon dioxide, is a general consensus among majority of scientists in the world.

According to the IPCC AR4 WG3 report (the report by Working Group III for the Fourth Assessment Report), there is substantial economic potential for the mitigation of global GHG emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels. Bottom-up studies indicate that the economic mitigation potential in 2030 is 9-17 $GtCO_2$-eq/yr in the carbon price of 20 US$/$tCO_2$-eq, and 16-31 $GtCO_2$-eq/yr for 100 US$/$tCO_2$-eq.

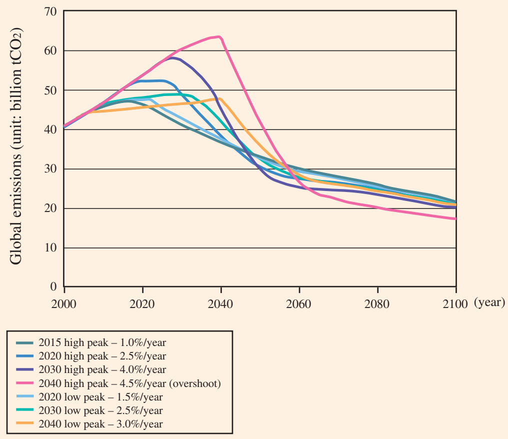
Table 1-1: Stabilization scenario

Category	CO_2 concentration	CO_2-eq Concentration	Global mean temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity	Peak year for CO_2 emissions	Change in global CO_2 emissions in 2050
	ppm	ppm	°C	Year	%
Ⅰ	350～400	445～490	2.0～2.4	2000～2015	-85～ -50
Ⅱ	400～440	490～535	2.4～2.8	2000～2020	-60～ -30
Ⅲ	440～485	535～590	2.8～3.2	2010～2030	-30～ +5
Ⅳ	485～570	590～710	3.2～4.0	2020～2060	+10～ +60
Ⅴ	570～660	710～855	4.0～4.9	2050～2080	+25～ +85
Ⅵ	660～790	855～1130	4.9～6.1	2060～2090	+90～+140

Source: Compiled by the Ministry of the Environment based on *the IPCC AR4 WG3 report*

It has also been suggested that the lower the stabilization level, the more quickly the peak and decline would need to occur. Mitigation efforts over the next two or three decades will have a major long-term impact on the availability of opportunities to avoid a rise in the global mean temperature and the corresponding climate change. (Table 1-1). In 2050, the global average macro-economic cost for multi-gas mitigation towards stabilization between 710 and 445 ppm CO_2-eq would be between a 1% gain to a 5.5% decrease of global GDP.

Figure 1-10 : Illustrative emissions paths to stabilize GHG concentration at 550ppm (CO_2 equivalent)



Note: "Overshoot" indicates a path in which the atmospheric GHG concentration peaks above the stabilization level and then falls.
Source: Nicholas Stern "*The Economics of Climate Change*" Cambridge University Press (2006)

The report also suggests that the range of stabilization levels assessed can be achieved by way of a deployment of a portfolio of technologies that are either currently available or expected to reach the commercialization stage in the coming decades, provided that appropriate and effective incentives are provided for development, acquisition, deployment and diffusion of said technologies and for addressing related barriers. While the report admits that a wide variety of national policies and instruments are available to governments to create the incentives for mitigation action and that there are advantages and disadvantages inherent to any given instrument, the report shows some selected instruments, including regulations and standards, taxes and charges, tradable permits, voluntary agreements, information instruments, and RD&D, etc.

It is also pointed out that policies that provide a price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products. Such policies could include economic instruments, government funding and regulation.

The Stern Review on the economics of climate change, submitted to the U.K. Government and the HM Treasury in October 2006 by Sir Nicholas Stern, a former Chief Economist of the World Bank, says it is still not too late. The Review argues that climate change could seriously deteriorate economic growth and development but that there is still time to avoid the worst climate change impact provided that strong collective action begins now. The Review also suggests that the benefits of strong, early action on climate change outweigh the costs and thus demands immediate international actions to address climate change. According to Stern, delay in taking action on climate change would eventually make it necessary to accept higher mitigation costs, because emissions must be reduced more rapidly to achieve the same stabilization goal, and emission will peak at a higher level (Figure 1-10).

In order for us to avoid the risk of inviting an irreparable outcome, it is essential to start fighting against global warming decisively under the precautionary principle. We need to take the status quo of global warming seriously and promote international cooperation to address the issue effectively and efficiently.

Chapter 2

Global Warming and Biodiversity

Chapter 1 explained that global warming, attributable to the increase of human-caused GHG emissions, is most likely to adversely and extensively change the global environment. This chapter focuses on biodiversity, with a view to clarifying its significance in supporting human life in its role as a foundation of human life itself, while also discussing the impacts to the Earth's biodiversity that human activities are incurring, resultant changes in ecosystems and their influence upon our way of life, with the emphasis on their relation to global warming,

Section 1: Geological Activity and Biodiversity

Over a long history of about 4 billion years, various species have evolved on Earth by adapting to diverse environmental conditions. These diverse manifestations of life, along with inanimate factors, have interacted with the atmosphere, water and soil. These interacting natural systems, referred to as "ecosystems," represent nets of natural elements woven together by way of their close interrelationship.

For example, most life inhale oxygen and exhale carbon dioxide. Green plants produce oxygen through photosynthesis and release it into the atmosphere. Carcasses and excreta of animals and plants are decomposed by microorganisms in the soil, and are transformed into inorganic nutrients that will be taken into plants again to be used for photosynthesis. Animals acquire energy by eating other life. Some plants benefit from insects carrying pollen for them as part of the pollination process, and others benefit from animals expanding their habitat by carrying their seeds to remote places.

Thus, there are interdependent relationships among diverse life in the Earth and the atmosphere, waters and soils; and such close relationships create diverse local ecosystems that are well-balanced. Such mutual interactions are so complicated that some of them are still not fully understood. However, it is understood that biodiversity, consisting of diverse life and their diverse ecosystems, constitute the basis of living for individual animals, plants and other organisms. This applies to human beings too, who are also part of terrestrial ecosystems. In the modern human society, people often forget their dependence on ecosystems in the biosphere, but we could not survive without respecting biodiversity in the Earth's ecosystems. And, our human activities have influences on mutually interacted constituents of ecosystems.

1. Ecosystem Services

Biodiversity is not only precious in and of itself, but it is also of great value to humankind, as we gain extensive benefits from these ecosystems that are supported by diverse life.

This relationship between biodiversity and the benefits we receive from the richness of nature had not been studied systematically until 2005, when a report from the Millennium Ecosystem Assessment used the concept "ecosystem services" to explain the said relationship in an accessible way (Figure 2-1-1). The Millennium Ecosystem Assessment is a scientific work initiated by the United Nations to make global comprehensive assessments of the status of biodiversity and conservation and the sustainable use of ecosystems. The core process of the Millennium Ecosystem Assessment took four years between 2001 and 2005, and it had the participation of about 1,360 researchers and scientists from 95 countries. Findings of the Assessment explain that biodiversity constitutes the basis of ecosystem services and that the richness of ecosystem services has a strong relationship with the human well-being. Here, biodiversity is regarded as the source of all ecosystem services.

The Millennium Ecosystem Assessment report published in 2005 classifies ecosystem services into the following four categories and explains the significance of biodiversity.

(1) Provisioning services

"Provisioning services" allow people to obtain essential resources for living, such as food, fuel, wood, fiber, biochemicals and fresh water.

For example, people eat animals and plants to survive, use hides and fibers to make clothes, and use wood, minerals and their processed products to construct buildings.

In addition to those existing, recognized benefits, there may be potential values, from which we may benefit in the future when the development of biotechnologies or commercialization of advanced technologies makes it possible for us recognize a potential and cultivate it for our well-being.

Biodiversity in this category is quite important in terms of the potentials of resource-utilization. In this light, the loss of certain life, regardless of whether they have already been recognized as resources that have a trade value or are unknown at this moment, would mean lost opportunities for us to utilize existing values or cultivate their potential values as a resource. Some researchers also point out that the wider the variety of flora, the higher "primary production" would be.

(2) Regulating services

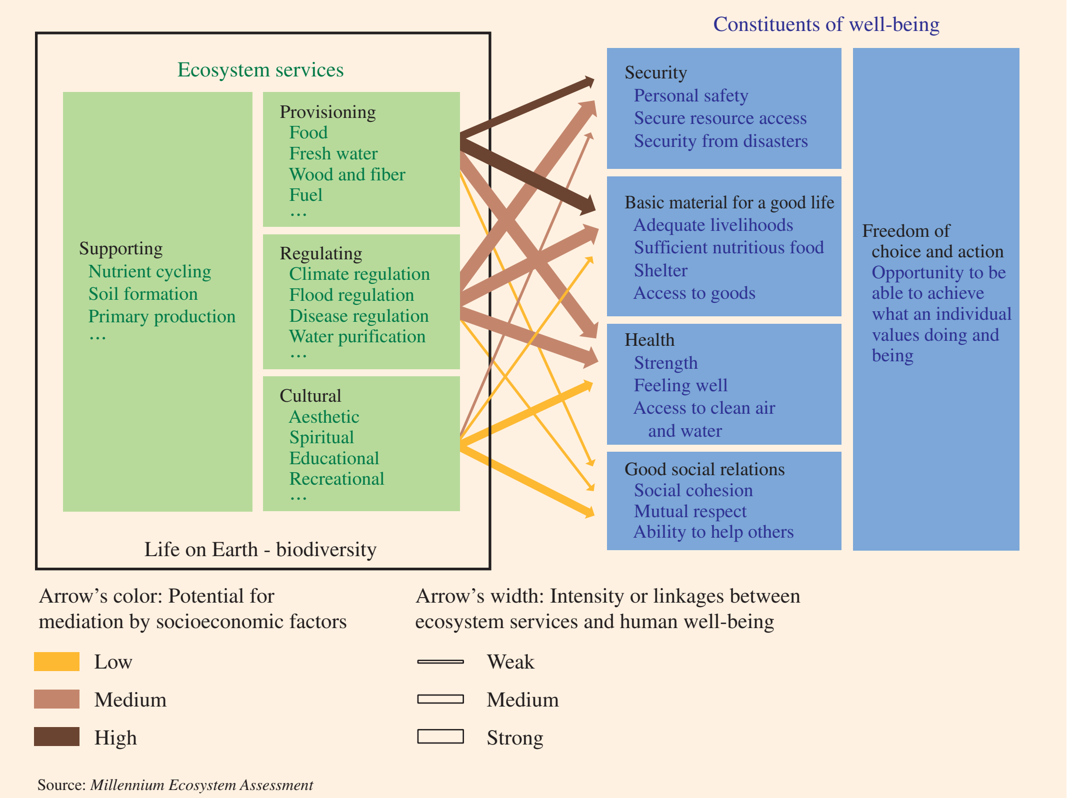
"Regulating services" allow people to obtain natural control of the environment, such as the ability of forests to mitigate climate change, to control flood, to purify water, etc. Such environmental control services, if artificially operated, would amount to enormous costs for us.

For example, forests store a vast amount of carbon. If all of the stored carbon happens to be released into the atmosphere at one time, it would cause strong greenhouse effects, most possibly resulting in the deterioration of the ecosystem balance.

Regulation of human diseases and pest control are also part of those services. There exist vulnerable species or genetically homogeneous creatures that are extremely susceptible to a certain specific disease or pest. They can be easily damaged when such diseases or pests happen to rapidly increase and spread. However, in normal natural ecosystems with rich biodiversity, explosive proliferation of a certain specific organism would not usually occur.

In this category, biodiversity contributes to the enhancement of enhancing the stability and recoverability of the ecosystem, in case of the entry of any invasive factors or any contingencies. Given a sufficiently rich biodiversity, there is a possibility that species with high levels of resistance or adaptability to certain diseases, pests, alien species, climate change, forest fires etc. will remain within the ecosystem, thus maintaining its stability. Also, areas of rich biodiversity often feature fast-growing species, which help the ecosystem recover from disturbances.

Figure 2-1-1: Ecosystem services and their links to the human well-being



Source: *Millennium Ecosystem Assessment*

Column : Monetary Evaluation of Ecosystem Services

Robert Costanza, an American researcher, attempted to put monetary value on seventeen different ecosystem services. According to his paper, published in Nature magazine in 1997, the total value is estimated to be between 16 trillion and 54 trillion dollars per year (with a mean value of 33 trillion). This is one to three times as large as the global GDP of about 18 trillion dollars at that time.

Costanza added that this calculation could only be said to represent a minimum estimate due to nature's many uncertainties, and he also mentioned that this value could well increase in the future as more facts about nature come to light.

(3) Cultural services

"Cultural services" allow people to obtain mental satisfaction, aesthetic pleasure, a basis of religious or social systems, opportunities of recreation, etc.

In most cases, locally-grown religion and culture have close relationships with local biota and ecosystems in that region.

In East Asia, which belongs to the monsoon climate zone, civilization based on rice farming and related production activity evolved. This has created a traditional belief in the sacredness of forests and all of the life contained therein in the societies of the region due to the large reserves of water contained in forests. On the other hand, in West Asia and countries westward, where it does not rain much in summer, wheat farming and stock-raising represent the core of civilization; people are not negative about deforestation and such lifestyle influences their attitudes toward nature.

Some Japanese names for colors, especially traditional ones, are etymologically related to animals or plants, such as the "color of toki" (safrano pink) and the "color of moegi" (kind of onion with young buds). This tells of the close relationship between human culture and the natural environment as well as the significant contribution that unique regional characteristics (of animals, plants, seasons, etc.) lend to local cultures. The enjoyment of seasonally blooming flowers is another important way of appreciating our ecosystems' gifts to our culture. "Ecotourism" is another example: it is based on recreational functions and educational effects of regional ecosystems and focuses on unique local landscapes or biota in a particular area. When we see regional cultures around the world, we realize that the local natural environment plays a significant role therein. For example, some ethnic costumes use a pattern of a native animal or plant and some regional food culture are greatly influenced by the nature in that region.

Thus, many regional cultures and religions are supported by ecosystems and biota in their region, and in this light, biodiversity constitutes the basis of the cultures. In other words, a loss of certain species could cause a loss of the culture to which the species belonged.

(4) Supporting services

"Supporting services" can be defined as the services that are necessary for the production of all other ecosystem services mentioned above from (1) to (3). For example, the supporting services include oxygen production through photosynthesis, soil formation, food chains and the water cycle.

Thus, services being provided by ecosystems to human beings are quite diverse. Therefore, it can be said that biodiversity, which supports ecosystem services, provides an essential foundation for human life.

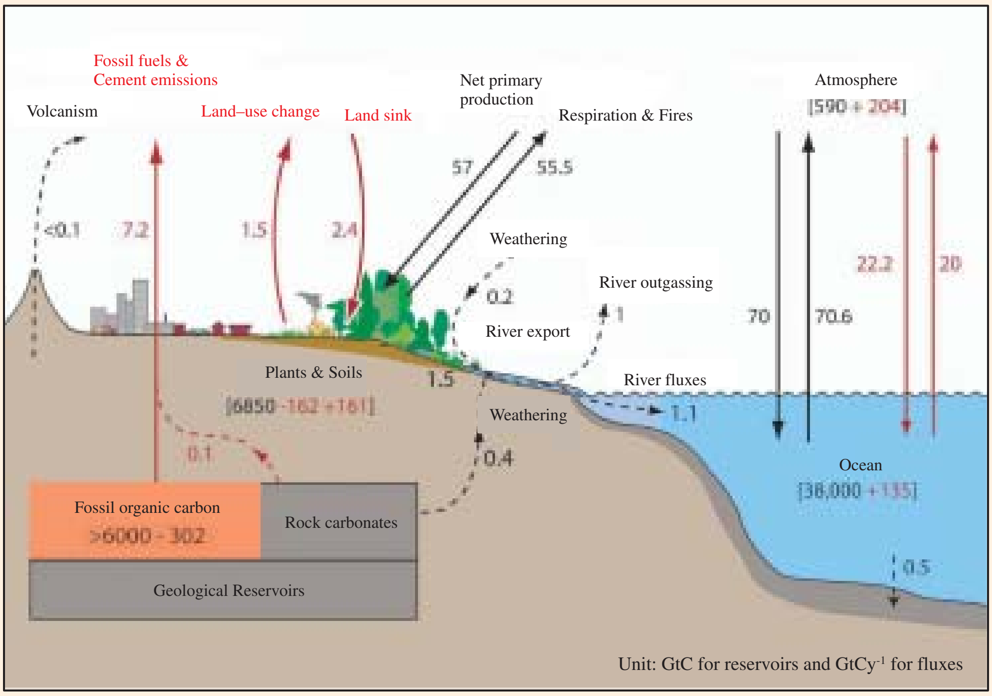
2. Material Circulation and Biodiversity that Support Ecosystem Services

As mentioned above at section 1, humans obtain great benefits from ecosystem services that constitute the basis of our life. Ecosystem services can be materialized through complicated interactions among various constituents of ecosystems (including diverse life) on Earth. Now, let's find details of those interactions and the basic roles of life in the mechanism of ecosystems.

Ecosystems consist of life and the surrounding environment, including the atmosphere, waters and soils. Every substance on Earth goes through some sort of ecological cycle. Also, solar energy flows through ecosystems as it is consumed by life at the same time.

All substances on Earth can be chemically identified as a finite set of elements, and they are consumed or used by life as they flow in a closed cycle of the geoecological system. Incoming solar energy into the Earth is always almost equal in volume to radiant

Figure 2-1-2: Carbon cycle



Note: Background or pre-anthropogenic pools and fluxes are in black. The human perturbation to the pools and fluxes are in red.
Source: "*The Global Carbon Cycle*" by the Global Carbon Project (2006)

energy released from the Earth into the space as infrared light. Life depends on certain elements of such energy flow, and actually plays an important role in the said material circulation and energy-flow mechanisms.

Recent environmental issues, such as global warming, that are attributable to disturbance of human activities can be defined as the consequences of destroyed equilibrium of those material circulation and energy flow. The following paragraphs will explain the basic mechanisms of the major material circulation (carbon cycle and nitrogen cycle), water cycle and energy flow, that constitute the basis of human life, as well as the significant contribution of biodiversity to those mechanisms.

(1) Carbon cycle

Ecosystems involving the atmosphere, waters, soils and lives of the Earth contain carbon compounds. Carbon dioxide (CO_2) is continuously exchanged between the ocean and the atmosphere through repeated dissolution into the ocean and release into the air, thus maintaining its equilibrium. Also, CO_2 is sequestrated in the form of an organic compound through the process of photosynthesis of plants. Those organic compounds are partially consumed by plants as an energy source and will be re-released into the atmosphere as carbon dioxide. Meanwhile, organic compounds stored in plants are partially consumed by animals as food, and will also be released into the atmosphere as carbon dioxide through the respiration of animals. Carcasses and excreta of animals and plants are decomposed by microorganisms in the soil and will also be returned into the atmosphere as carbon dioxide. Such carbon transformation via living organisms exists inside the ocean too. Dissolved CO_2 in the sea-surface layer is sequestrated in the form of organic compounds by photoplanktons. Some of them will sink into the deep ocean in the form of zooplanktons or carcasses/excreta of the large animals who consumed them (Figure 2-1-2).

Besides the aforementioned short-term carbon cycle, such as exchanges of carbon between the atmosphere and the ocean or transformation via living organisms, a long-term cycle also exists. Most of the carbon in the Earth is sequestrated in the form of calcium carbonate, through the process of sedimentation of carcasses and excreta of animals and plants, (including limestone of coral reef or limestone caves) or in the form of coal, petroleum, etc. that have been formed through underground transformation over the geological time of organic substances of ancient life.

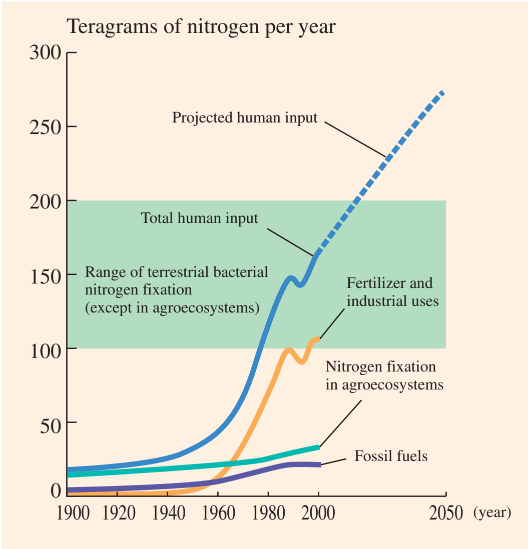
Column : Increase of Nitrogen loads Caused by Human Activities

The amount of nitrogen taken from the atmosphere and fixed through the ecosystem mechanisms is supposed to be almost equal to the amount of gaseous nitrate–nitrogen and returned to the atmosphere.

However, as a result of human activities, such as mass production of chemical fertilizers, crops and combustion of fuels, a large amount of fixed nitrogen has been accumulated and remains in ecosystems today. It is estimated that such human-produced accumulation of fixed nitrogen in ecosystems is now almost equal to the amount of naturally fixed nitrogen in terrestrial ecosystems and will further increase in the future.

According to the Millennium Ecosystem Assessment, one of the five major direct drivers of change in ecosystems and of deterioration of biodiversity is "pollution," and nitrogen is one of the principal substances causing pollution. Accumulated nitrogen in the natural environment flows into soils, ground waters, rivers and, eventually, into the ocean while it transforms itself. In this process, it causes eutrophication in lakes, reservoirs and sea areas, creates oxygen-deficient bottom water and induces nitric-acid pollution in ground water. The Millennium Ecosystem Assessment points out that such excessive accumulation of nitrogen in ecosystems could have serious, adverse impact on biodiversity.

Figure 2-1-4: Human-produced reactive nitrogen

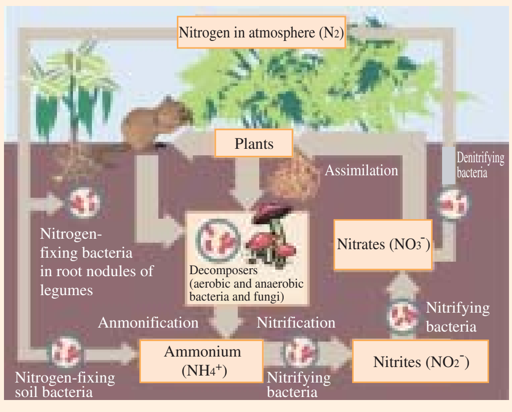


Source: *Millennium Ecosystem Assessment*

(2) Nitrogen cycle

It's not only carbon that is cycled through ecosystems. Nitrogen is an essential element for the formation of protein needed by humans and other life. Although inorganic nitrogen constitutes as much as about 78% of the Earth's atmosphere, it cannot be of immediate use for most life; it needs to be converted into forms usable by living organisms through the process of fixation, where microorganisms, etc. combine inorganic nitrogen with hydrogen or carbon. Fixed nitrogen can be taken into plants in the form of either ammonium ions or nitrate ions, and will be transformed into amino acid or protein that will be consumed by animals. This is the only way that allows animals to take in necessary nitrogen for their nutrition. Carcasses of plants or animals are consumed by other animals or decomposed by microorganisms. Then, denitrifying microorganisms will return inorganic nitrogen to the atmosphere (Figure 2-1-3).

Figure 2-1-3: Nitrogen cycle



Source: EPA (U.S. Environmental Protection Agency)

(3) Water cycle

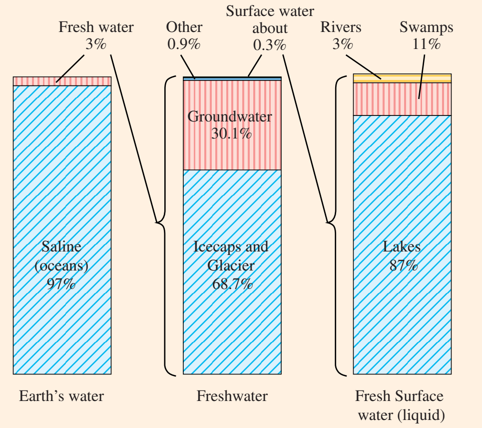
Water is an indispensable substance for the survival of all life. To our knowledge, the Earth is the only solar planet that enjoys the presence of water, and this has much to do with the birth and existence of the Earth.

The Earth has as much as 1.386 trillion tons of water, most of which (about 97%) belongs to the oceans. Fresh water constitutes only about 3%, a large part of which takes the form of glaciers, snow or groundwater. Thus, surface-running waters such as lakes, reservoirs and rivers constitute only a small fraction of the Earth's water, but they play a central role in the lives of most terrestrial life, including human beings.

Water comes in diverse forms, including glaciers, snow, lakes, rivers, ground water and atmospheric moisture (solid, liquid or gas), and it cycles in ecosystems. First, water in the form of vapor is released from the surface of the ocean or ground through the process of evaporation or transpiration. Vapor migrates in the atmosphere while it takes the form of cloud, fog or mist, and falls back down in the form of rain or snow. Those waters flow on the earth's surface or penetrate the ground, while heading for the ocean for the most part. In this sea-bound process, water plays diverse roles: it is consumed by life as nutrition, it mitigates climate change, it forms habitats for animals and plants, it supports biodiversity, etc.

Also, water moves long distances as rivers or sea currents, making it possible to transport various substances and energies. In addition, through the process of erosion, water functions as a determinant of geographical features of land.

Figure 2-1-5: Distribution of the Earth's waters



Source: Gleick, P.H., "*Water Resources*" *Encyclopedia of Climate and Weather, S.H.* Edited by Schneider, Oxford University Press, New York, vol. 2 (1996)

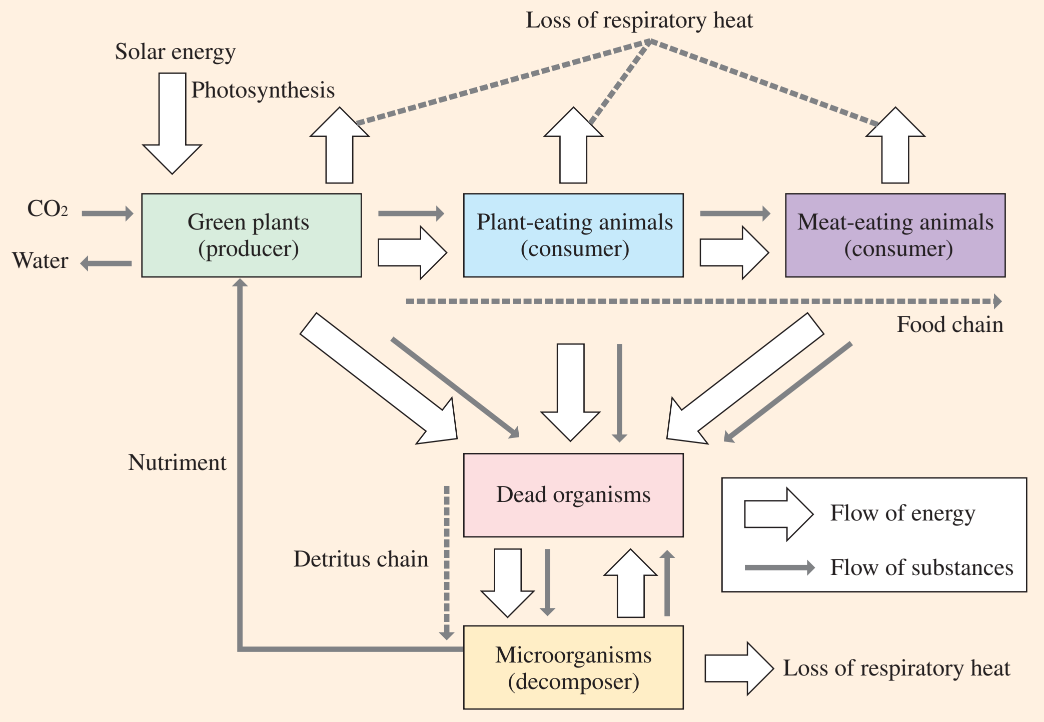
(4) Energy flow

The Earth receives solar energy from solar light coming into the atmosphere. Solar energy flows throughout ecosystems, where it is partially taken into life and supports respective lives.

As the primary producer, plants fix solar energy in the form of an organic substance through photosynthesis. More than half of that fixed energy will be consumed by plants themselves for their respiration, and will be partially stored internally in the form of starch, etc. Then, it will enter animals when they eat plants ("grazing food chain"), or in some cases will enter a "detritus food chain" where carcasses or excreta of animals or plants are consumed by decomposing organisms such as bacteria. In either case, it eventually enters the ecosystems.

In the grazing food chain, 10% to 20% of plant-fixed energy is estimated to enter animals that eat plants. Then, about 10% to 20% of the energy consumed by those animals is estimated to enter meat-eating animals, and 10% to 20% of the energy consumed

Figure 2-1-6: Energy flow in terrestrial ecosystems



Source: Ministry of the Environment

by those meat-eating animals is estimated to enter their predator animals. Thus, energy is transferred to higher-level creatures (from pray to predator). The higher the energy that is transferred, the more energy is consumed. Therefore, the remaining energy becomes smaller and smaller as it is transferred to higher-level creatures.

Thus, energy is consumed by various life at different levels, and heat generated as a result of their activities will be returned to the atmosphere. (Energy not consumed immediately is temporarily stored inside life or in the form of organic sediments, but it will eventually be released into the atmosphere, except for those organic compounds accumulated little by little underground such as petroleum and coal.) Then, heat in the atmosphere will be radiated into outer space. The amount of such heat is supposed to be equal to the incoming counterpart when the integrity of the ecosystem is maintained.

Section 2: Crisis of Ecosystems

Development of science and technology that embodies the integration of people's wisdom has provided human beings with a great fortune. Modern technology has made it possible for us to act decisively. People today receive great benefits from such activities: they take the form of artificial alteration of river flows for agricultural or flood-control purposes, deforestation, land reclamation, etc. However, today, people are sometimes unable to forecast the outcome of their activities due to unprecedented development of science and technology. We have acquired strong powers of advanced technologies, but any abuse of such high-level technology could possibly lead to an irrevocable alteration of ecosystems, including that of human beings.

The said scientific development has also brought about an increase in the world population. During the period between 1960 and 2000, the global population doubled from about 3 billion to about 6 billion. This means that we need twice as much ecosystem services, assuming that all other prerequisites remain the same as before.

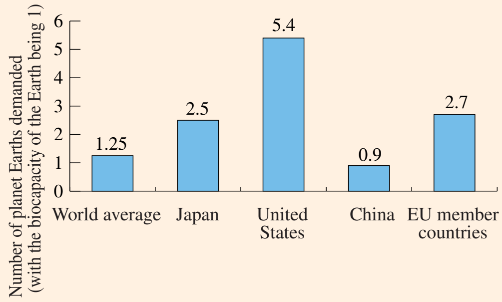
In addition, in the latter half of the 20th century, the per capita demand for ecosystem services increased dramatically, especially in advanced countries due to their economic growth and people's stronger desire to enjoy comfortable life.

There is a new analytical methodology named "Ecological Footprint" that attempts to measure human consumption of natural

Column : Ecological Footprint

The Ecological Footprint (EF) is an index developed by the University of British Columbia to represent the level of human being's dependence on the natural environment, in an easy-to-understand way. The Global Footprint Network defines the Ecological Footprint as "a resource management tool that measures how much land and water area a human population requires to produce the resources it consumes and to absorb its wastes under prevailing technology," and makes a global assessment of the EF. The analysis of the EF includes the measurement of cropland required for the production of food, etc., grazing land required for the production of stock farm products, etc., fishing grounds required for the production of marine products, forests required for the production of timbers, forests required for the absorption of carbon dioxide.

Ecological Footprint by country



Note: Figures indicate the number of planet earths in terms of the ecological footprint of specific countries
Source: Compiled from *the Living Planet Report 2006 (WWF)* by the Ministry of the Environment

According to the "Living Planet Report 2006," published by the World Wildlife Fund for Nature (WWF), the Ecological Footprint ("demand") exceeded the Earth's biocapacity ("supply") by about 25% as of 2003. If this state of demand over supply continues, ecological resources on the Earth will not be able to meet human needs in the end. Especially in many advanced countries such as the United States, EU nations and Japan, the EF shows overshooting. (CO_2 emissions caused by the consumption of fossil fuels occupy a large part of the EF.) Japan's EF as of 2003 was 2.5 times the global mean biocapacity (per capita), and the EF of EU nations (member nations as of 2006) and the United States were 2.7 times and 5.4 times respectively. This means that if the entire world adopts Japan's, the EU's or United States' lifestyles, a world population would demand 2.5, 2.7 or 5.4 planet Earths respectively.

Table 2-2-1 Global status of ecosystem services

Services	Sub-category	Status	Notes
Providing services			
Food	Crops	▲	Substantial production increase
	Livestock	▲	Substantial production increase
	Capture fisheries	▼	Declining production due to overharvest
	Aquaculture	▲	Substantial production increase
	Wild foods	▼	Declining production
Fiber	Timber	+/−	Forest loss in some regions, growth in others
	Cotton, hemp, silk	+/−	Declining production of some fibers, growth in others
	Wood fuel	▼	Declining production
Genetic resources resource		▼	Lost through extinction and crop genetic resource loss
Biochemicals, natural medicines, pharmaceuticals		▼	Lost through extinction, overharvest
Water	Fresh water	▼	Unsustainable use for drinking, industry and irrigation; amount of hydro energy unchanged, but dams increase ability to use that energy
Regulating Services			
Air-quality regulation		▼	Decline in ability of atmosphere to cleanse itself
Climate regulation	Global	▲	Net source of carbon sequestration since mid-century
	Regional and local	▼	Preponderance of negative impacts
Water regulation		+/−	Varies depending on ecosystem change and location
Erosion regulation		▼	Increased soil degradation
Water purification and waste treatment		▼	Declining water quality
Disease regulation		+/−	Varies depending on ecosystem change
Pest regulation		▼	Natural control degraded through pesticide use
Pollination		▼	Apparent global decline in abundance of pollinators
Natural hazard regulation		▼	Loss of natural buffers (wetlands, mangroves)
Cultural services			
Spiritual and religious values		▼	Rapid decline in sacred groves and species
Aesthetic values		▼	Decline in quantity and quality of natural lands
Recreation and ecotourism		+/−	More areas accessible but many degraded

Source: *Millennium Ecosystem Assessment*

resources by converting it into the size of land/water area. (See the Column below.) According to the World Wildlife Fund for Nature (WWF), the Ecological Footprint has exceeded the Earth's biocapacity since the 1980s (in terms of ecologically productive land/water area). This overshooting status means that people are consuming resources faster than nature can recover from the damage caused thereby, and that the biocapacity can no longer keep pace with human consumption.

Japan is now experiencing population decreasing. But, the United Nations Population Division projects that the global population, currently about 6.5 billion people, will continue to increase in the future, with the estimated population as of 2050 being over 9 billion (medium variant). If the global demand for ecosystem services continues to increase, the demand is most likely to exceed the potential supply of the Earth's ecosystems, possibly resulting in the devastation of ecosystems themselves.

In particular, increased dependence of human activities based on fossil fuel since the Industrial Revolution has had a serious impact on ecosystems and their core element, biodiversity. As mentioned above in Section 1, sound ecosystems that are supported by rich biodiversity are supposed to have the ability to self-recover and correct any ill conditions by coordinating their functions. Even if any temporal malfunction happens due to the damage from drought, tsunami, cold wave, flood or other natural disasters, ecosystems are supposed to be able to recover and regain their integrity. However, the recent impacts of human activities on ecosystems are strong enough to impair the said self-recovery ability. Also, recent extensive damages of biodiversity have been generating a vicious spiral of deteriorating the ecosystem's integrity.

From the standpoint of the carbon cycle, CO_2 emissions caused by massive combustion of fossil fuels can be defined as the discharge of sequestrated CO_2 that ecosystems took a very long time to fix. This affects the water cycle too. This has changed precipitation intensity and conditions as well as the abundance and melting seasons of ice and snow, and has altered river flows significantly, and all of those changes could fatally affect water resources for future generations.

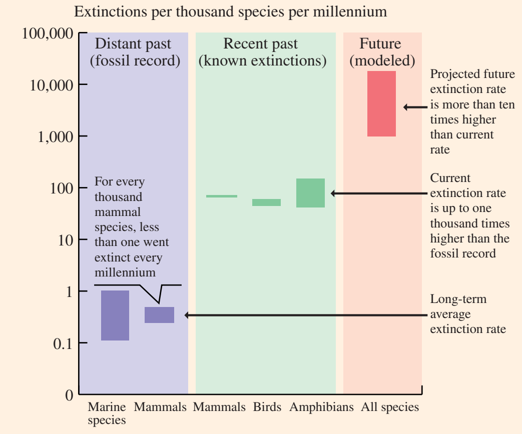
The Millennium Ecosystem Assessment (MEA) aforementioned analysis of the benefits (services) that people obtain from the Earth's ecosystems, and also evaluated the recent global state and trends of ecosystem services by focusing on twenty-four specific quantifiable services for the past several decades (Table 2-2-1). Through this evaluation, it has been found that fifteen services, including essential services such as water purification, air quality regulation and natural hazard regulation, have been degraded as a result of the human abuse or modification of ecosystems to satisfy our demand (e.g., increased demand for food) while four services

Column : Species-Extinction Rate is up 100 to 1000 Times Higher than that in the Past

The World Conservation Union (IUCN)-classified Red List of Threatened Species show endangered species at risk of extinction in different ranks under objective criteria. According to the 2006 threatened species database, which covers those species evaluated by the IUCN, endangered species are made up of 23% of all mammals, 12% of all birds, and 31% of all amphibians. This data tells us that so many species are on the verge of extinction.

In the course of evolution of life, species extinction is a natural process, as dinosaurs and many other species became extinct in history. According to the Millennium Ecosystem Assessment, however, humans have caused extreme acceleration of species extinction rates, and the rate today is estimated to be roughly 100 to 1000 times worse than the average normal rate in the past. Through researches on fossil records, it is known that there were five mass extinction events in the past, when there was a sharp decrease in the number of species in a relatively short period of time. The current status of species extinction exceeds in scale any of the past extinction events, and is therefore referred to as the sixth mass extinction event caused by mankind.

Figure 2-2-2: Species extinction rates



Note:"Distant past" refers to average extinction rates as estimated from fossil record.
Source: *Millennium Ecosystem Assessment*

During the recent Conference of the Parties to the Convention on Biological Diversity, the 2010 Biodiversity Target was established. Toward this target, which is intended to achieve a significant reduction of the current rate of biodiversity loss by 2010, the parties to the Convention have been making efforts to attain their respective goals.

have been enhanced (increased benefits for human well-being) instead.

Among those degraded services, the deterioration of fisheries landings is serious. The marine biomass has been substantially reduced in much of the world to one tenth of the levels prior to the onset of industrial fishing. Also, loss of forests and wetlands had led as loss of natural flood control basins, which means an increased likelihood of disasters such as floods, etc.

Global Biodiversity Outlook 2, which is a report released in March 2006 during the 8th Conference of the Parties to the Convention on Biological Diversity, assesses the current status and trends of biodiversity and points out that twelve out of the fifteen assessment indicators show downward trends, meaning that the accelerating deterioration of our biodiversity continues.

Millennium Ecosystem Assessment gives major direct drivers that make anthropogenic impacts on ecosystems and biodiversity. One of them is climate change with the other four including habitat change, invasive alien species overexploitation, pollution through increased nitrogen loads, etc. (See Column at (2), 2 of Section 1) .

Regarding climate change, it has been getting more and more noticeable recently, as explained in detail in Chapter 1 above. The recent phenomena, such as the reduced population of polar bears as a result of lost habitats due to sea ice melting and the coral bleaching attributed to rising seawater temperature, can be considered "warnings" sent by life to human beings.

Section 3: Global Warming-Caused Changes in Ecosystems and its Impacts on Human Beings

Section 2 explained how human activities have caused the critical conditions of the Earth's ecosystems and biodiversity. Such deteriorated biological conditions have a significant influence on the ability of human beings to survive and their living conditions.

As mentioned above, people cannot maintain sound living without the benefits we receive from our planet's varied ecosystems and the material and spiritual value that they represent. Because biodiversity supports the ecosystem services, great changes in biodiversity and ecosystems (as a result of global warming, etc.) can be interpreted as changes in quality and quantity of ecosystem services available to humans, and they can also imply the possibility of unprecedented events or growing adverse impacts.

This section will explain the impacts that global warming-caused changes in ecosystems have on human beings.

1. Impact on the Agricultural and Stock-Raising Industries

Humans depend on animals and plants for food as energy source which means that changes in the status of inhabitation of those life could affect our food-security status enormously.

It is known that rice plants would be damaged if the daily mean temperature were to exceed 27 or 28°C during the ripening period from the time ears are formed to the full maturity stage, and that it would result in the increase of immature milky white rice kernels, including white-back kernels. It is also known that a rise of CO_2 concentration could help increase rice yields, but that the higher the temperature, the lower the yield-increasing effect ("Data on the recent climate change and its impact on the growth of farm produce" by the Ministry of Agriculture, Forestry and Fisheries). According to a simulative future estimate of rice yields, based on climate change models and atmospheric circulation models, the yield in the southern part of Japan is estimated to be reduced by nearly 40% when an atmospheric circulation model developed in Canada is applied. It is also estimated that global warming could increase the population of insects harmful to rice, such as Chilo suppressalis (rice stem borer moths), Nephotettix cincticeps and Laodelphax striatella, and also could change their habitats or activity season. Therefore, there is a concern that rice quality will be degraded in extensive areas nationwide. Actually in Kochi Prefecture, the ratio of the first-grade (top quality) rice to the entire yield, that had been maintained around 60% to 80% traditionally in this region, has already dropped to 30% to 40% ("For overcoming high-temperature damage on deepwater rice" a report by the Ministry of Agriculture, Forestry and Fisheries). Cultivation of rice requires a lot of water in the preparation stage (at the time of planting). As the recent climate change has damaged the integrity of the water cycle, leading to changes in the river flow and seasonal natural characteristics as well as reduced-irrigation water supply, those changes are likely to affect conventional cropping seasons and production patterns.

It is known that fruit trees are particularly susceptible to climate change. This is because of the low adaptability of fruit trees to adjust their cropping period to climate conditions, while on the other hand annual plants are relatively adaptable due to their adjustable seeding time, which makes it possible to obtain optimal temperatures every year regardless of climate fluctuations. Citrus unshiu (Japanese tangerine), which occupies the largest share over all Japan-grown fruit trees in terms of production, has actually been found, by a survey, to be affected by the recent global warming, resulting in the northward shifting of its optimal growing zone (having a yearly mean temperature of 15°C or higher but less than 18°C). Traditional growing regions for Citrus unshiu, which currently range over coastal regions along the Pacific Coast, the Seto Inland Sea or in Kyushu, will be most possibly found as outside the optimal growing zone by 2060s, because their temperatures will be higher.

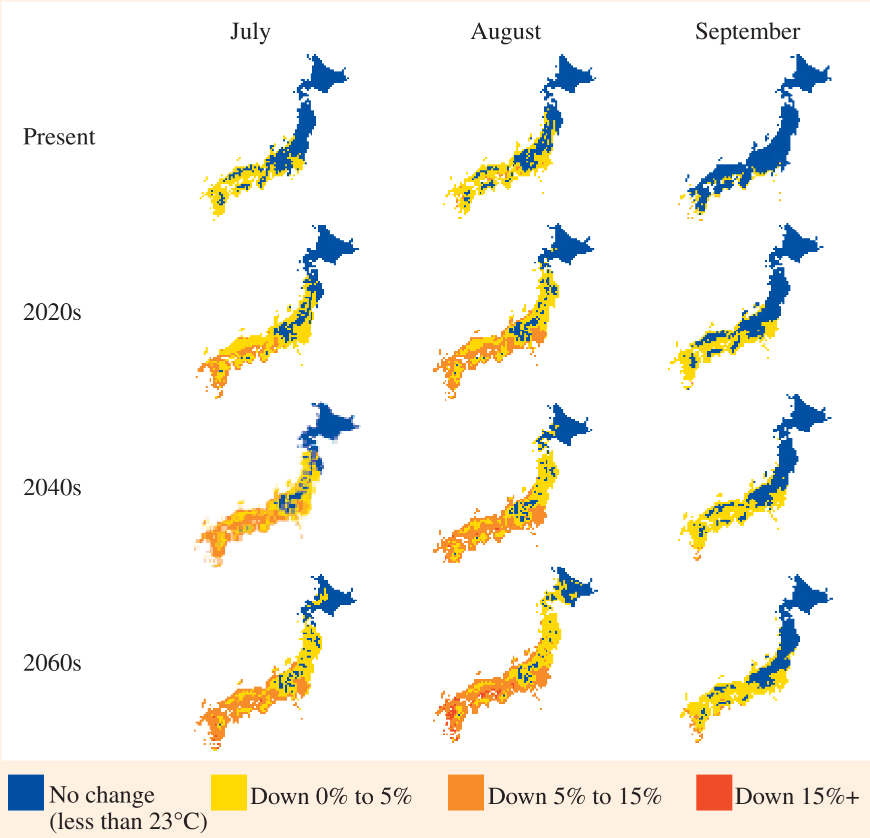
Europe had a severe record-breaking heat wave in 2003, suffering heavy casualties mainly in Western Europe. In addition, it caused significant damage to farm produce due to high temperatures and dried weather. This year, grain production in the EU dropped by as much as about 23 million tons from the previous year. Although it is too early to conclude that global warming was a direct cause of this devastated heat wave, it can be estimated that accelerated global warming could increase similar heat waves, possibly resulting in chronic and expanded damage.

Stock farming also receives serious damage from global warming. For example, a study conducted by the National Agriculture and Food Research Organization (NARO) based on climate models shows that accelerated global warming would invite serious damage to broiler-meat production. NARO reports that it could significantly reduce chicken-meat production especially in the

Basal-white rice | White-back rice | Milky white rice

Immature white rice kernels Photo: courtesy of Hideki Nagahata of Ishikawa Prefectural University

Figure 2-3-1: Estimated decline of broiler-meat production and projections as of today, 2020s, 2040s and 2060s



Source: "Impact of Global Warming on Broiler-Meat Production Estimated from Changes of the Mean Ambient Temperature" by Makoto Yamazaki et al, Nihon Chikusan Gakkaiho, 77 (2).

western part of Japan including Kyushu, Shikoku, Chugoku and Kinki regions (Figure 2-3-1). There is also a report showing the trend of degrading quality of farming conditions for milk cows, beef cows and pigs.

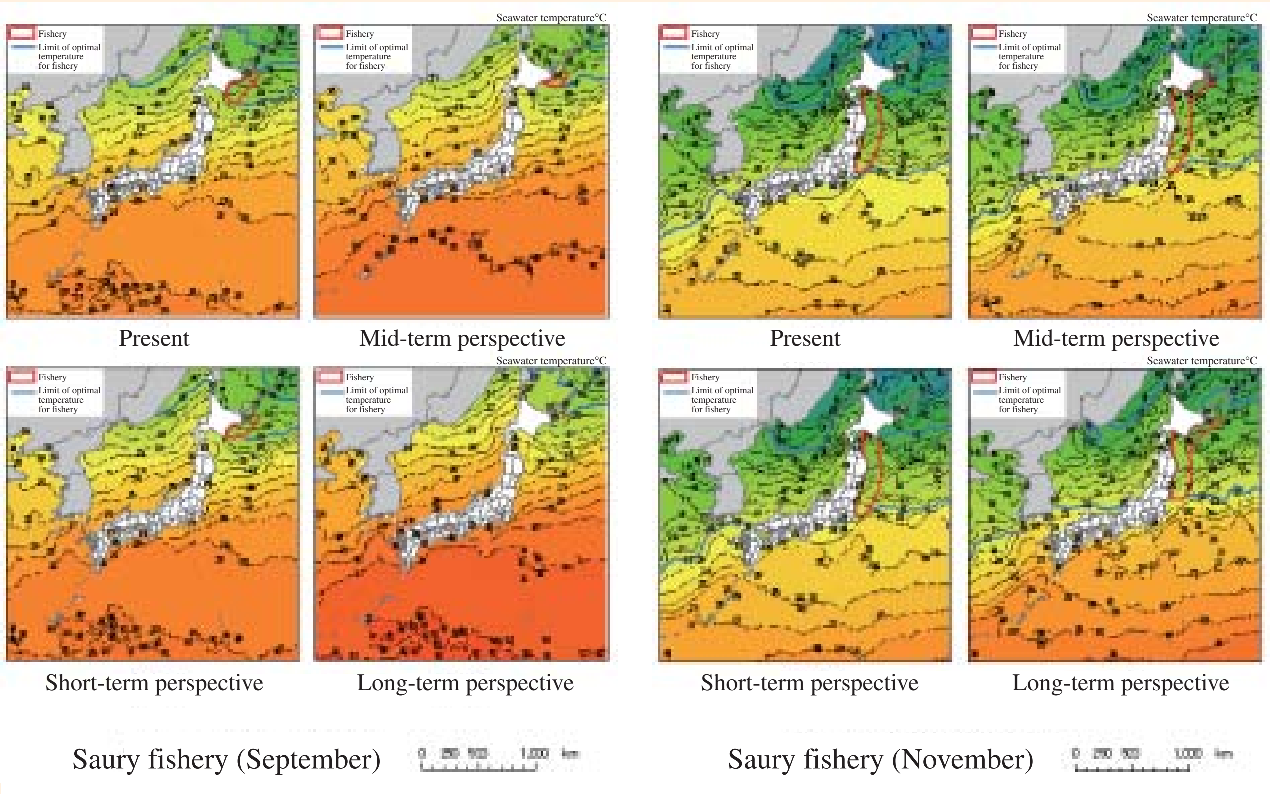
Although some impacts of global warming tend to emerge slowly, an incremental, extreme climate change, including drought and heat wave, could invite a serious sudden decline in the production of crops or stock-farm products. Such change and damage, large or small, could happen anywhere in the world. Since such damage is directly related to food supply for human beings, which is the key need for people's survival, appropriate measures should be introduced to avoid a global food crisis. Since Japan depends on imports for food (Japan's food self-sufficiency rate as of FY2005 was 40% in terms of calories), the impact of a global downward trend of food production on Japan is immense, in terms of not only food supply but also national security.

2. Impact on the Fishing Industry

Global warming is expected to invite changes in ocean currents and rising sea surface temperatures. Such changes in oceanographic conditions could have a serious influence on oceanic biodiversity, and also affect people who live close to the ocean and would otherwise enjoy rich marine-biological benefits. Japan is especially susceptible to those changes since the country is surrounded by the ocean and depends heavily on marine products for food. Therefore, appropriate measures are needed to avoid any devastating damage.

According to the results of a survey conducted by the Fisheries Research Agency, fisheries of migratory fish, such as saury, sardine, pacific mackerel and horse mackerel, are expected to shift northward in the future. For example, saury migrates seasonally, and in September they usually gather off the coast of the Nemuro Peninsula, east Hokkaido. However, the recent trend of rising seawater temperatures is expected to cause a northward shifting of the fishery, which could result in a change in distribution and fishing season in the long run. Flounder is also affected by rising seawater temperatures, and it has been reported that the southern limit of the habitat of this coastal fish could possibly make a northward shift in the future. Similarly, an optimal nursery for

Figure 2-3-2: Estimated shifting of saury fishery caused by rising seawater temperature



Note 1: "Present" shows current sea-surface temperatures measured by the Japan Metrological Agency (for future global warming trend analysis). "Short-term perspective" represents a rise of 1.0°C from the present, and "Middle-term perspective" indicates estimates based on the Agency's long-term projection (for future global warming trend analysis) (a rise of 1.4°C from the present), and "Long-term perspective" represents a rise of 1.5°C from the "Middle-term perspective" values.
Note 2: Fishery location is based on the assumption that sea-surface temperature is 16 to 20°C in August, 16 to 19°C in September, 12 to 23°C in October and 12 to 22°C in November.
Source: "Estimated Impacts of Global Warming on the Distribution of Marine Organisms in Japan" by Hisami Kuwahara et al, Chikyu Kankyo vol. 11, No. 1 (2006).

globefish, a hatchery fish, could also shift northward.

Some marine creatures that are a nuisance to the fishing industry also seem to be moving northward. Aetobatus flagellum (longheaded eagle ray), whose habitat ranges over the subtropics from the Indian Ocean to the East China Sea and tropical coastal areas, is a predator of bivalves such as clams and pen shells, and thus interferes with fishermen. Since 1989, when this ray was first discovered in the Goto Islands (Nagasaki Prefecture), a great many of them have been located in the Ariake Sea and the Seto Inland Sea, and fishery damage in those areas has been repeatedly reported.

Also, increased acidity of seawater attributed to increased CO_2 concentration is considered to affect marine planktons, which could endanger oceanic biodiversity. In addition, a rising sea-surface temperature is expected to adversely affect the biosphere in southern water zones, although it could help to improve productivity in northern water zones. In southern waters, if surface temperatures rise, it would hamper vertical circulation of sea water because of the lowered ability of surface water to be exchanged with cold deep water. This would weaken the upwelling flow of abyssal nutritious salts, etc., which could seriously affect the distribution of phytoplankton that constitutes the basis of oceanic food chains. Consequently, it could affect marine products to be consumed by human beings.

3. Impact on Human Health

In the Earth, there are many infectious diseases that could be transmitted via vectors that convey pathogens from one host to another.

For example, malaria spreads through mosquitoes and is potentially threatening to 2.5 billion people in the world, which accounts for 40% of the global population. Every year, it causes disease in 300 million to 500 million people and kills 1.5 million to 2.7 million people worldwide. It is known that Plasmodia, malaria parasites, become active at a temperature of 15–20°C or higher, and that Anopheleles, transmission vectors of Plasmodia, become active at a temperature of 22°C or higher. Malaria has been eradicated in Japan, but due to accelerating global warming, Japan will be closer and closer to potential malaria-vulnerable regions again.

Aedes aegypti sucking human blood
Photo: courtesy of Hitoshi Kawada, Institute of Tropical Medicine of Nagasaki University

Dengue fever is also a vector-borne infectious disease transmitted via mosquitoes living in hot regions, such as Aedes aegypti and Anepheleles. Each year, about 100 million people around the world contract this disease, and about 250,000 of them are estimated to develop life-threatening dengue hemorrhagic fever. Children in the tropical and subtropical regions are especially vulnerable to the menace of dengue fever. Historically, Southeast Asian countries and Caribbean countries used to be the center of the dengue infection, but the disease has been expanding recently to reach the southern part of China, South Pacific countries and South America. In tourist-abundant Hawaii, dengue fever spread in 2001 and 2002, registering 122 patients. Like malaria, dengue fever could also be a new menace to Japan because of global warming.

Also, due to the expanding habitats of vector mosquitoes, there is a concern that Africa-centered infectious diseases such as Rift Valley Fever and West Nile Fever could become widespread in other regions.

Prevalence of infectious diseases is dependent on multiple factors such as residential environment and public health, but it is necessary for the international society to understand that global warming could cause infectious diseases to spread and it is necessary to give attention to this matter.

4. Impact on Culture

Quantitative and qualitative changes in ecosystem services could have not only material or physical impacts but also societal and cultural impacts.

Lake Suwa in Nagano Prefecture is known for its unique natural phenomenon of a frozen upheaval of lake water surface, called “omiwatari.” It is caused by repeated expansion and contraction of ice as a result of ups and downs of temperature. Traditionally in Suwa City, a holy ceremony to appreciate “omiwatari” is held where the chief priest and a representative of the parishioners of Yatsurugi Shrine (in Suwa City) identify and certify the formation of “omiwatari.” During the ceremony, cracked water-surface conditions are observed, and the results of the observation tell the year’s fortunes, including weather forecasts, crop harvests and even the fortunes of society. As a result of warm winters, Lake Suwa has frequently missed “omiwatari” in recent years .

Cherry blossoms tell Japanese people the arrival of the spring season, and have a long history of cultural significance to the Japanese, who have celebrated this flower since ancient times. Cherry blossoms appear in many old Japanese poems. One of the six great poets in the early Heian era, Ariwara no Narihira, wrote, “If there were no cherry blossoms in this world, how much more tranquil our hearts would be in spring.” (In other words, it is because of the unpredictability of the blooming and falling of the cherry blossoms that spring is such a time of agitation and excitement.) Recently, global warming and other causes have an effect to the season of this best-loved flower. For the past fifty years, since the Japan Metrological Agency started phonological observations in 1953, the official “blooming” announcement day has come earlier and earlier, and today, cherry blossoms start blossoming about 4.2 days (national average) earlier than fifty years ago.

“Omiwatari” of Lake Suwa Photo:courtesy of Suwa CityMuseum

It has also been reported that some areas in Kyushu show an extraordinary phenomenon in which a temperature rise does not necessarily induce earlier blooming, and some researchers have pointed out that hot winters tend to detune blooming. Cherry blossoms have an internal mechanism that triggers blooming after a certain minimally-required period of dormancy in winter, and they cannot bloom when dormant low-temperature winter days are too few. If the recent rising temperatures detune the blooming of cherry blossoms to a large extent, and should it result in cherry blossoms not necessarily blooming in spring, it would upset Japanese people since the cultural significance of cherry blossoms is now closely related to the spring season. The pleasure of appreciating the spring season with cherry blossoms would be lost, and it would affect regional traditional recreational events. It is also possible that global warming could similarly affect ume (plum) blossoms, peach blossoms, hydrangea, camellia, peony and other plants in which temperatures play an important role in forming flower buds.

5. Vicious Spiral of Global Warming

Besides the direct impacts mentioned above, deteriorating functions of ecosystems could also have indirect but serious impacts on human beings. For example, it has been reported that the weakening ability of ecosystems to mitigate climate change could invite further acceleration of global warming.

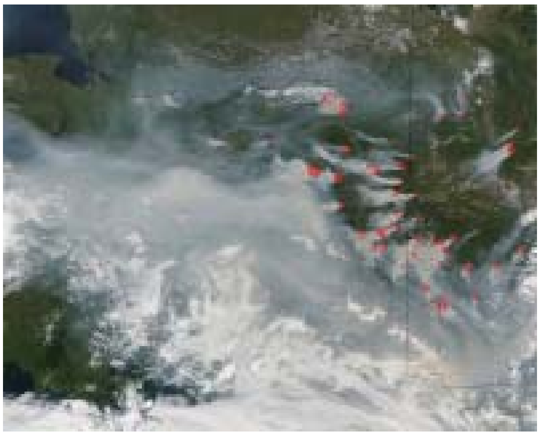
Forests, where massive carbon sequestration takes place, are also affected by global warming in the form of extraordinary loss of moisture, which actually leads to frequent occurrences of fire. Forest fires release CO_2 as a result of combustion and also accelerate the release of CO_2 and methane from tundra and frost soil. It was reported that the forest fires that occurred in Indonesia as a result of El Nino effect from 1997 to 1998 burned down trees over several million hectares. It was discovered by a survey that Indonesia's carbon emission during 1997 was as much as 810 million to 2570 million tons, which accounts for 13% to 40% of the yearly global total CO_2 emission attributable to the consumption of fossil fuels.

In addition, global warming promotes decomposition of underground organic substances, and net carbon uptake by terrestrial ecosystems is weaken or even reverse.

Consequently, GHGs stored in ecosystems would be released into the atmosphere, further promoting global warming. And it could then adversely affect ecosystems. This is how a vicious spiral could be formed.

Thus, global warming has an enormous influence on ecosystems and biodiversity. Ecosystems support geoecological integrity and biodiversity support ecosystems. Therefore, it can be said that global warming would immensely harm, human beings either directly or indirectly. Human survival depends on the integrity of the biodiversity that supports ecosystems. However, human activities after the Industrial Revolution have significantly deteriorated global environment, and have invited critical conditions to affect themselves.

Global warming is a fact, and it is accelerating without doubt. It is our responsibility to make the right decisions to promote actions to protect the nature and its integrity so that we and future generations can continue to benefit from nature. Urgent and appropriate measures are required to stop global warming now.



Forest fire at Alaska
Photo :courtesy of MODIS Rapid Response Project as NASA/GSFC
This forest fire in Alaska was observed on July 30, 2004 by MODIS (optical sensor of NASA). Ascending gray smoke was detected.

Chapter 3

Technologies to Support Measures for Mitigating Global Warming

The previous chapters explained that global warming resulting from human-caused massive CO_2 emissions may threaten the basis of our living. This chapter will discuss the role of Japanese environmental technologies to assist international efforts to build a sustainable society by mitigating global warming and the significance of development and effective utilization of those technologies.

Section 1: Transformation into a Sustainable Society

1. Policy for a "Sustainable Society"

Chapter 2 explained important organic interactions among diverse living creatures, the atmosphere, water and soil on the Earth that support material circulation, and that such a support system is essential for the continued survival of human beings. It also explained that human activities in recent years have polluted the atmosphere, water and soil, threatening ecosystems and their core element, biodiversity. Actually, more and more people have become aware of the fact that geo-environmental resources are exhaustible and limited. Now we need to build a "sustainable society" on this planet, with its limited resources, by making efforts to protect the material circulation, ecosystems and human society from destruction.

The concept of "sustainability" was introduced for the first time in 1987 by the U.N.'s World Commission on Environment and Development (WCED) in its final report, "Our Common Future" (known as the "Brundtland Report"). In the Brundtland Report, "sustainable development" is defined as development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs." Since then, the idea of "sustainable development" has become widely known throughout the world. For example, this idea was introduced as a key concept to the Rio Declaration on Environment and Development and Agenda 21, which were respectively agreed upon during the U.N. Earth Summit in 1992. Now the idea of "sustainable development" is a common keynote of geo-environmental conservation efforts in the world.

In the Third Basic Environment Plan, which was adopted during the Cabinet meeting in April 2006, a "sustainable society" is defined as "a society where we are able to ensure global and local protection of a healty, nature-rich environment, protect human well-being for individual citizens and hand over such protection to future generations." In order to build such a society, we need to solve existing problems regarding (1) limited resources on the Earth and (2) the limited ability of nature to manage human-caused pollution.

Mineral resources and fossil fuels are all limited. From the standpoint of the security of a stable supply of energy resources, it is important to reduce consumption, improve waste collection and recycling, and promote the development of alternative materials and the use of recyclable materials. For example, metallic materials are renewable and thus need to be recycled properly and efficiently. Also, replacement of fossil fuels with renewable energies such as solar energy or biomass should be promoted.

Regarding issue (2) above, we should make sure that the amount of human-caused emissions of pollutants will not exceed the potential of natural systems (the atmosphere, waters, soils, organisms, etc.) to handle them. For example, the excess of human-caused CO_2 emissions over the potential of forests, etc. to absorb CO_2 is a major cause of global warming today. Therefore, it is necessary to reduce and control CO_2 emissions with an understanding of the potential of natural systems.

2. Age of Massive Consumption of Fossil Fuels

After the Industrial Revolution, society has established a mechanism in which industrial products of high quality and low cost are mass-produced through automated processes in large factories and are then mass-consumed by consumers. Through this mass-production/mass-consumption system, advanced countries have obtained fortune and prosperity far beyond what people had experienced before. Developing countries also seek to build the mass-production/mass-consumption structure with the hope of gaining similar fortune and prosperity.

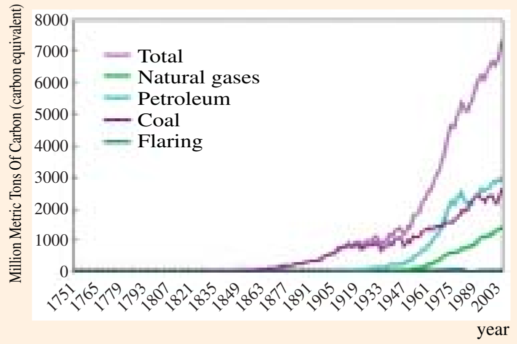
It was fossil fuels including coal and petroleum that made it possible to materialize the said mechanism. Fossil fuels came to be consumed more and more, with increasing speed, as the world promoted mass production and mass consumption (Figure 3-1-1).

It can be estimated that a continuing heavy consumption of fossil fuels at the current pace would result in an exhaustion of those resources on Earth in the near future. Humans are about to use up those fossil fuels in such a short period of time after the Industrial Revolution, despite the fact that it took hundreds of millions of years for those fuels to be formed and stored, in the course of a long process from carbon sequestration through photosynthesis, stabilization as organic substances, to underground accumulation.

The heavy consumption of fossil fuels has also invited the excess of CO_2 emissions over the potential of natural systems to handle them.

Modern human society has consumed a large volume of fossil fuels out of limited resources and released a more-than-absorbable amount of CO_2 into the atmosphere. As a result, the atmospheric CO_2 concentration has been rising higher and higher. It can be said that modern society is far from sustainable.

Figure 3-1-1: Global CO_2 Emissions from Fossil-Fuel Burning and Gas Flaring



Source: Carbon Dioxide Information Analysis Center (CDIAC) of the U.S. Department of Energy

In order to protect the integrity of ecosystems with an understanding of their significant contribution to the basis of our living and ensure sustainability of humanity, we must build a society where a balance between emissions and absorptions of the atmospheric GHGs (including CO_2) can be maintained so that global warming will not reach a critical level.

Section 2: Current Status of Countermeasures and the Contribution of Technologies

Global CO_2 emissions as of 2004 were 26.5 billion tons in total. Of those, the United States occupied the largest share at 22.1%, followed by China at 18.1%. Japan was in the fourth position, accounting for 4.8%. In FY2005, Japan emitted a total of 1.36 billion tons of GHG (CO_2 equivalent), which was up 7.8% from 1990 (1995 for HFC, PFC and SF_6). Various countermeasures against global warming have been introduced so far in Japan, and the following paragraphs will explain the current status of the implementation of those countermeasures and the significant contribution of our technologies to those measures.

1. Status of Various Countermeasures against Global Warming

In an effort to global warming countermeasures, the international society adopted the U.N. Framework Convention on Climate Change in May 1992 and the Kyoto Protocol in December 1997 (entered into force in February 2005).

The Kyoto Protocol sets numerical targets of emissions reduction for respective countries, with the goal of reducing collective GHG emissions from all advanced countries during 2008 and 2012 by 5% compared to the year 1990. Under the Protocol, Japan is required to attain a 6% reduction.

In this situation, the Japanese government established, through the Cabinet meeting in April 2005, the Kyoto Protocol Target Achievement Plan, which covers necessary policy measures to be taken to attain the reduction target. Those policy measures included in the Plan can be categorized into the following four types: (1) policy measures concerning GHG emissions reduction and removals, (2) cross-sectoral measures including national movements and efforts to be initiated by public organizations, (3) measures for establishing the foundation for activities, such as the promotion of technology development and international cooperation, and (4) policy measures concerning the Kyoto mechanisms (Figure 3-2-1). Those respective policy measures are explained in detail in the Plan. For example, category (1) covers the measures for forest sink, and category (3) covers the CCS (Carbon Dioxide Capture and Storage) technology and “adaptability” improvement measures (See Columns). Based on this Plan, the integral promotion of diverse measures is underway, including the implementation of energy-saving measures, introduction of renewable energies and promotion of national movements to review life styles, etc.

Approximately 90% of the total GHG emissions in Japan are regarded as energy-originated carbon dioxide. Policy measures for reducing such CO_2 emissions include technology-based “measures for individual energy-related equipment,” and “promotion of efforts at individual workplaces and businesses, etc.” as well as “establishment of low-carbon socioeconomic mechanisms, including urban and regional structures and public transport systems.” Figure 3-2-2 shows the overview of those policy measures for reducing energy-originated carbon dioxide.

Figure 3-2-1: Gist of the Kyoto Protocol Target Achievement Plan

Target

- Ensure 6% reduction commitment under the Kyoto Protocol
- Steady implementation of a continuous as well as long-term GHG emissions reduction on a global scale

Basis Idea

- Integration of the environment and the economy
- Promotion of technological innovation
- Promotion of participation and collaboration by all the stakeholders
- Utilization of various policy measures
- Prioritization of the evaluation and review process
- Ensuring international collaboration

Targets of GHG reduction/ absorption

GHGs	Target: Emissions in FY2010 (million tons-CO_2)	Target: Compared to FY1990 (Total emission over the base year)	Projected reduction in FY2010 under existing measures (+12%*) * Total reduction with projected increase caused by economic growth and reduction by existing measures over actual achievement in FY2002 (+13.6%)
(1) Energy related CO_2	1,056	+0.6%	▲4.8%
(2) CO_2 from Non-energy source	70	▲0.3%	▲0.4%
(3) Methane	20	▲0.4%	
(4) N_2O	34	▲0.5%	
(5) Other GHGs	51	+0.1%	▲1.3%
Sink including forests	▲48	▲3.9%(*)	▲3.9%(*)
Kyoto Mechanism	▲20	▲1.6%*	▲1.6%*
Total	1,163	▲6.0%	▲12%

* Difference between reduction target(minus 6%) and domestic measures.
(*) It is necessary to conduct a detailed review and adjustments as to numerical estimates based on the inventory of GHG emissions and removals since the estimated amount of emissions as of the base year (1990 in principle), which was figured out at the time of the establishment of the Target Achievement Plan, is not consistent with the estimates today.

Policy measures to accomplish the target

1-1. Policies and measures on GHGs emissions reduction and sinks

(1) Policies and measures on GHGs emissions reduction
1) Energy related CO_2
- Promote measures on energy related apparatus as well as on individual facility/stakeholder
- Take measures to shift socio-economy including urban/regional structure and public transportation infrastructure into low carbon one

2) CO_2 from Non-energy sources
- Promote the use of blended cement and promotion of reduction of reduction measures on CO_2generated by waste incineration

3) Methane
- Reduction of final disposal volume

4) N_2O
- Improvement of incineration prcess in incineration facility for sewage sludge and municipal solid waste

5) Other GHGs (HFC,PFC,SF_6)
- Promote systematic actions by industries and development and use of alternatives
- Collect HFC filled in apparatus as refrigerant complying with regulation

(2) Policies and measures on GHGs sinks
a. Securing absorption
- Comprehensively and steadily promote measures to achieve the goals of the Basic Plan for Forest and Forestry

b. Promote urban greening

1-2. Cross-sectoral measures
- GHG accounting, reporting and announcement
- Promotion of environment-conscious attitudes in business activities
- Public awareness raising campaign
- Initiative by public institutions
- The daylight saving time
- Policy mix (The idea of introducing an environment tax will be discussed.)

1-3. Basic measures
- Domestic system to account GHG emissions and absorption
- Promotion of technology development and R&D
- Promotion of international collaboration and cooperation

2. Policies and measures on the Kyoto mechanisms
- Promotion of overseas projects for emission reduction, etc.
- Efforts to obtain GHG Credits

Organizational arrangements
- Annual review and quantitative assessment of the Plan in FY2007
- The Headquarters will take the lead in steadily implementing the Plan

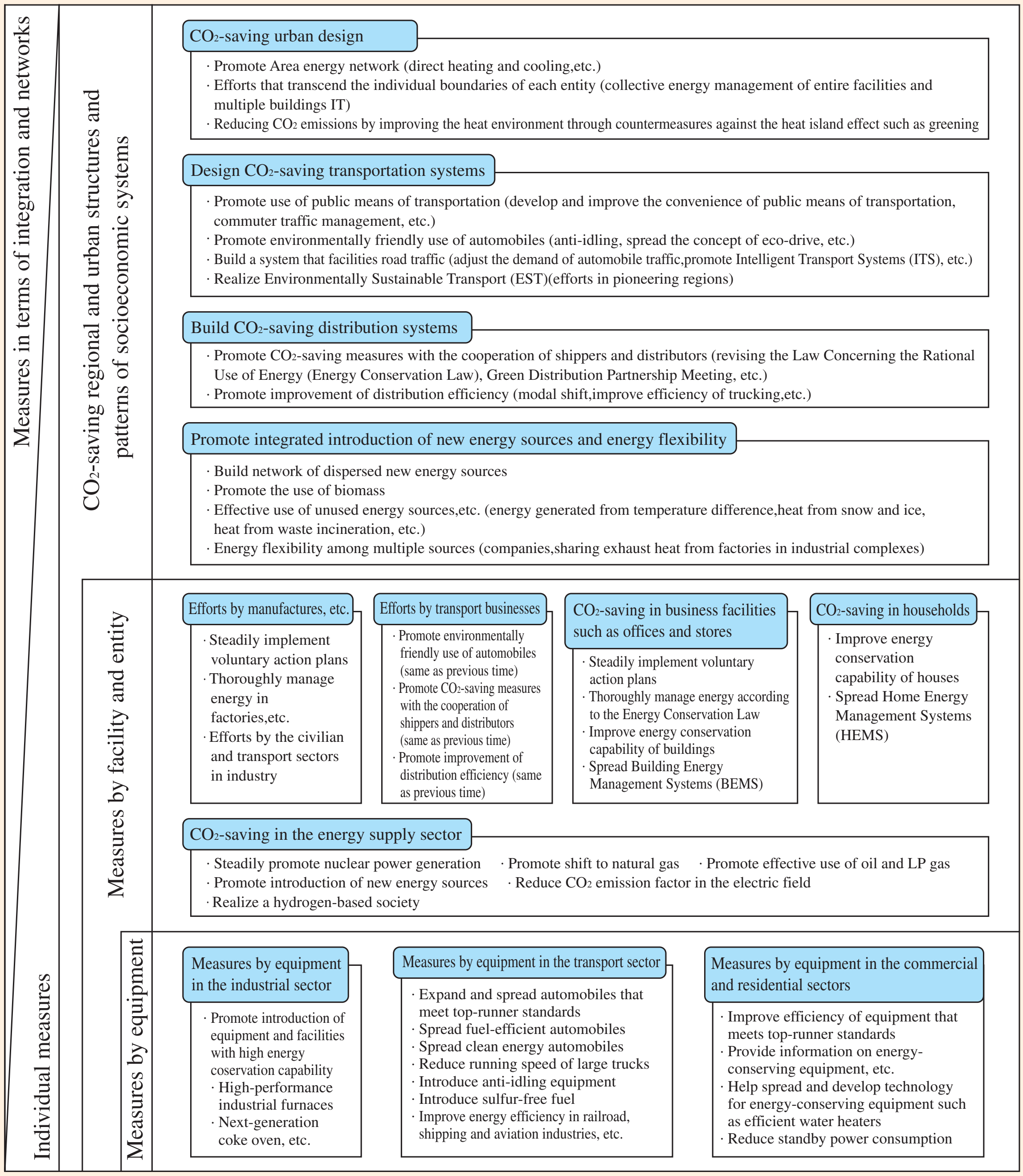
Source: Ministry of the Environment

Column : Measures to Ensure our “Aadaptability”

It is expected that accelerating global warming will have local and global impacts such as a rising sea level and changes in agricultural production, water sources, ecosystems and their core factor, biodiversity. Even our best efforts to mitigate GHG emissions would probably not arrest global warming completely. Facing this reality, we need to not only promote conventional GHG reduction measures but also think about how we should “adapt” ourselves and our socioeconomic systems to climate change.

Measures to ensure our “adaptability” include the promotion of the efficient use of water in preparation for increasing dry weather along with accelerating global warming, improving disaster-prevention facilities in preparation for heavy rains, constructing breakwaters to prevent or mitigate any damage that can be expected from a rising sea level, constructing seashore barriers through tree planting, etc. in preparation for coastal flooding, and introducing alternative cropping patterns, crop replacement or selective breeding in preparation for any defective growth of farm produces as a result of any extreme climate event.

Figure 3-2-2: Overview of Measures Concerning Energy-originated Carbon Dioxide Sources



Source: Ministry of the Environment

2. Significant Role of Technology in Implementing Global-Warming Mitigation Measures

When we make efforts to reduce GHG emissions, it is necessary to promote institutional development, including reform of conventional systems and mechanisms as well as improvement of people's attitude and behaviors. In implementing the policy measures mentioned in the Kyoto Protocol Target Achievement Plan, the development and effective utilization of advanced technologies would certainly make great contributions to our efforts to achieve targets. The following sections will explain the significant role of technology in implementing global-warming mitigation measures, especially in the category of measures for reducing energy-oriented carbon dioxide that occupy a large share of GHG emissions in Japan.

(1) Measures for forming CO_2-saving regional and urban structures and socioeconomic systems

Those measures include CO_2-saving urban design. Technologies that are considered to contribute to the promotion of such measures include the "co-generation" technology, which is designed to use waste heat (generated by heat engines) to simultaneously generate both electricity and useful heat (for air-conditioners, water heaters, etc.) to improve overall energy efficiency, BEMS (Building Energy Management System) and HEMS (Home Energy Management System), which use information technologies to monitor indoor conditions for ensuring energy-saving control and management.

(2) Measures according to facility and by entity

Those measures can be roughly divided into "measures to be promoted by the demand sectors" and "measures to be promoted by the supply sectors."

a. Measures to be promoted by the energy-demand sectors such as the industrial sectors and the transport sector

All energy users should make efforts to reduce the total amount of their CO_2 emissions in their activities. Here, technologies that are expected to make significant contributions to CO_2 emission-reduction efforts include energy-saving process technologies, instruments and control technologies, etc. for the industrial sectors, eco-drive management systems, information systems to improve logistics efficiency, etc. for the transport sector, and insulating materials, solar power systems, etc. for the residential sector.

b. Measures to be promoted by the energy-supply sectors such as nuclear power plants

Energy suppliers also need to make efforts to promote the use of low-CO_2 emission factor sources. For example, the role of nuclear energy is particularly important in promoting global-warming mitigation measures since no carbon dioxide is generated in the process of nuclear-power generation. It is necessary to promote further utilization of nuclear energy, with an understanding that the first priority is to regain people's trust in the safety of nuclear energy and secure nuclear safety. It is also important to promote cooperation between public and private sectors to facilitate steady promotion of nuclear energy as a key energy source. Also, technologies to commercialize or utilize new energies such as solar energy and technologies to promote the use of natural gases are expected to make further progress in the future.

Column : CO_2 Capture and Storage (CCS)

The CCS technology makes it possible to ensure long-term carbon sequestration by capturing CO_2 from large point sources (e.g., power plants, mines of natural gases), isolating it from other gases, and subsequently storing it in underground geological formations or in the ocean, instead of releasing it into the atmosphere.

The forms of CO_2 storage can be roughly divided into underground storage and ocean storage. The approach of underground storage tends to inject collected, separated CO_2 into underground geological formations for the purpose of removing CO_2 from the atmosphere. The approach of ocean storage tends to inject collected, separated CO_2 into deep ocean basins for the purpose of isolating it from the atmosphere.

Researches are underway to improve understanding of underground storage and ocean storage respectively. Some underground storage projects have already been carried out on a commercial basis in Norway, including the North Sea project conducted by a petroleum/gas developer. In Japan, the Research Institute of Innovative Technology for the Earth (RITE) has been carrying out an experiment in Nagaoka City, Niigata Prefecture to verify the feasibility of injecting carbon dioxide into an aquifer system, as a subsidized public project managed by the Ministry of Economy, Trade and Industry. This experiment has injected carbon dioxide totaling about 10,000 tons (carbon equivalent) into the approx. 1,100-meter-deep aquifer for the period of eighteen months starting from July 2003. Currently, post-injection conditions are being monitored.

Also, technologies to isolate and collect carbon dioxide from other gases have been developed and researches are underway to study those technologies.

Table 3-2-1: Contribution of measures and technologies concerning Energy- originated Carbon Dioxide

Forming CO_2-saving regional and urban structures and socioeconomic systems

	Measures	Relevant technologies (examples)
CO_2-saving urban design		
1	Promote Area energy network	district heating and cooling, co-generation, fuel cells
2	Efforts that transcend the individual boundaries of each entity	BEMS, BA-FA integration platform technologies
3	Reducing CO_2 emissions by improving the heat environment through countermeasures against the heat island effect such as greening	Greening of special spaces such as rooftops, artificial-waste heat-control technologies, water-retentive pavement, solar-reflective paint, sewage/spring-recycling technologies
Design CO_2-saving transportation systems		
1	Promote use of public transportation	LRT, IC card technologies
2	Promote environmentally friendly use of automobiles	anti-idling equipment, eco-drive management system (EMS)
3	Build a system that facilitates road traffic	Intelligent Transport System (ITS), Vehicle Information and Communication System (VICS)
4	Realize Environmentally Sustainable Transport (EST)	LRT, CNG bus
Build CO_2-saving distribution systems		
1	Promote CO_2-saving measures with the cooperation of shippers and distributors	Information systems to improve logistics efficiency
2	Promote improvement of distribution efficiency	new technology such as the next generation domestic vessels (Super Eco-Ship)
Promote integrated introduction of new energy and energy interchange		
1	Build network of dispersed new energy sources	MicroGrid
2	Promoting use of biomass	Technologies for utilizing biomass resources, technologies for conversion/utilization of biomass energies
3	Effective use of unused energy sources	Technologies for utilizing unused energies (energy generated from temperature difference using seawater, sewage, etc.,heat from snow and ice),technologies to use waste heat(heat from waste incineration)
4	Energy conservation through cooperation among multiple businesses	Companies sharing exhaust heat from factories in industrial complex (high-efficiency heat-storage equipment)

Measures according to facility and by entity

	Measures	Relevant technologies (examples)
Efforts in manufactures,etc.		
1	Steadily implement on voluntary action plans	Energy-saving process technologies, energy-saving production facilities and systems, development of high-function steel materials, etc.
2	Thoroughly manage energy by plants, etc.	Instruments and control technologies
3	Efforts by the civilian and transport sectors in industry	development of lighter and more functional materials,products that are highly energy-efficient
Efforts by transport businesses		
1	Promote environmentally friendly use of automobiles (same as the above)	anti-idling equipment, eco-drive management system (EMS)
2	Promote CO_2-saving measures with the cooperation of shippers and distributors (same as the above)	Information systems to improve logistics efficiency
3	Promote improvement of distribution efficiency (same as the above)	New technologies such as next generation domestic vessels (super eco-ships)
CO_2-saving in business facilities such as offices and stores		
1	Steadily implement on voluntary action plans	Introduction of energy-conserving equipment, replacement of conventional machines with energy-conserving equipment
2	Thoroughly manage energy according to the Energy Conservation Law	BEMS
3	Improve energy conservation capability of buildings	Energy-saving technologies for building skeleton (structural materials, windows, insulating materials, etc.)
4	Spread Builiding Energy Management Systems (BEMS)	BEMS
CO_2-saving in households		
1	Improve energy conservation capability of houses	Energy conservation renovation work, heat insulation materials, photovoltaic power generation systems, glass with a high energy conservation capability (multiple-layer glass), sashes with a high energy conservation capability (wooden or plastic), greening of rooftops or wall surfaces
2	Spread Home Energy Management Systems (HEMS)	HEMS
CO_2-saving in the energy supply sector		
1	Steadily promote nuclear power generation	Improvement of the nuclear power plant's capacity factor, nuclear fuel cycle technologies
2	Promote introduction of new energy sources	Utilizing sunlight, wind power and biomass(use of heat from biomass, solar and waste incineration, fuel derived from biomass, photovoltatic and wind power generation, power generation from waste)
3	Promote shift to natural gas	Improving efficiency of gas turbines and gas engines, natural gas cogeneration, highly efficient gas air conditioning, GTL (gas-to-liquid) technologies for natural gases, dimethyl ether, methane hydrate
4	Reduce CO_2 emission factor in the electric field	Improvement of the heat efficiency of thermal power generation, thermal storage systems
5	Promote effective use of oil and LP gas	Petroleum co-generation systems, highly efficient boilers with low NO_x, LPG co-generation systems, gas engine boilers
6	Realize a hydrogen-based society	Fuel cells, hydrogen manufacturing

Measures and policies, etc. by equipment

	Measures	Relevant technologies (examples)
Measures and policies, etc. by equipment in the industrial sector		
1	Promote introduction of equipment and facilities with high energy conservation capability	various kinds of energy-conserving equipment, high efficiency industrial furnaces, high efficiency boilers, next-generation coke ovens, fuel efficient construction machinery
Measures and policies, etc. by equipment in the transport sector		
1	Expand and spread automobiles that meet top-runner standards	automobiles that meet top-runner standards (introduction of LPG passenger autobobiles, etc.)
2	Spread fuel-efficient automobiles	Technologies to improve fuel efficiency, clean diesel passenger automobiles
3	Spread clean energy automobiles	Hybrid automobiles, natural gas automobiles, electric automobiles, methanol automobiles, fuel cell automobiles
4	Reduce running speed of large trucks	Speed-limiting device
5	Promote environmentally friendly use of automobiles (same as the above)	Anti-idling systems, eco-drive management system (EMS)
6	Introduce sulfur-free fuels	Sulfur-free petroleum fuel
7	Improve energy efficiency in railroad, shipping and aviation industries etc.	Light vehicles, vehicles with VVVF equipment(*), electrical propulsion ships, ships equipped with electronically-controlled engines
Measures by equipment in the commercial and residential sectors		
1	Improve efficiency of equipment that meets top-runner standards	Energy-saving technologies for those machines and equipment covered by the top-runner standards (Air-conditioners, fluorescent lamps, television sets, electric refrigerators, gas cooking appliances, electric toilet seats, passenger vehicles)
2	Provide information on energy-conserving equipment, etc.	Various kinds of energy-conserving equipment, energy conservation technologies
3	Help spread and develop technology for energy-conserving equipment such as efficient water heaters	Natural refrigerant heat-pump water heaters, latent heat recovery type water heaters, gas engine water heaters(miniaturization and facilitating installation),electromagnetic cookers, electric kettle using a vacuum-insulation panel, electric washer and dryer heat-pump laundry, highly-efficient commercial-use air conditioners utilizing heat pump technology, highly-efficient commercial-use water heaters and low temperature natural refrigerant freezer units that do not use chlorofluorocarbons, integrated systems combining energy-efficient refrigerators and freezers, and air conditioning for the use of retail stores, light emitting diodes (LEDs), fluorescent lamp using an inverter system, Hf lamp
4	Reduce standby power consumption	Equipment of low standby power consumption

Note: (*) VVVF stands for vehicles equipped with a mechanism that efficiently controls the revolutions per minute of the motor without using electrical resistance.
Source: Ministry of the Environment

(3) Measures for individual energy equipment

Technology makes a great contribution to the implementation of measures for individual energy equipment, and here are some examples.

In the industrial sector, energy-saving equipment, high efficiency industrial furnaces and boilers have been introduced to improve the efficiency of the combustion process and enhance energy-saving performance. In the transport sector, technologies to develop lightweight vehicles, technologies to improve engine efficiency and control technologies for hybrid vehicles help improve fuel economy and enhance energy-saving performance. In the residential/commercial sectors (Commercial and other sector, and residential sector), there exists a water heater with the function of latent heat recovery (where heat released into the atmosphere in the form of vapor can be recycled). Also, LED makes a great contribution to lighting equipment. Thus, technologies help improve energy efficiency and energy saving.

For more information on technologies that contribute to the improvement of energy efficiency and energy saving and support policy measures to reduce energy-oriented carbon dioxide, see Table 3-2-1.

Besides the contribution to reduce energy-originated carbon dioxide, technologies also play a significant role in the measurement and future estimation. Furthermore, their indirect contributions are also noteworthy. For example, an anti-idling system would encourage more drivers to resist engine idling, and LRT (Light Rail Transit) systems would increase the convenience of public transport, resulting in the increase of public transport users. Also, there are some energy-saving products for home electricity users (power outlet called “Eco-Tap,” outlet equipped with a timer, etc.) that make it possible to conveniently shut off the power without unplugging a unit, and such products would help promote the reduction in standby power consumption. Those technologies make great contributions to the improvement of people’s attitudes toward energy saving and adoption of ecology-conscious lifestyle.

Thus, many of the measures that we have been implementing under the Kyoto Protocol Target Achievement Plan greatly benefit from the development and commercialization of technologies and their indirect effects. In making our continued efforts to global warming countermeasures in the future, the development and utilization of technologies should have significant meaning, along with institutional development and reform of people’s attitude and behaviors.

Section 3: Our Past Experiences to Overcome Environmental Problems with Technologies

Having faced various pollution problems in the past, Japan overcame each of those problems by introducing diverse environmental conservation measures. One of the elements that helped us successfully tackle the problems was technology.

The development and introduction of an environmental conservation technology costs a business a large amount of additional expenditures. At the same time, however, such technology contributes not only to environmental conservation but also to improvement of the business’ technological strengths and international competitiveness, as well as creation of new business opportunities and the comfort of people. This section will explain past examples of how environmental conservation technologies made significant contributions to the Japanese society.

a. Flue gas desulfurization facility to reduce sulfur oxides (SOx) emissions

After World War II, Japan had achieved rapid industrial restoration at an unprecedented pace, which was amazing to other countries. At the same time, the increase of smoke generated by plants nationwide aggravated air pollution rapidly in Japan.

In order to overcome this industrialization-caused air-pollution problem, our industrial sectors promoted the use of low-sulfur petroleum and invested in the development and introduction of a flue gas desulfurization facility. As a result, the number of businesses that introduced such desulfurizer increased significantly during the period from the mid-1960s to mid-1970s (Figure 3-3-1), successfully mitigating air pollution.

By exporting technology developed through the commercialization of flue gas desulfurization facilities, Japan could help developing

Flue gas desulfurization facility
Photo: courtesy of Mitsubishi Heavy Industries, Ltd.

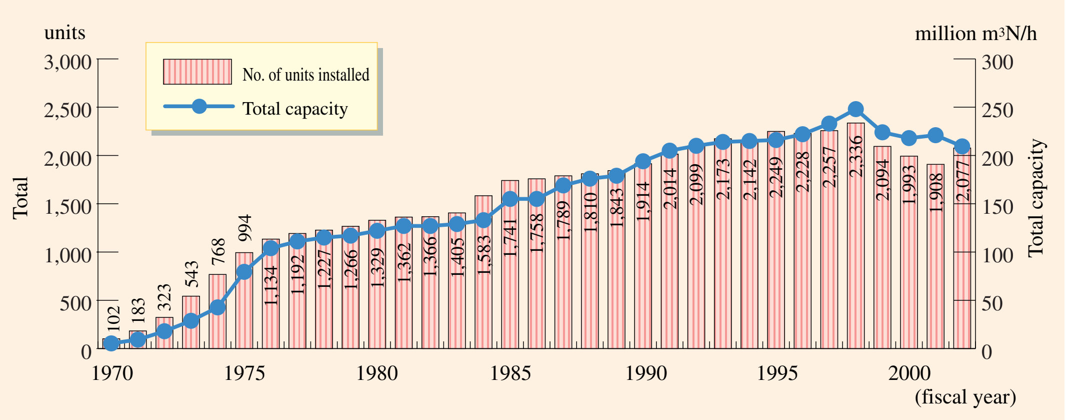
Column : Countermeasures against Smoke Damage in the Area around Besshi Copper Mine

In the middle of the Meiji era, the area around Besshi copper mine in Ehime Prefecture started to suffer crop damages in farmlands caused by sulfurous acid gas generated at a local refinery. In an effort to solve this problem, the refinery was moved to a uninhabited neighboring island in Niihama, but an air current above the Seto Inland Sea brought the sulfurous acid gas to the entire Toyo region, resulting in extensive damage to farm produce in that region.

To solve this problem, the manager of Besshi copper mine attempted to introduce the desulfurization technology to produce sulfuric acid from the refinery-producing sulfurous acid gas as well as the technology to produce fertilizers by using sulfurous acid (ammonium sulfate). Through repeated trials, the technologies have been improved to successfully materialize practical application. Those technologies put an end to long-lasting smoke damages that suffered Besshi copper mine for about fifty years, and also made it possible for the region to maintain their local agricultural businesses while enjoying the benefits of their key industry of copper business (a key industry in Japan at that time). Also, the idea of producing agricultural fertilizers by using sulfurous acid is quite close to today's concept of a sustainable society, where it is based on recycling wastes to produce useful goods.

countries in Asian fight the growing air-pollution problems they face in their industrialization. Such strengths and skills also lead to expanding business opportunities.

Figure 3-3-1: State of Installation of Flue Gas Desulfurization Facilities by year (FY1970-2002)



Source: Compiled from *Survey on the State of Stationary Sources Relating to Air Pollution*, Ministry of the Environment

b. Energy-saving efforts by the industrial sectors after the oil crises

The outbreak of the Fourth Middle East War in October 1973 triggered a crude oil price hike, and this first oil crisis greatly threatened advanced industrial countries worldwide who were highly dependent on Middle East petroleum for energy sources to support their socioeconomic activities. At that time, Japan's dependence on imported petroleum was enormous, accounting for as much as three-fourths of the entire domestic demand for energy fuels. To survive this crisis, business owners and managers aggressively promoted the introduction of energy-saving technologies, such as the continuous casting technology introduced by the steel industry, in an effort to maximize cost performance. Later, even after the industries regained stable economic growth and stabilization of crude oil prices, Japanese businesses continued their investments in development and research of energy-saving technologies. As a result, the introduction of effective energy-saving technologies has spread widely, including energy-efficient equipment, recycling techniques, and collection of waste heat and waste energy.

Now, Japan enjoys world-class industrial energy efficiency (Figure 3-3-1). Our efforts to lower the demand of energy input in the manufacturing process not only reduced environmental loads but also led to cost reduction in production activities, contributing greatly to the improvement of the international competitiveness of Japanese industries.

Table 3-3-1: International comparison of energy efficiency

Iron and Steel

Integrated steelworks energy consumption intensity

Japan	South Korea	EU	China (large scale)	China (whole country)	United States	Russia
100	105	110	110	120	120	125

(Japan Iron and Steel Federation)
Source: Data from the Korea Iron and Steel Association and the China Iron and Steel Association, and individual interviews

Chemicals

Electric power consumed in relation to production of electrolytic caustic soda

Japan	Taiwan	South Korea	China	United States	Western Europe	Eastern Europe
100	100	100	104	110	119	115

(Japan Chemical Industry Association)
Source: *SRI Chemical Economic Handbook*; Japanese Soda Industry Association, *Soda Handbukku (Soda Hand book)*

Paper

Total energy consumption for paper and paperboard produced (before adjustments for imported and exported pulp)

Japan	United States	Canada	Sweden	Germany
100	144	134	123	52

(Japan Paper Association)
Source:
Data from Japan from Japan Paper Association follow-up report for 2003, for United States from the American Forest & Paper Association's *annual statistics for 2002*; for Canada from Forest Product Association of Canada, *Environmental Reports 2000-2001*; for Sweden and Germany from Confederation of European Paper Industries, *Energy Profile 2001*.
Since Germany relies largely on recycled pulp and imported pulp, its energy consumption related to pulp production is low. In addition, demand for quality such as whiteness of toilet paper is relatively low in Germany, which can also be considered a factor contributing to low energy consumption.

Cement

Energy consumption per clinker ton (for 2000)

Japan	Western Europe	South Korea	Central and South America	China	United States	Russia
100	130	131	145	152	177	178

(Japan Cement Association)
Source: "Toward a Sustainable Cement Industry Substudy 8: CLIMATE CHANGE (March 2002)" (Battelle)

Note: Energy intensity is a value that represents energy efficiency. The lower the energy intensity value, the better the energy efficiency.
Source: Nippon Keidanren "Results of the Fiscal 2006 Follow-up to the Keidanren Voluntary Action Plan on the Environment (Summary) -Section on Global Warming Measures - < Performance in Fiscal 2005 >"

c. Technologies for motor vehicles to address exhaust-gas restrictions and to improve fuel economy

In Japan, motor vehicles came to be widely used by the public from the latter half of the 1960s. Accordingly, the problem of air pollution caused by vehicle exhaust emissions became conspicuous. Under such circumstances, the government introduced control over vehicle exhaust emissions and strengthened regulations from time to time. Today, Japan has the strictest vehicle exhaust-emission restrictions in the world (See Section 3, Chapter 2 of Part 2).

Japanese automakers have been promoting technology development to address the issue of aggravated air pollution caused by vehicle-exhaust gas. There are a wide variety of such development projects including improvement of engine-combustion control and heat efficiency, introduction of lightweight vehicles, and catalyst for exhaust-gas purification. Through the industrial efforts to promote those RD&D projects and commercialization, Japanese automakers have established its world-class status in terms of technological strengths in the field of exhaust-gas control.

Japanese automakers have also been promoting technological innovations aimed at improving fuel economy, and they have now established world-leading technology aimed at ensuring improved fuel economy.

Such improvements as to control of exhaust gas and fuel economy have not only contributed to environmental conservation, such as air-pollution mitigation and CO_2 emission reduction, but also produced added product value and improvement of international competitiveness. Today, there is a worldwide tendency for government-imposed restrictions over vehicle exhaust gas to be stricter and stricter in response to people's increasing interest in environmental issues. This trend is an advantage for the Japanese auto industry, which has been making great efforts to create more sophisticated environmental technologies that will lower exhaust-gas emissions and improve fuel economy. Actually, after the second oil crisis (1979), Japanese cars, which are small and energy-efficient, increased in sales substantially in the U.S. market.

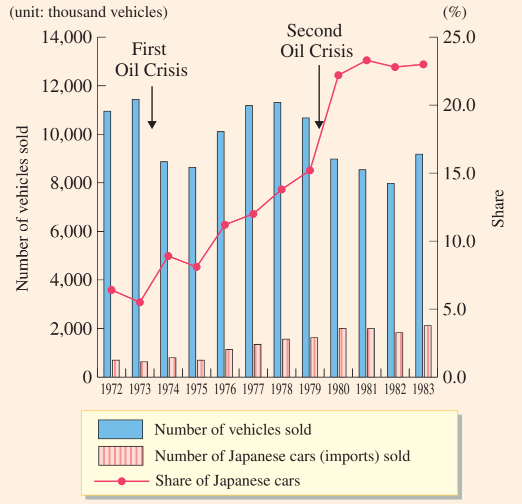
d. Soil contamination in those lands previously occupied by plants

Since the early 1990s, facts of serious soil contamination have been revealed one after another in lands planned to be used for town redevelopment, and drew much public attention. Since Japan is a small country, the issue of land use in urban areas is treated carefully especially when land use for a particular purpose is changed or redevelopment is planned. In response to the situation, various RD&D projects for the disposal of underground pollutants have been promoted according to purposes of land use and types of contaminant, where techniques to confine pollutants as well as technologies to isolate and dispose of contaminated soils are being studied.

Technologies to decontaminate soils contribute to the protection of human health in neighboring areas and also to the removal of negative factors in land-utilization efforts. In addition, soil purification of a contaminated idle land helps prevent deforestation of other land that would otherwise be developed as an alternative, and also helps create business opportunities and promote regional vitalization. According to a survey conducted by the Geo-Environmental Protection Center, the total amount of money paid during fiscal year 2005 to contracts for soil-contamination surveys or soil-decontamination projects registered at 162.4 billion yen, and such expenditures are expected to continue to increase in the future (Figure 3-3-3).

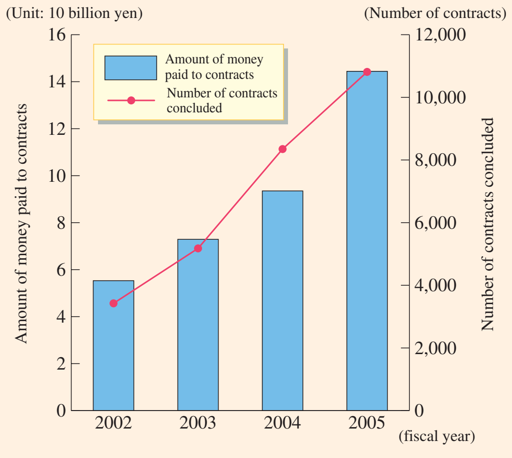
Thus, technologies helped Japan to overcome various environmental problems in the past. The significant contributions of technologies are not limited to the effects of environmental conservation but extend over various benefits, including improved international competitiveness and new business opportunities. In our efforts to global warming countermeasures, the significance of technologies is enormous, as mentioned above, and is expected to further increase as global warming accelerates in the future.

Figure 3-3-2: Trend of car sales in the U.S. market for new American cars and imported Japanese cars



Source: Compiled from the data of the U.S. Department of Commerce by the Japanese Ministry of the Environment

Figure 3-3-3: Expanding geo-environmental businesses



Source: Geo-Environmental Protection Center *Results of the fact-finding survey on soil-contamination researches and countermeasures (during FY2005).*

Section 4: Global Warming Countermeasures

The previous sections explained how important technology development and wide utilization of effective technologies are to the promotion of global warming countermeasures. Also, Section 3 discussed specific meaningful achievements attained from technology development and wide utilization of developed technologies. This section will provide overviews of current conditions of how technologies that are effective to mitigating global warming are actually being used and producing effects. Here, based on the understanding of the current status of CO_2 emissions in respective major sectors in Japan, a focus will be put on those technologies that are being practically used and are expected to come into widespread use in the future and will thereby reduce CO_2 emissions substantially.

1. Current Status of CO_2 Emissions in Japan

(1) Overall conditions

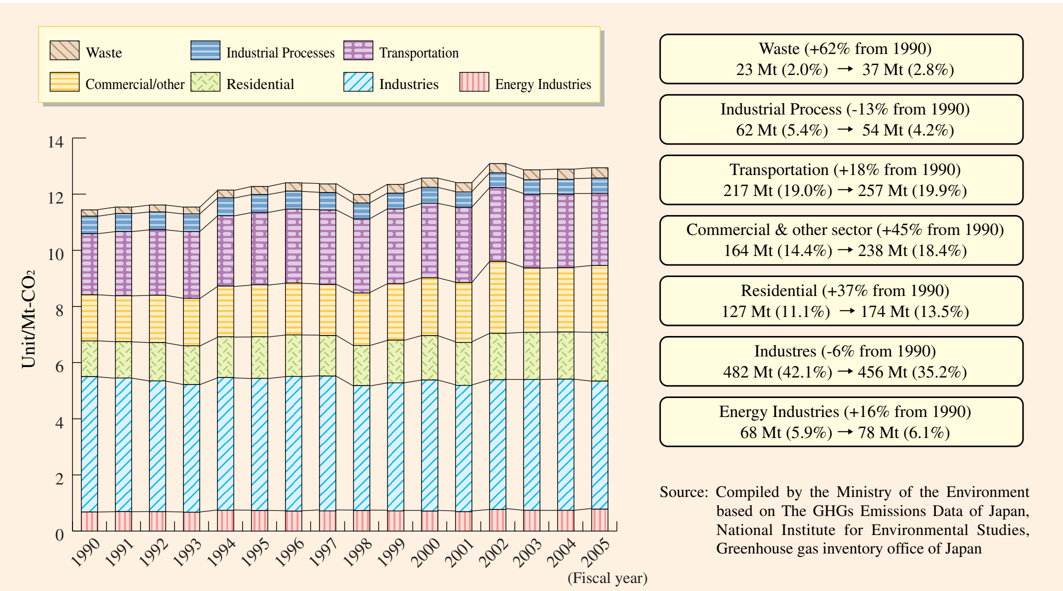
Figure 3-4-1 shows changes over time of CO_2 emissions in major sectors in Japan, and the data begins with the year 1990, which is the base year under the Kyoto protocol.

(2) Status of the industrial sector

As mentioned in the previous section, the industrial sector started introducing various energy-saving technologies after the oil crises, and since then this sector has been continuing its energy-saving efforts. As shown in Figure 3-4-1, however, the level of CO_2 emissions attributable to activities within the industrial sector still constitute a large proportion of Japan’s total emissions and therefore needs to promote further emission-reduction measures toward the achievement of their assigned target under the Kyoto protocol. At the same time, when compared to the base year 1990, emissions caused by the industrial sector have declined.

This declining tendency indicates the effective wide utilization of excellent energy-saving technologies in Japan in comparison with other countries. The aforementioned data of international comparison on CO_2 emissions intensity by industry in major manufacturing sectors (Table 3-3-1) is evidence of Japan’s superiority in emission-reduction efforts. Therefore, it can be expected that the export of Japanese advanced technologies to foreign countries would be contributive to those countries pursuing emission-reduction efforts. In this light, Japan is capable of making valuable contributions to the international society’s global warming countermeasures.

Figure 3-4-1: Trends in CO_2 emissions in Japan



Source: Compiled by the Ministry of the Environment based on The GHGs Emissions Data of Japan, National Institute for Environmental Studies, Greenhouse gas inventory office of Japan

(3) Status of the commercial and residential, and transport sectors

In contrast to the industrial sector, CO_2 emissions caused by the commercial and residential, and transport sectors have increased substantially from the base year 1990 (44.6% increase for commercial and other sector, etc., 36.7% increase for residential and 18.1% increase for the transport sector). Also, those three sectors collectively account for as much as 57% of all CO_2 emissions in 2005. At the same time, however, it can be translated into a large reduction potential expected from those sectors, and this potential could be realized by way of an adoption of emission reduction measures by a large number of representatives from these three sectors. Thus, it is important to understand how technologies could specifically contribute to CO_2 emission reduction in those sectors in particular, and the following subsections will explain the details of such potential, while focusing on those technologies at the stage of practical utilization.

2. Statuses of Practical Application of Various Technologies to Products and Systems

Technologies could contribute to CO_2 emission reduction only after they are successfully applied to products or systems, commercialized and widely utilized.

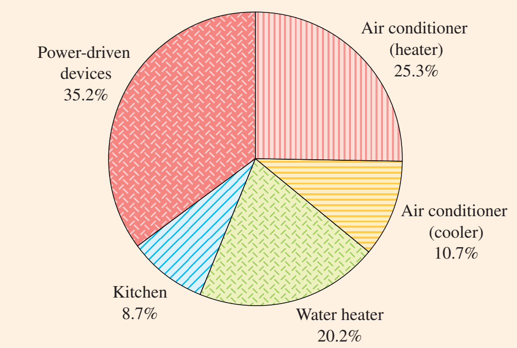
Here are examples of such applications that have a large potential of wide utilization. Those can be roughly divided into technologies for energy users and technologies for energy suppliers.

(1) Energy saving technologies for energy users

Figure 3-4-3 and Figure 3-4-4 show the CO_2 emission structure in the commercial and residential sectors, including households, offices and business facilities. Those figures show that water heaters, air conditioners and power unit (refrigerators, lighting equipment, etc.) collectively occupy a large proportion of the CO_2 emissions. Also, about 90% of the total CO_2 emissions generated by the transport sector are attributed to the use of motor vehicles, and about 50% originate from private passenger cars, as shown by Figure 3-4-5.

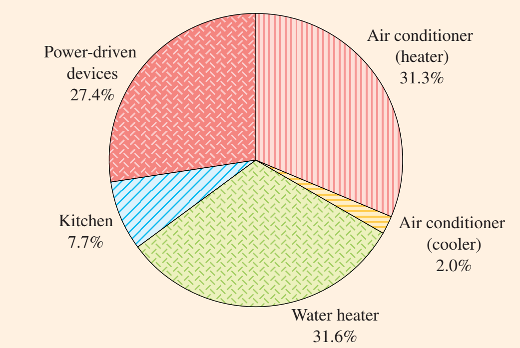
Since the CO_2 emissions attributed to the said equipment and machines are large, reduction of them would produce substantial effects, and it is therefore important to work aggressively on those equipment and machines. The following subsections will explain the potential of CO_2 emission reduction expected mainly from the said equipment and machines through the promotion of technology utilization.

Figure 3-4-4: Structure of CO_2 emissions in commercial and other sector (FY2005)



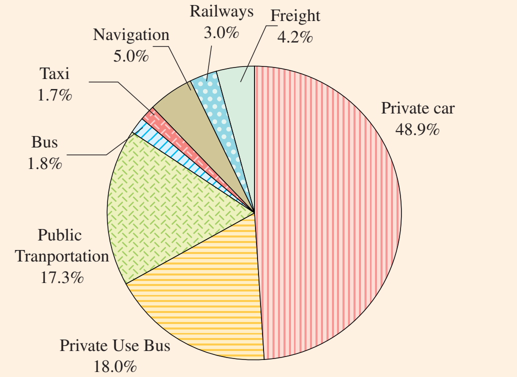
Source: Compiled by the Ministry of the Environment based on the Institute of Energy Economics, Japan, *Handbook of Energy & Economic Statistics in Japan*

Figure 3-4-3: Structure of CO_2 emissions in residential sector (FY2005)



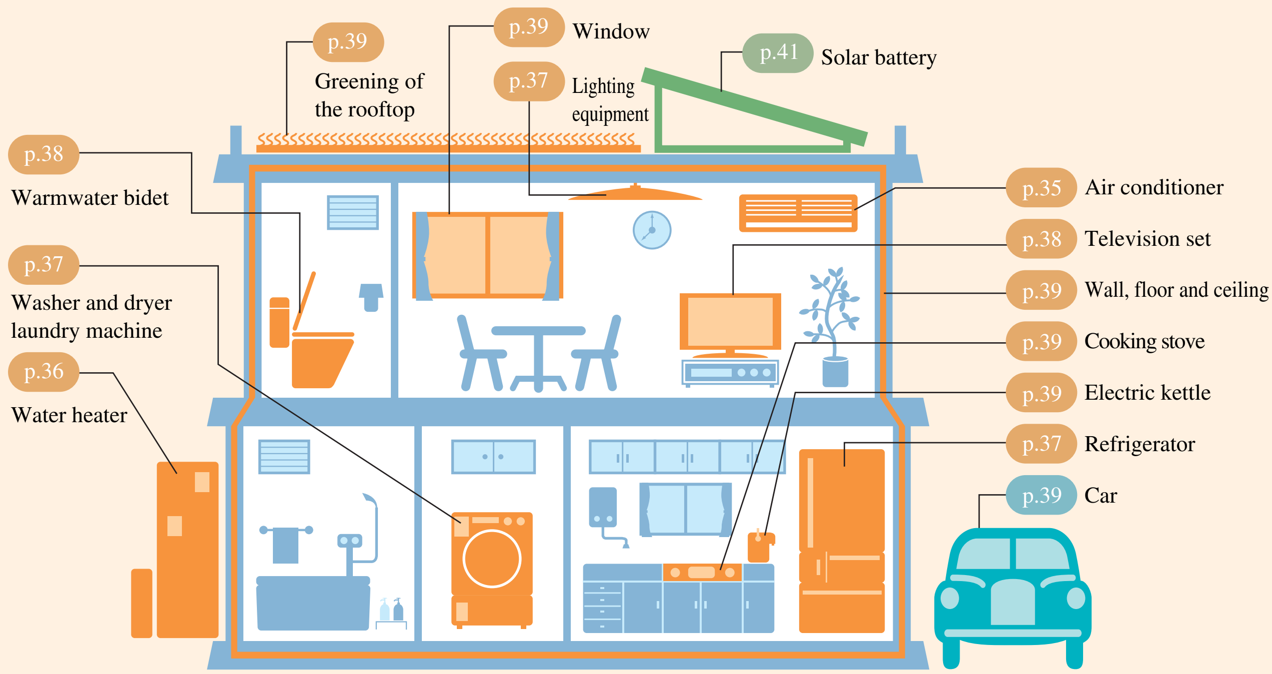
Source: Compiled by the Ministry of the Environment based on the Institute of Energy Economics, Japan, *Handbook of Energy & Economic Statistics in Japan*

Figure 3-4-5: Structure of CO_2 emissions from the transport sector (FY2005)



Source: Compiled by the Ministry of the Environment based on Greenhouse Gas Inventory Office of Japan, of the National Institute for Environmental Studies, National GHGs Inventory Report of Japan

Figure 3-4-2: Potential application of environmental technologies to households



Source: Ministry of the Environment

a. Thermal and heat pump technologies

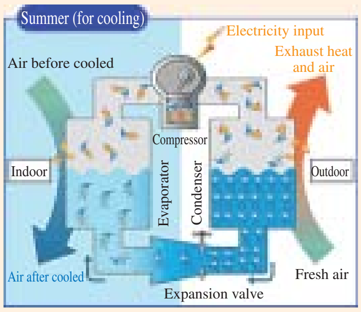
Heat pump technology, which moves collected atmospheric heat from one location to another, is being applied to air conditioners, food refrigerators and freezers, etc. This technology allows for the use of low-temperature thermal energy in a highly efficient manner. Recent improvements of various technologies have upgraded performance of heat pumps to a large extent. Actually, the use of heat pump technology has been expanded to include water heaters and dryers and washing machines , resulting in enormous energy-saving effects. In addition, heat pump air conditioners capitalizing on the use of underground heat or the use of sewage or river water as a heat source have been commercialized.

Also, advanced technologies to improve thermal efficiency, such as the technique of phased use of heat, latent heat recovery system, etc. are applied to commercial products one after another.

(a) High-efficiency air conditioners

Today, most houses and offices have air conditioners and many of them have a heating system in addition to a cooling system. Since air conditioners are the major electricity consumer in homes, improvement of their energy efficiency is especially demanded.

Figure 3-4-6: Mechanism of heat pump



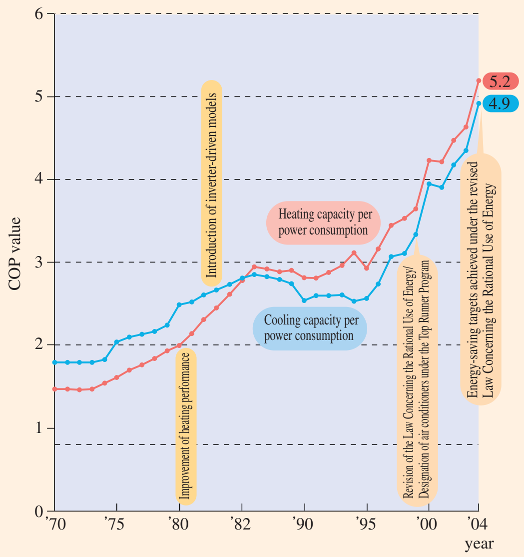
Source: Tokyo Electric Power Company

Actually, through the development and commercial application of high-efficiency heat pump technology and new control technologies, energy efficiency of air conditioners has improved greatly in recent years.

For example, some of the latest high-performance models have an excellent COP value of 6 or higher ("COP" or "Coefficient of Performance" is an index representing energy consumption efficiency in term of the cooling/heating capacity per power consumption of 1kW). These are much lower CO_2 emissions than those of conventional products. Actually, the recent COP trend for air conditioners (Figure 3-4-7) shows a rapid improvement of efficiency in the last decade. You can save your money for electricity charges if you buy one of the latest high-performance models to replace your old one.

The number of air conditioners being installed at home in Japan is estimated to be more than 120 million units today, and quite a few of them are considered to be conventional models. Therefore, much energy-saving effects can be expected from replacement of those models with the latest models.

Figure 3-4-7: COP trend for air conditioners (in terms of sales)



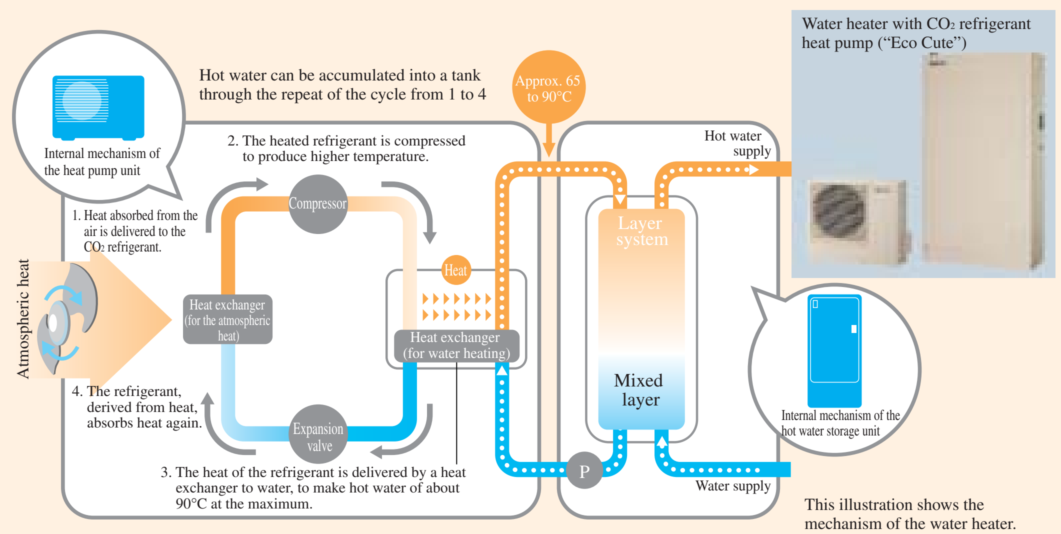
Source: Jyukankyo Research Institute Inc.
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

In addition, those high-performance models have various energy-saving functions, including a system to create a pinpoint air current that would effectively and immediately make users feel warmth when they turn on the heater and a system of automatic cleaning of internal structures (the latter system prevents dust accumulation from causing deteriorated operation efficiency). It can be said that the latest models embody an integrated improvement of convenience, economy and environmental-friendliness.

(b) Electric water heater with natural refrigerant heat pump and high-efficiency gas water heater with the latent heat-recovery function

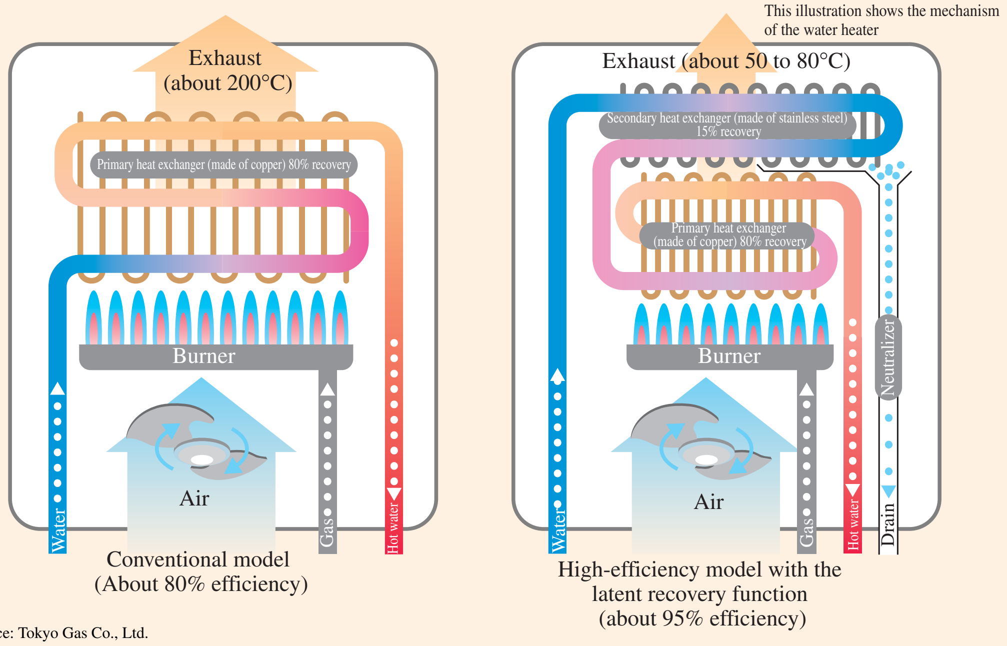
The electric water heater with a natural refrigerant heat pump (known under the trade name "Eco Cute") has been developed to use carbon dioxide as a refrigerant together with a heat pump system, just like ones used in many air conditioners, where electricity and atmospheric heat is used to heat water.

Figure 3-4-8: Mechanism of the electric water heater using a natural refrigerant heat pump



Source: Tokyo Electric Power Company
"Fact Sheet on energy-saving houses" issued by the Ministry of the Environment

Figure 3-4-9: Mechanism of gas water heater with the latent heat-recovery function



Source: Tokyo Gas Co., Ltd.
"Fact Sheet on energy-saving houses" issued by the Ministry of the Environment

Because of the use of atmospheric heat, this water heater is energy-efficient, allowing for about a 30% saving of primary energy as well as about a two-fold reduction of CO_2 emissions, when compared to combustion-type products. This makes it possible for users to save a lot of money for electricity charges when compared to conventional models.

The high-efficiency gas water heater with the latent heat recovery function has also been developed and widely distributed as an energy-saving product (known under the trade name "Eco-JOES"). The function of latent heat recovery from vapor contained in exhaust gas allows for about a 95% efficiency, instead of about 80% for conventional models.

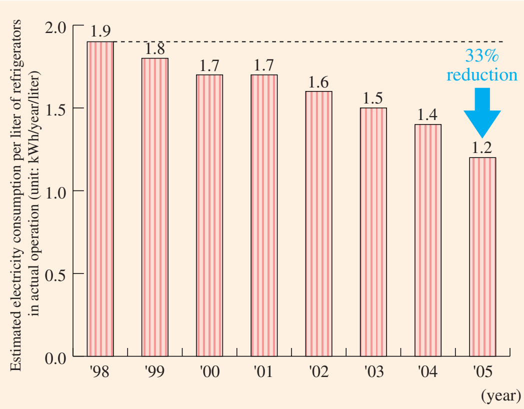
In addition, the gas engine heat pump system is now being widely used.

(c) Electric refrigerator

Electric refrigerators have also improved their energy-saving performance significantly through the introduction of advanced refrigeration technology, insulation technology, control technology and so on.

For the last twenty years, electric refrigerators have achieved more than the three-fold reduction in electricity consumption per liter of capacity. During the past several years, the improvement of their energy-saving performance has been further accelerated, achieving more than 30% reduction in overall electricity consumption. It means that replacement of a conventional model with one of the latest high-performance models would result in great energy-saving effects (Figure 3-4-10).

Figure 3-4-10: Changes over time in yearly electricity consumption of 450-liter-capacity electric refrigerators in actual operation



Source: Final Report by the Electric Refrigerator Evaluation Standards Subcommittee of the Advisory Committee on Natural Resources and Energy
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

(d) Heat-pump washer & dryer laundry machine

In recent years, more and more households have come to use an electric dryer for laundry. Those laundry machines with an electric drying system generally consume a lot of electricity when compared to those using a non-electric drying process, but the latest models introduce heat pump technology, which allows for substantial energy saving and more than twice the reduction in electricity consumption. Those heat-pump models have been launched by several manufacturers one after another recently.

b. Energy-saving technology for lighting equipment

Lighting products have also been substantially improving their energy-saving performance through the introduction of advanced materials and devices.

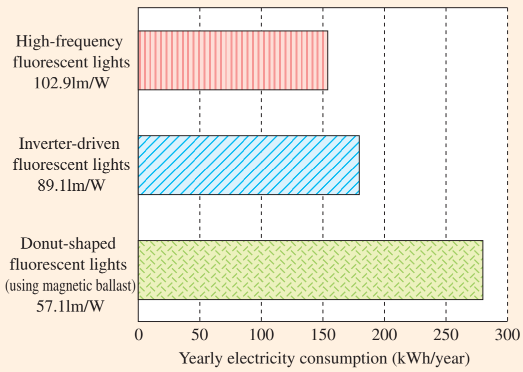
Light bulbs have increased their efficiency by introducing inverter-driven fluorescent lights, high-frequency (Hf) fluorescent lights, etc. (Figure 3-4-11). Those products are also user-friendly, as they light instantly and do not flicker.

The energy efficiency of electric bulb-type fluorescent lamps is four or five times higher than that of incandescent light bulbs. The former is more expensive than the latter in terms of unit price, but is more economical in the long run due to higher durability and a lower consumption of electricity (Figure 3-4-12).

Also, LED (light emitting diode) has excellent energy-saving characteristics, including low electricity consumption, longer life and a small size. LED has already been successfully introduced in traffic signals and display components, and it can be expected to be widely utilized for general lighting equipment in the future. In addition, organic electroluminescence (EL), which is the technology to electrify illuminable organic materials, has several advantages, such as low electricity consumption, the ability to create a thin product and foldablity. Organic EL has been already practically applied to display components, and is expected to be widely applied to lighting equipment in the future.

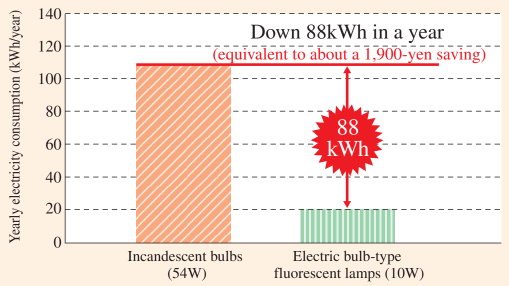
Reflectors made of high-performance reflective materials are also drawing attention. Installing such reflectors in a way that creates an appropriate angle of reflection would substantially improve lighting effects and reduce electricity consumption, and such techniques have already found practical applications. As a matter of fact, in 2006 the Ministry of the Environment succeeded in achieving about a 30% year-on-year energy saving at the Ministry's main office in Kasumigaseki, Tokyo, by installing such reflectors with fluorescent lights and adjusting their illumination intensity.

Figure 3-4-11 Comparison of energy-saving performance among diverse fluorescent lights



Source: Jyukankyo Research Institute Inc.
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

Figure 3-4-12 Comparison of electricity consumption between electric bulb-type fluorescent lamps and incandescent light bulbs



Source: Jyukankyo Research Institute Inc.
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

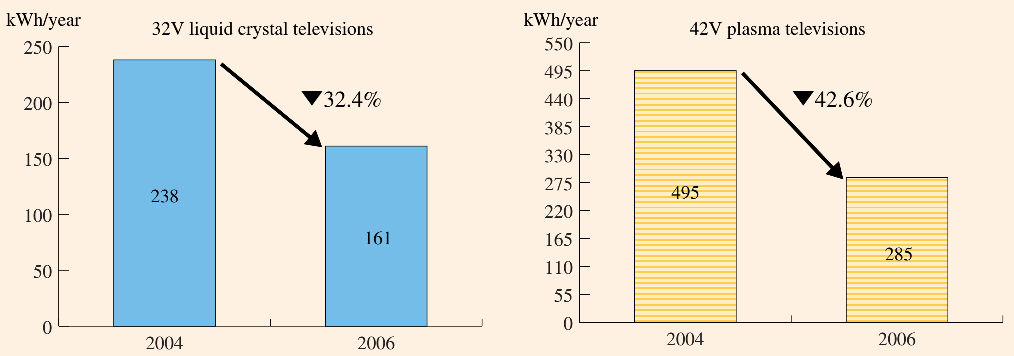
c. Energy-saving technologies for other electric home appliances

Recent trends in the television market can be characterized by the widespread introduction of thin displays, including liquid crystal displays and plasma displays, coexisting with conventional cathode-ray tubes (CRT). Since thin televisions have a wider display in general, they tend to increase electricity consumption. However, energy-saving performance has been improving at the same time, resulting in overall reduced power consumption when size and system are the same. As far as medium-sized or smaller televisions are concerned, there is a general tendency for liquid crystal televisions to consume less electricity than plasma televisions or CRT televisions. Energy-saving efforts under the top-runner standards have been also promoted for televisions.

The demand for warmwater bidets has been increasing recently, where user needs are diverse. Some people use it for comfort, some use it because of health problems, and others need it during cold weather. Although those products consume electricity to warm a seat, etc., their energy-saving technology has been upgraded at the same time. For example, the "instantaneous heating system" has been recently introduced, where the heating system is activated on demand. This system consumes less electricity than the conventional "hot water storage system," as the former does not require power for heat retention even though its instantaneous electricity consumption is large. In addition, in an effort to save the electricity to be used for warming a seat, an automatic on/off power control function as well as a sensor to detect a user for automatic heater activation have been developed (Figure 3-4-14).

When compared to conventional electric kettles, latest-model counterparts equipped with a vacuum-insulation panel have a superior energy-saving performance for heat retention. This vacuum-insulation technology makes it possible to achieve about an

Figure 3-4-13: Energy-saving technologies for television sets (comparison between 2004 models and 2006 models)



- Improved permeability of liquid crystal panels
- Decreased electricity demand of fluorescent backlight bulbs
- Decreased electricity demand of backlight driving circuit
- Improved efficiency of materials used in a backlight unit (reflector and fluorescent screen)
- Improved image quality and energy saving through the backlight control system interlocked with video signal

- Improved panel efficiency (Improved fluorescent materials)
- Improved illumination efficiency of sustained discharge
- Improved efficiency of pre-discharge emission
- Improved reactive power
- Optimized driving system
- Improved control circuit (new LSI system)
- Reduced standby electricity consumption (IPD (Intelligent Power Device) for semiconductor device for switch mode power supply)

Source: Japan Electronics and Information Technology Industries Association

80% reduction in electricity consumption for heat retention and a combined reduction of about 50% in electricity consumption for water boiling and heat retention. Those models also use various advanced technologies such as control technology and material technology.

d. Energy-saving technologies for kitchen appliances

Cooking stoves have improved their energy efficiency. The improved efficiency of gas ranges, for example, is attributable to various technical improvements, including optimized flame angles, downsized burner diameter and optimized air supply for combustion.

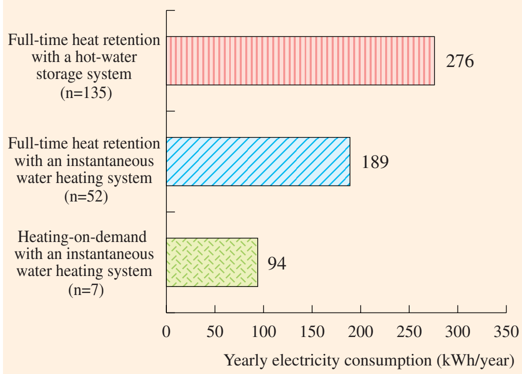
Figure 3-4-15: Heat-insulation performance by type of glass/sash

Level of heat insulation	Structure
High 35.7	Plastic sash + High performance heat shield double-glazed glass
35.7	Wooden sash + High performance heat shield double-glazed glass
35.7	Aluminum sash of double-sash structure with single-layer glass + Resinous inner window with double-glazed glass
53.5	Aluminum sash of heat insulation structure + Double-glazed glass
53.5	Aluminum/resin-compound sash + Double-glazed glass
71.4	Aluminum sash + Double-glazed glass
Low 100	Aluminum sash + Single-layer glass

(Heat insulation performance)

Source: Japan Construction Material & Housing Equipment Industries Federation
"Fact Sheet on energy-saving houses" issued by the Ministry of the Environment

Figure 3-4-14: Comparison of yearly electricity consumption by type of warmwater bidets



Source: Product brochures published by respective manufacturers as of July 2006
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

e. Energy-saving technologies for buildings

In order to ensure heat-insulating performance of a building, it is important to pay attention to windows because they easily let in heat. When compared to single-layer glass sheets, double-glazed glass, especially high performance heat shield double-glazed glass, exhibit excellent energy-saving performance. It is also necessary to pay attention to the thermal conductivity of sliding frames in sash windows, and the use of wooden or resinous frames that have a low thermal conductivity would be effective for improving energy conservation.

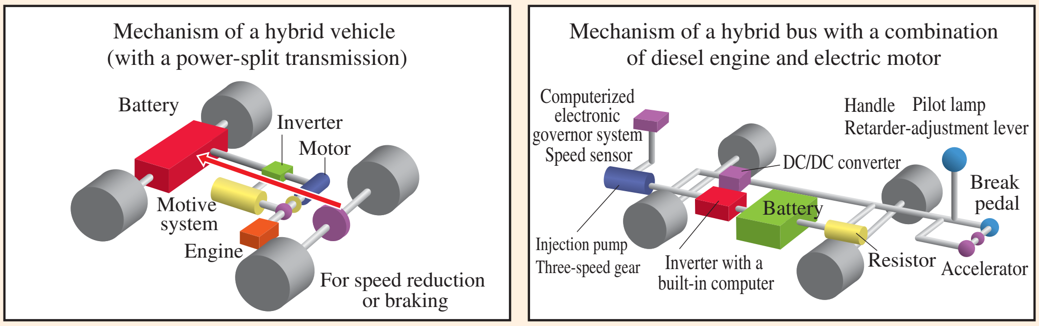
In addition, it is necessary to use insulating materials for walls or ceilings when structures other than windows have low heat-insulating performance. Improved building-wide heat-insulating performance would be beneficial not only in terms of energy saving but also in terms of the comfort of the people inside, since it would reduce a temperature gap between room air and the surfaces of floors, walls or ceilings. Such improved insulation could be obtained all the more effectively through the introduction of advanced material technology, component technology, design technology and construction technology.

Rooftop greening and wall greening are also effective for moderating the heat, as they improve light-shielding performance and insulation and have the effect of the transpiration of plants, resulting in a decrease in radiant temperatures of a building. Actually, those greenings have been increasing recently, with the support of various technology developments, including light-weight soils, automated water supply systems, etc. Also, rooftop and wall greenings are expected to enhance CO_2 absorptions.

f. Technologies for motor vehicles

About 90% of transport-attributed CO_2 emissions come from motor vehicles. In order to reduce those CO_2 emissions, it is important to introduce various measures integrally, including transportation-demand management efforts to control or reduce automobile traffics, promotion of a modal shift for better traffic management ("modal shift" means a shift from road transportation

Figure 3-4-16: Mechanism of a hybrid vehicle



Source: NEDO (New Energy and Industrial Technology Development Organization)

Column : ESCO (Energy Service Company)

The ESCO program, which represents one of the emerging business models, has been launched and expanding. An ESCO project offers energy-saving services to clients, such as building owners; and saved energy expenses or cut utility costs, which result from the project implementation, will be appropriated for payment (remuneration) to the project operator, future ESCO project expenses, etc. This mechanism allows building owners to introduce energy-saving measures without paying extra money and while enjoy continuing cost reduction after the completion of payment to the project operator.

The ESCO program effectively supports the comprehensive implementation of various energy-saving measures. In this respect, this business model is a "technology" that uses the wisdom of achieving energy savings in a profitable manner. Implementation of ESCO projects makes it possible to promote comprehensive energy-saving measures including the introduction of various energy-saving equipment and systems, BEMS-utilized monitoring practices and efficient operation controls.

Households used to be outside the scope of the ESCO program, since energy-saving achievements obtainable from individual households are so small in size that they could not pay as a profitable business. However, the Ministry of the Environment received a noteworthy proposal from Biwako Bank and others who were entries in the Ministry-sponsored competition program for environmental policy measures (http://www.env.go.jp/press/press.php?serial=7992). The proposal suggests the use of the ESCO scheme for the introduction of preferential interest rates for consumer loans that would encourage private citizens to buy on credit energy-saving latest-model electric appliances to replace their conventional machines. This proposal, titled "Promotion of energy saving at households under the home-version ESCO scheme through multilateral cooperation," received an award in the competition. Thus, it is expected that private enterprises will play more important roles in promoting CO_2 emission reduction in the residential sector in the future.

Column : Mechanisms to Promote Wide Utilization of Technologies

Recent achievements from technology development have been remarkable, and various products with an embedded energy-saving system are commercialized one after another today. In order for those products to be widely used and produce substantial energy-saving effects, it is necessary to promote publicity of those products so that more and more consumers and businesses will be aware of them and come to use them. In short, the development of tactics or mechanisms for effective publicity is necessary in addition to the development of technologies themselves. Here are some examples of such mechanisms that have been actually introduced to facilitate the wide distribution and utilization of energy-saving products.

1. Labeling system

In order to promote the wide utilization of environmentally friendly products, it is necessary to provide appropriate, easy-to-understand product information that motivates people to choose those products.

In this aspect, the labeling system is considered to be effective, since people can easily identify energy-saving products by a mark or label attached to respective qualified products. There are several kinds of marks and labels, including the high-efficiency proof called “eco mark” as well as the label showing fuel economy for motor vehicles, the “energy-efficiency” label certifying the observation of the Law Concerning the Rational Use of Energy, etc. Starting from October 2006, the energy-efficiency labeling system has been introduced for air conditioners, electric refrigerators and television sets, where the uniform “energy-efficiency” label is supposed to be attached to all of the said designated products, to show whether or not the product satisfies the energy-saving standard under the said Law (Top-runner standards under the Top Runner Program). In addition, the label shows the level of energy-efficiency of the product through a five-grade evaluation system, yearly electricity consumption, and estimated yearly cost for electricity charge. Thus, the label allows consumers to easily identify and evaluate energy-saving products.

2. Financing programs

The introduction of energy-saving measures requires an initial investment. There are various financing programs that make it easier for businesses to make such investments. For example, an environmental activities evaluation program known as “Eco Action 21” allows medium- and small-sized business to enjoy a preferential interest rate, provided that they use a loan for introducing environmental protection measures (http://www.ea21jp/). This financing program encourages businesses to take actions for environmental protection.

Figure 3-4-17: Uniform Energy-Saving Label

Source: The Energy Conservation Center, Japan (ECCJ) to railway transportation or marine transportation, which is more efficient), improvement of distribution systems, reform of urban structures, etc. Besides, it is quite essential to improve fuel economy for motor vehicles, and therefore the promotion of relevant supporting technologies would have significant, immediate energy-saving effects.

Hybrid vehicles use two or more distinct powers or fuel sources, such as a combination of an engine and a motor, and can be characterized by a very high energy-saving performance and a significant reduction of exhaust gas. Among the widely used hybrid system configurations for passenger cars is that which combines gasoline engines with electric motors, wherein the battery is charged not by an external power source but by the engine's rotation, and a vehicle can run on just the engine, just the battery or a combination of both. A combination of a diesel engine and an electric motor is also seen in some commercially marketed passenger cars. These hybrid vehicles use high-level control technology. Also, battery technology plays an important role.

Electric vehicles and natural gas vehicles had many requirements and difficulties for commercialization and wide utilization, including the battery-recharging system, installation of charge stations for user convenience and the necessity of frequent recharging or refilling. On the other hand, hybrid vehicles do not require any new facilities or frequent recharging, and are user-friendly, allowing people to easily enjoy the energy-saving benefits.

Although the prices of hybrid vehicles are relatively higher than conventional cars, hybrid vehicles will reduce fuel consumptions substantially (which means substantial reduction in CO_2 emissions) and also improve fuel economy significantly.

In addition, conventional vehicles with a gasoline or diesel engine also benefit from technologies. Their fuel economy has been improved considerably with the introduction of the improved fuel-injection system, control system, adoption of a continuously variable transmission, etc.

g. Facility-wide maintenance systems

In recent years, much attention has been paid to BEMS (Building Energy Management System) and HEMS (Home Energy Management System). Those systems intend to achieve comprehensive energy saving for an entire building or house, where a building-wide status of energy supply and demand is monitored to integrally promote comprehensive, efficient operation of equipment and facilities inside the building.

(2) Energy-saving technologies for energy suppliers

Technologies to be used by energy suppliers include the efficiency improvement technology used by power plants as well as the energy shift from conventional energy sources to new sources of low CO_2 emissions.

This section will focus on solar energy, wind energy and biomass energy, all of which are renewable, relatively familiar to consumers, and are currently at the diffusion stage in commercial and residential, and transport sectors. Those energies have come into widespread use partly because of the enforcement of the Law Concerning Special Measures for Promotion of the Use of New Energy (RPS Law), which binds electric utility companies to the requirements to use the designated amount of new energies, such as solar power and wind power.

a. Solar energy technologies

One of the major forms for the use of solar energy is the power-generation system using solar cells.

Solar cells convert solar energy directly into electricity. Sunlight collected on a rooftop is used to generate electricity, and this process causes no CO_2 emissions. In recent years, solar cells have been becoming increasingly commonplace among ordinary households.

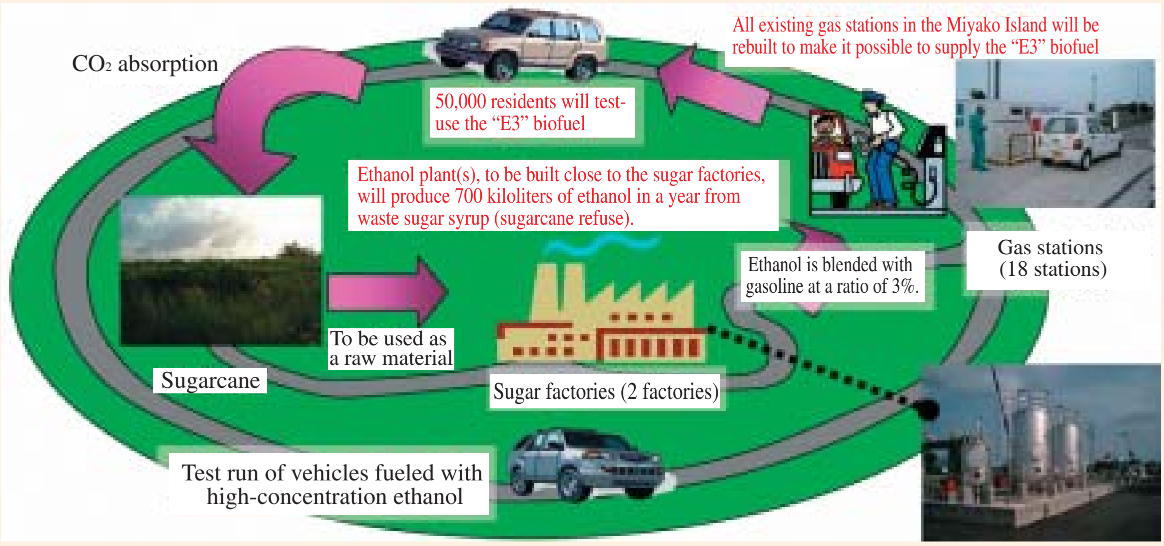
Here, key technologies include the conversion device from sunlight to electricity and control systems for electricity utilization.

Also, the level of efficient use of solar heat has been improved, thanks to emerging technologies, such as solar heat collection and heat accumulation.

b. Wind energy technologies

Wind power is considered to have a large potential for effective utilization as an energy source, including the utilization of ocean wind. Although there are some disadvantages, such as instable power or voltage, the use of wind power has been increasing. Since the efficiency of electricity generation can be increased when wind blows stronger and a wind turbine is larger, there is an upsizing tendency for wind turbines. Also, small-sized wind-power generators, which have an advantage of user-friendliness while having a

Figure 3-4-18: "Bio-ethanol Island" plan in Miyako Island



Source: Ministry of the Environment

disadvantage of low efficiency, are practically utilized today, and the combined use of such a small wind-power generator with a solar cell has been commercialized as well.

c. Biomass energy technologies

Biomass energy is obtainable from renewable, biodegradable organic resource (except fossil fuels). It is a sequestrated energy in the form of plant materials converted from sunlight through photosynthesis, and CO_2 emissions caused by the use of such energy can be deemed as offsettable by the breeding of plants, etc.

In addition to traditional materials such as firewood and charcoal, more and more new materials are currently achieving increasingly widespread use. For example, used cooking oil is being used for diesel fuel, livestock excreta is being used for methane fermentation, and natural materials are being used for ethanol fermentation. In particular, bio-ethanol draws a great deal of attention today as a biofuel alternative to gasoline (for motor vehicles). Currently, various technologies to produce bio-ethanol fuels are at the commercialization stage, including the use of discarded wood construction material, non-standard farm produces, wastes generated during food processing and byproducts such as sugarcane syrup. In January 2007, the world's first commercial-scale plant to produce ethanol from wood construction waste was established in Osaka Prefecture. The plan is that, starting from fiscal year 2007, demonstration projects for regional mass-introduction of bio-ethanol fuels for local transport systems will be launched in some metropolitan areas as well as in Miyako Island, Okinawa Prefecture.

Thus, various energy-saving products, systems and technologies are at the stage of commercialization and expanding utilization, including the aforementioned heat pump technology for utilization of unused heat, integral and comprehensive energy control systems, and new-energy-utilizing technologies allowing energy suppliers to avoid emitting CO_2. CO_2 emissions can be expected to be substantially reduced through the expansion and acceleration of the use of those technologies.

3. Development of National Campaigns

The aforementioned energy-saving technologies would fail to contribute to CO_2 emission reduction if not widely utilized among the public. In this light, it is necessary for grassroots activities to improve people's actions and change their lifestyles.

The national "Team Minus 6%" project initiated by the Prime Minister, which aims to promote large-scale civic campaigns to global warming countermeasures, is now in operation, and its activities have been expanding to involve many citizens, businesses and organizations, with registered membership numbering about 1.1 million individuals and about 11,000 companies and organizations as of March 2007. For example, the "Cool Biz" campaign, which advises people to save energy by limiting air

Column : The "UCHI-ECO (Home-Eco)" Campaign

In October 2006, Mr. Masatoshi Wakabayashi, Minister of the Environment, announced the launch of the "UCHI-ECO (home-eco)" campaign, which aims to promote people's daily efforts at home in the fields of food, clothing and housing to global warming countermeasures.

This campaign makes specific energy-saving proposals to the general public in the fields of clothing, food and housing. They include home-version "Cool Biz" and "Warm Biz" to seek comfortable indoor living in summer/winter while limiting air conditioning, the wise choice of food that would cool down your body in summer and warm up your body in winter, the effort to turn off electric appliances immediately after use, and the use of energy-saving fluorescent lights or bulbs (http://www.team-6jp/).

Figure 3-4-19: An example of the "UCHI-ECO (home-eco)" campaign logo

Source: Ministry of the Environment

conditioning in the summer while seeking clever ways to spend hot days comfortably, and the winter counterpart "Warm Biz" campaign are respectively estimated to have reduced CO_2 emissions by about 1.14 million tons (summer of 2006) and about 1.41 million tons (fall and winter of 2005). The "UCHI-ECO (home-eco)" campaign has also been increasing its participants, where people are advised to global warming countermeasures by making daily efforts at home in the field of food, clothing and housing.

Thus, development of national campaigns play important roles in promoting global warming countermeasures. The awareness of individual citizens has significant impact on the effective utilization of CO_2 emission-reduction technologies and products, and national campaigns are expected to produce enormous energy-saving effects, if promoted successfully. Therefore, it is necessary to promote them extensively through combined efforts among diverse entities, while seeking ecology-conscious lifestyles.

Section 5: Visions of the Future Utilization of Global Warming Countermeasures

In making our efforts to global warming countermeasures, technology plays important roles. This section will explain visions of how Japanese technologies could be effectively utilized for promoting global warming countermeasures into the future, with the focus on the following three directions: the promotion of thorough utilization of available technologies, new innovative technologies and the development of technologies for ensuing harmony between nature and people.

1. Ensuring Diffusion and thorough Utilization of Available Energy-Saving Technologies

Section 4 explained specific technologies pertaining to global warming countermeasures closely related to people's daily lives and discussed how they are actually being used in the commercial and residential sectors (households, office, etc.) in particular and how they effectively reduce CO_2 emissions. The promotion of replacement of conventional models with energy-saving models with the said technologies can be expected to produce substantial effects in terms of CO_2 emission reduction.

The first part of this section will explain the potential for CO_2 emission reduction expected from an extensive introduction of energy-saving equipment to households, offices, buildings, etc.

(1) Simulative analysis of the potential CO_2 emission reduction expected from the introduction of energy-saving equipment to households

a. Introducing high-efficiency home appliances

Here are three estimation examples as to the potential CO_2 emission reduction expected from the replacement of conventional appliances with energy-saving models together with the introduction of some improvements (heat insulation, etc.) to house fittings.

(a) A household of a family consisting of a married couple in their forties and children living in a detached house

A married couple in their forties has two children and they live in a ten-year-old detached house (of their own) with three bedrooms.

This family has an air conditioner, electric refrigerator, lighting equipment and gas range, which the family bought at the time they built the house, as well as a television set, washing machine, electric clothes dryer, warmwater bidet, water heaters, etc., which the family bought later but is now considering replacing. Suppose the family is going to replace all of those appliances with up-to-date energy-saving models, and also replace existing window glasses with multiple-layer glasses that have high heat insulation performance in order to improve air-conditioning efficiency.

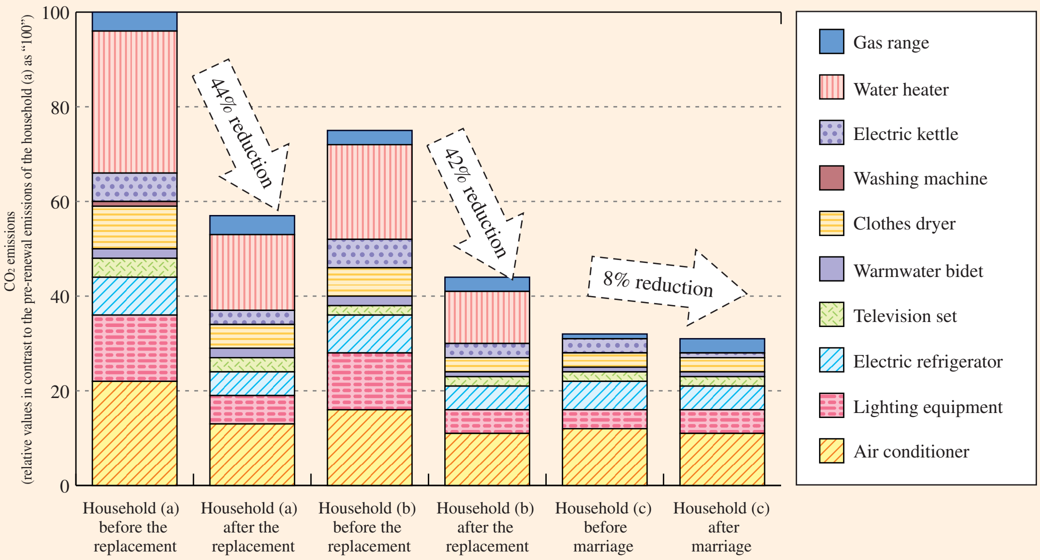
The resulting effects are estimated to be more than a two-ton reduction in CO_2 emissions per year. This is about a 40% reduction in emissions when compared to the emissions before the replacement, and is equivalent to a nearly 150,000-yen saving of yearly utility costs (gas and electricity charges). Furthermore, as a result of the introduction of double-glazed window glasses, the family will enjoy reduced energy costs for their air conditioner as well as enhanced comfort from the avoidance of condensation nuisance.

(b) A household of a married couple in their sixties living in a detached house

An elderly couple in their sixties lives in a ten-year-old detached house (of their own) with three bedrooms. Although the age and size of this house are the same as those of house (a) above, the operation hours of electric appliances and lighting equipment are different between households (a) and (b) due to the difference in their lifestyles.

Suppose this couple is going to replace their air conditioner, electric refrigerator and lighting equipment, as well as an old television set, washing machine, electric clothes dryer, warmwater bidet and water heater with the latest energy-saving models, and also replace existing window glass with multiple-layer glass that has high heat-insulation performance in order to improve air-

Figure 3-5-1: Changes in CO_2 emissions as a result of the replacement of home appliances for the three households



Note1: Calculation method

The reductions in CO_2 emission have been based on the estimated yearly reduction in electricity and gas consumption as a result of the replacement. The energy intensity of 0.378kg-CO_2/kWh (*1) for electricity and 2.08kg-CO_2/Nm3(*2) for gas are applied. The new products to replace existing products are assumed to be the latest models with the highest energy-saving performance in the industry as of 2006. Specifically, the new television set is assumed to be a liquid crystal television, and the new warmwater bidet is assumed to have the instantaneous heating function. The new water heater is assumed to be an electric model with a natural refrigerant heat pump, replacing a gas-fueled water heater. The new lighting equipment is assumed to consist of inverter-equipped Hf fluorescent lights, introduced in place of the conventional magnetic fluorescent lights and bulb-type fluorescent lights, replacing incandescent light bulbs.

The assumed electricity/gas consumption before the renewal is based on the industrial data on average general models of the relevant year of production. The assumed year of production is determined based on the results of the Consumer Confidence Survey conducted by the Cabinet Office on average life of electric home appliances, etc. Other technical data of electric appliances are based on information from The Japan Refrigeration and Air Conditioning Industry Association, final report by the Electric Refrigerator Evaluation Standards Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee on Natural Resources and Energy, information from Japan Electronics and Information Technology Industries Association, the handbook "*Wa-no-Kurashi*" (meaning "eco-life") published by the Ministry of the Environment and the handbook "How to choose and use energy-saving products" published by the Energy Conservation Center, Japan.

(*1) Guidelines for Measurement of Greenhouse Gas Emissions from Businesses issued by the Ministry of the Environment (July 2005)

(*2) Emission factor under the system of emissions calculation, reporting and announcement

Note2: The estimations are based on the assumption that the replacement takes place at a reasonable time for renewal. The purchase of the mentioned electric appliances can be estimated to require one million yen or more, and the renewal of water heater and window glasses is estimated to cost an additional 500,000 yen or so.

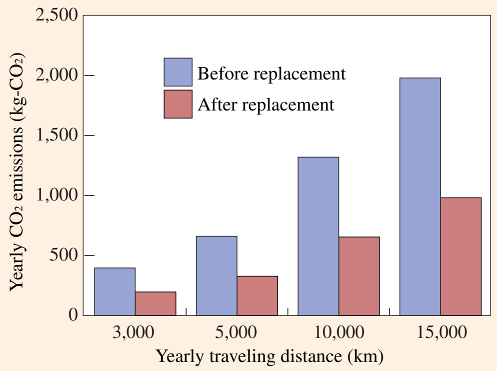
conditioning efficiency.

The resulting effects are estimated to be slightly less than a two-ton reduction in CO_2 emissions per year. This is about a 40% reduction in emissions when compared to the emissions before the replacement, and is equivalent to more than a 100,000-yen saving of yearly utility costs.

(c) A household of a single male in his thirties who is getting married soon and is currently living in a rented apartment

A single male in his thirties is getting married soon. Upon marriage, he is going to move to a rented apartment with one bedroom, from the current one-room rented apartment that he moved into ten years ago, when he first started his current job. Suppose he is going to replace all of his electrical appliances with up-to-date energy-saving models when he moves.

Figure 3-5-2: Effect of CO_2 emission reduction through the replacement of a conventional car with a new model



Note: The estimations are based on the assumption that a 1500cc-gasoline vehicle is replaced with a hybrid vehicle of the same size. For the estimates, the 10.15-mode fuel consumption is applied.

Source: Ministry of the Environment

The new refrigerator, television set and washer-and-dryer laundry machine he is going to buy will all be bigger in size than the current ones. Furthermore, his household will be upsized from a single to two. Still, however, CO_2 emissions in his new household can be estimated to be possibly lower than the present, thanks to the high-efficiency models.

Figure 3-5-1 shows the summary of the estimations for the above three households.

b. Replacing a private car with a high-efficiency model

Now let's see how much CO_2 emission reduction can be expected from the replacement of an existing conventional car with a new model that has excellent fuel economy.

The amount of CO_2 emissions to be generated by the use of a car greatly depends on the way it is driven and on traveling distance. A traveling distance varies significantly among households. Figure 3-5-2 shows four examples of different traveling distances.

(2) Simulative analysis of the potential CO_2 emission reduction that can be expected from the introduction of energy-saving technologies to a building for business use

Now, let's figure out the potential CO_2 emission reduction that can be expected from the introduction of currently available energy-saving technologies to existing buildings for business use. Two examples follow: the first one represents the case wherein operational optimization is thoroughly introduced to existing facilities and equipment and the second one represents the case wherein moderate capital investments are made to introduce energy-saving measures in addition to the said optimization. Here, the capital investments are limited to those that are expected to pay off in a relatively short period time, such as a replacement of conventional lighting equipment with new models. The building concerned is assumed to be an average construction located in Tokyo (with eight stories above ground and one below, having the total floor space of about 7,500 square meters).

a. Introducing the thorough operational optimization to existing facilities and equipment

The potential CO_2 emission reduction effects that can be expected from the introduction of operational optimization, such as outdoor air-intake control, use of outdoor air for indoor cooling, etc. has been figured out based on the assumption that existing facilities and equipment, such as air conditioners, pumps, heat source equipment, lighting equipment, power outlets, water heaters, water supply systems, drainage systems and elevators, continue to be used. The result is about a 2.6% reduction of CO_2 emissions in a year (equivalent to about 23 tons) (Figure 3-5-3).

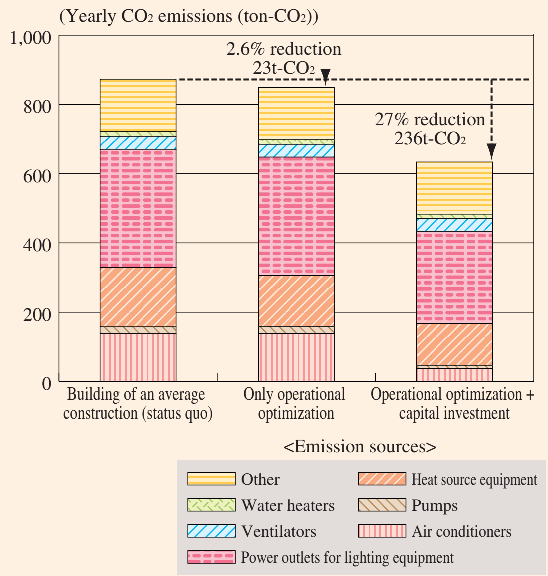
b. Introducing capital investments to major facilities and equipment

The potential CO_2 emission reduction effects that can be expected from the introduction of capital investments in addition to the optimization as mentioned above has been figured out. Here, the capital investments are limited to those considered to pay off in a relatively short period of time and include the installation of an inverter to introduce variable air-volume control for air-conditioning systems, the installation of an inverter to introduce flow control of coolant and hot and cold water for pumps, the installation of high-efficiency lighting system, and the installation of a total heat exchanger for recovery of exhaust heat and air. The calculation result is about a 27% reduction of CO_2 emissions in a year (equivalent to about 236 tons) (Figure 3-5-3).

Building conditions are diverse and appropriate energy-saving measures and the resulting effects vary according to the buildings. However, as shown by the above estimations, a considerable amount of energy conservation can be achieved through the introduction of low-cost, currently available energy-saving technologies to existing facilities and equipment, without any building reconstruction.

As mentioned above, it is possible for homes as well as buildings for business use to achieve relatively large effects of CO_2 emission reduction in a relatively short period of time by introducing currently available energy-saving technologies. (It

Figure 3-5-3: Potential CO_2 emission reduction expected from introducing energy-saving measures to a building for business use.



Note: The estimations are made by using the "management tool for intensity of energy consumption" of the Energy Conservation Center, Japan
Source: Ministry of the Environment

Column : An Example of the Successful Introduction of Energy-Saving Measures to a Building for Business Use

Energy-saving technologies or measures to be introduced into buildings for business use should be cost-effective in terms of initial investment as well as expected reduction of running costs after the introduction. ESCO programs are being inaugurated in support of the increasing number of measures with significant energy-saving potential (See the Column in Section 4).

Recently, an energy-saving project was carried out under the ESCO program for a building (hereinafter referred to as "Building X") located in the Tokyo metropolitan area (with six stories above ground and a total floor space of about 47,000 square meters).

The project included the renewal of a freezer and a water chiller/heater, the installation of an inverter, the introduction of a new control system for air conditioners and the introduction of BEMS. As a result of the project, this building succeeded in reducing CO_2 emissions by about 15%.

It is known that the introduction of the cogeneration system is quite effective especially for large-sized buildings such as hotels that have a large thermal demand. Many of those buildings are reported to have achieved as much as a 20% reduction in CO_2 emissions through the introduction of the cogeneration system.

Table 3-5-1: Energy-saving measures introduced to Building X

Renewal of heat source equipment to introduce high-efficiency models	Two water chiller/heaters have been replaced with a high-efficiency turbo freezer and two high-efficiency water chiller/heaters, and quantity control has been introduced.
Introduction of the DDC (direct digital control) systems to air-conditioners	PMV control system (that ensures user comfort while controlling and conditioning), the control system for outdoor-air intake for indoor cooling, CO_2 control system and the on/off control-optimization system have been introduced.
Introduction of an inverter to fans	Fans in which inverters are installed have load-corresponding air volume.
Introduction of an inverter to pumps	Water pressure optimization has been introduced for the secondary water supply system with the introduction of a pump inverter for hot and cold water and coolant. Flow control has been introduced for the primary hot and cold water and coolant.
Introduction of BEMS	BEMS, which monitors two buildings simultaneously, has been introduced to enhance integral energy control.
Introduction of high-efficiency lighting equipment	A total of 2,000 fluorescent lights and downlighters have been replaced with newer models.

Source: "Implementation Examples of the ESCO Projects" issued by the Energy Conservation Center, Japan (ECCJ). Compiled by the Ministry of the Environment.

Turbo freezer and water chiller/heater Photo: courtesy of ECCJ should be noted that air conditioners, refrigerators and other machines using CFC gas as a refrigerant should be treated carefully when discarded, as CFC gas causes the greenhouse effect several thousands times more intensively than carbon dioxide, and therefore a release of CFC gas into the atmosphere would be devastating, possibly voiding our efforts for reducing CO_2 emissions.)

However, the introduction of such effective technologies has not yet been promoted thoroughly. But it means there exists a large potential: the introduction of state-of-the-art energy-saving machines and equipment or operational optimization of existing equipment could reduce CO_2 emissions considerably. Thus, in order to effectively promote emission reduction, not only technology development but also the efforts to expand thorough utilization of available technologies is extremely important.

Column :Technologies with High Potentialities

Here are some examples of potential technologies that are currently at the RD&D stage but are expected to produce substantial effects to mitigate global warming in the future, especially in the commercial, residential and transport sectors.

(1) Storage technologies (for electricity and heat)

Electricity is being widely used today. Although this energy is very convenient in general, it has an efficiency problem, since it is difficult to use electricity in a remote location from a power plant or supply line, as it cannot be stored easily. Therefore, it is hoped that high-performance batteries or condensers for accumulating an electric charge (lithium battery, sodium-sulfur battery, large-capacity capacitor, etc.) will be developed. For example, it would be quite useful if there were a durable large-capacity capacitor that can be recharged quickly and would scarcely deteriorate even after repeated charge and discharge. Such capacitor would make it possible to commercialize plug-in hybrid vehicles or other high-performance, high-efficiency electric vehicles that people dream of.

Electric double layer capacitor
Photo: courtesy of Nippon Chemi-con Corporation

Heat is generated in various energy-consumption activities, and a potential for energy efficiency improvement exists here too. An effective heat storage device would make it possible to use stored heat regardless of time and place. An idea of a "TransHeat Container" is a technology to store and transport heat without time/space restrictions, such as day and night, cold place and hot place, and winter and summer. The development and commercialization of such technology as well as peripheral supporting systems are pending.

Fuel cells, which can convert chemical energy directly to electricity, are also potential electricity storage devices, where electricity could be stored in the form of hydrogen with the utilization of water electrolysis technology for hydrogen production. Early commercialization of such fuel cells is also pending.

TransHeat Container Photo: courtesy of Sanki Kogyo Co., Ltd.
This container carries a tank equipped with a latent heat-storage system, and is used to supply heat to a remote place by road transportation.

(2) Utilization of cryogenic heat or unused heat

Consumption of thermal energy leads to a reduced heat temperature, which means a lower value of "exergy" (available energy). For example, high-temperature vapor has a high exergy, and can thus be used as a power source or for power generation. On the other hand, when the temperature of the water vapor lowers to that of the surrounding air, the low-temperature water is not able to provide energy. In the process of a temperature shift from high to low, waste energy is released into the atmosphere, and the idea of collecting such waste energy at every state of temperature shift would be quite noteworthy from the standpoint of energy efficiency improvement.

Here, there is a hope for the development of the so-called "cascade" technology. This technology would allow for thermal energy to be consumed gradually and thoroughly, at any stage regardless of the level of its energy, which would maximize energy efficiency. The cascade-like stage-by-stage utilization of thermal energy can be depicted as a linear flow from "engine" or "gas turbine" to "vapor turbine," "hot water for water heater" and "warm water for air conditioner," for instance.

Also, cryogenic heat draws attention. Cryogenic heat remained unused until its potential as an energy source came to be revealed thanks to an emerging potential technological application, and the value of cryogenic heat is now being recognized. For materializing practical utilization of cryogenic heat, it is hoped that the binary power-generation technology for geothermal power, etc. will be promoted.

(3) Control technology for sophisticated integration

There is a technology that aims to improve energy efficiency by making integrated controls of an entire system in a comprehensive manner. Here, the system includes products, buildings and regional networks, and such technology is already being put to use in some areas. It is important to further promote such control technology from the standpoint of energy efficiency.

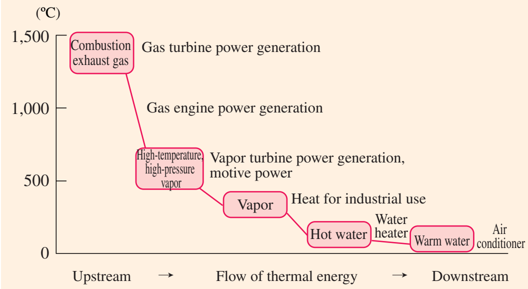
It is hoped that this technology will be integrated with information technologies to establish regional networks of local businesses for the purpose of energy trade, for example. Also, a system for effective utilization of dispersed energies, such as natural energies, could be materialized through the practical use of control technology.

(4) Development of new materials or devices

Development of sophisticated high-performance materials or devices that have a new function or ability could possibly provide a breakthrough in our fight against global warming. Here, utilization of microtechnology or nanotechnology might be effective. For example, such new materials that support effective, efficient utilization of energy include carbon nanotubes, which are hoped to upgrade semiconductors, thermo-electric materials (which would allow for mutual conversion between thermal energy and electric energy) and organic electroluminescence, which is a promising material for lighting equipment. RD&D activities for those new materials are in progress.

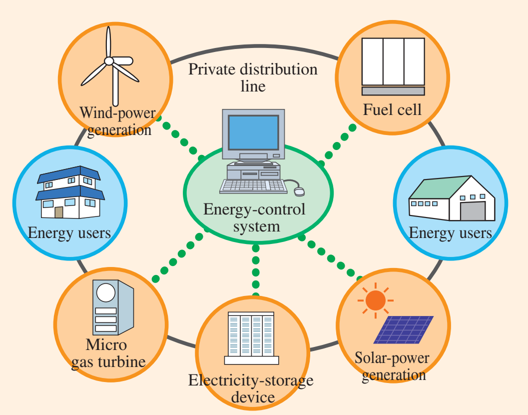
There are other potential innovative technologies such as the CCS (CO_2 capture and storage) technology (See the Column in Section 2) and nuclear reactor technologies. It is hoped that the development and promotion of those technologies will effectively contribute to global warming countermeasures.

Figure 3-5-4: Cascade-style utilization of thermal energy, in the case of heat generated through the combustion of natural gas

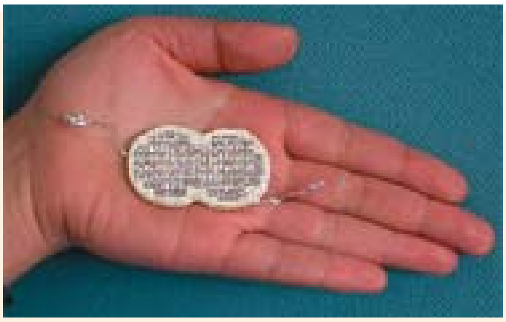


Source: Hiroshi Morishima, "The new century for natural gases," Gas Energy News (2003)

Figure 3-5-5: System for the control of dispersed energy (Micro-grid)



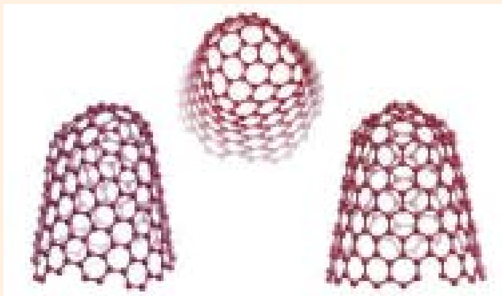
Source: New Energy and Industrial Technology Development Organization (NEDO)



Ceramic thermo-electric module composed of 140 pairs of thermo-electric junctions

Photo: courtesy of National Institute of Advanced Industrial Science and Technology (AIST)

Figure 3-5-6: Carbon nanohorn



Sources: NEC Corporation, Japan Science and Technology Agency (JST)

2. Promoting the Development of New Innovative Technologies

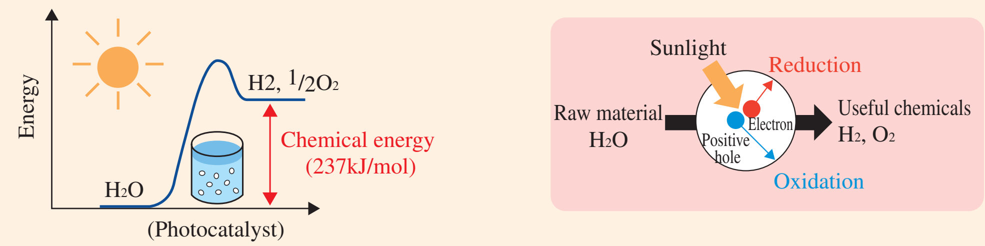
Section 4 and the previous subsection of this section (Section 5) explained effective currently available technologies with a focus on the commercial, residential and transport sectors. In addition to those existing technologies, there are many potential technologies at the RD&D stage, and if those potential technologies come into widespread use in a practical manner in the future, further CO_2 emission reduction can be achieved in the said sectors, covering offices, households and motor vehicles. Promotion of technology development could invite various innovations in our socioeconomic activities. Moreover, those innovations could induce further technological innovations, which we hope will facilitate our efforts to global warming countermeasures.

3. Ensuring Harmony with Nature

Previous sections and subsections discussed the significance of technology development and wide utilization of available effective technologies in pursuing our measures for reducing greenhouse gas emissions. As explained in Chapter 2, human beings are part of ecosystems and our survival depends on the integrity of ecosystems. Therefore, it is necessary for us to ensure harmony between human activities and ecosystems, especially when we develop and introduce new technologies.

When we think of global warming countermeasures from this standpoint, utilization of natural or biological mechanisms is one of the important fields for future technological innovation. For example, in the field of agriculture, it is hoped that an appropriate balance will be maintained between the measures to cope with the natural environment and changes thereto such as cropping period optimization or breed improvement and the R&D projects aimed at strengthening environmental resistance with the utilization of genetic recombination technique. Also, there are projects to study artificial photosynthesis. They use solar energy to synthesize oxygen and organic matters from water and carbon dioxide or decompose water into hydrogen and oxygen.

Figure 3-5-7: Artificial photosynthesis



Source: Research Center for Solar Energy Chemistry, Osaka University

The goal of our development and utilization of global warming countermeasures is not limited to the reduction of GHG emissions in Japan. Japanese technologies and embedded products are strongly hoped to contribute to the international society, particularly the Asia-Pacific, not only in terms of the contribution to the reduction of GHG emissions or solutions to energy issues but also to the mitigation of other environmental problems such as air pollution. Also, as energy-saving needs are getting stronger and stronger all over the world today, demand for our technologies is estimated to be quite strong in the international market. In this respect, the development and promotion of our energy-saving technologies are considered to be quite meaningful in terms of economical benefits and improvement of international competitiveness of Japanese industries and businesses.

As discussed in Section 1 above, our society needs to be transformed into a sustainable one as accelerating global warming becomes evident. In the course of pursuing environmental protection, including global warming mitigation, our society benefits from technology in various ways as mentioned above. If we promote effective utilization of our technologies with a focus on the above-mentioned three directions, such technology will continue to play an important role in our society as a key element of global warming countermeasures, and the materialization of such innovations will open the door to a new society.

Conclusion: A Low-Carbon Society

As mentioned above, accelerating global warming is a fact. Actually, we have various impacts in the form of extreme climate events, such as extraordinarily hot weather, frequent formation of high-intensity tropical depressions, an increase of heavy rain, rising sea-surface temperatures, etc. Human beings benefit from ecosystems in various ways in the form of ecosystem services supported by biodiversity. However, global warming is affecting ecosystem services adversely and seriously. According to the IPCC's Fourth Assessment Report, global mean temperature increase due to global warming is projected up to 6.4°Cby the end of 21th century. Thus, our earth faces truly critical conditions.

In order to avoid the crisis, we need to accelerate our global warming countermeasures. The Japanese government has been reviewing the Kyoto Protocol Target Achievement Plan with a view to clarifying the direction of our environmental policy in regards to measures to be implemented both inside and outside the country, and is now finalizing the "Becoming A Leading Environmental Nation Strategy in the 21st Century: Japan's Strategy for a Sustainable Society" as a guideline for Japan's contribution to future international frameworks.

It is necessary to combine our short-term and long-term efforts based on the said national plan. First of all, we need correct knowledge and information. That's why this report focuses on specific information regarding global warming and technologies effective to reduce GHG emissions; it will help readers understand the current status and potentialities of technologies for emission reduction in our everyday living. Implementation of global warming countermeasures requires the integral promotion of technology development, institutional reforms and behavioral improvement. In other words, we need institutional developments such as the creation of social mechanisms to facilitate thorough utilization of effective technologies as well as behavioral revolutions such as changes in actions or lifestyles on the part of all members of the general public. Through those efforts and reforms of socioeconomic systems, to be promoted nationally and regionally, we need to create a "low carbon society" on this earth so as to protect ourselves and future generations as well as the foundation for human survival. On May 24, 2007, Prime Minister Abe announced a strategic package titled "Cool Earth 50," which consists of three major proposals to tackle global warming. This initiative is supposed to play the central role in the "Becoming A Leading Environmental Nation Strategy in the 21st Century: Japan's Strategy for a Sustainable Society " We have now started working together to make "a low carbon society" a reality.

Invitation to Cool Earth 50 delivered by Prime Minister of Japan, Shinzo Abe

[The Issue]

○ We must create a new framework which moves beyond the Kyoto Protocol, in which the entire world will participate in emissions reduction.

○ Three concerns have been raised about the endeavor to create a new framework. However, we can overcome all these concerns.

1. Wouldn't endeavors to reduce greenhouse gas emissions hinder economic growth?
2. Even if your own country takes steps to address the issue, it will not lead to the resolution of the issue on a global scale unless other countries also take action.
3. Isn't it unfair to ask developing countries to take steps?.

○ Japan has overcome serious pollution and oil crises, and reduced oil consumption by 8 percent even though its GDP has doubled. The keys for resolving the issues were advanced technologies, social mechanisms and traditions harmonious with the environment, and the solid will of our people.

[Overview of the Proposal]

○ "Today, I would like to extend an invitation to a beautiful planet, Earth in the year 2050."

○ "I am calling my initiative "Cool Earth 50," a strategy consisting of the following three pillars.

Pillar 1: a long-term strategy to reduce the emissions of greenhouse gases globally

○ Propose a long-term target of cutting global emissions by half from the current level by 2050 as a common goal for the entire world.

- ○ Present a long-term vision for developing innovative technologies and building a low carbon society.

Pillar 2: three principles for establishing an international framework to address global warming from 2013 onwards

- ○ proposition to the world “3 principles” in designing a concrete framework for addressing global warming beyond 2013.
  1. All major emitters must participate, moving beyond the Kyoto Protocol, leading to the global reduction of emissions.
  2. The framework must be flexible and diverse, taking into consideration the circumstances of each country.
  3. The framework must achieve compatibility between environmental protection and economic growth by utilizing energy conservation and other technologies.
- ○ we will create under international cooperation a new financial mechanism to extend support to developing countries with high aspirations
- ○ we will expand the endeavor for improving energy efficiency to the entire world. we will promote international efforts to expand the use of nuclear power, as well as providing assistance such as infrastructure development.
- ○ we will study methods such as an integrated approach to fight pollution and global warming; emissions trading; and economic incentives.

Pillar 3: Launching a national campaign for achieving the Kyoto Protocol target.

- ○ The Kyoto Protocol Target Achievement Plan will be reviewed to ensure Japan achieves its Kyoto Protocol objective to reduce emissions by 6 percent.
- ○ The Government will promote its initiatives and urge municipalities and major business entities to accelerate their actions for reduction of emissions.
- ○ We will launch a national campaign and call for efforts and creative ideas with the motto of reducing greenhouse gases by “1 person, 1day, 1kg.”
  We will solicit and adopt new proposals from the people for expanding the national campaign.

[Conclusion]

“My vision of ‘a beautiful country’ is also about raising a question: should we not transform our civilization in order for humanity to continue its path of development while striking harmony with the global environment. So, let us join hands and work together to make “Cool Earth” a reality.”

Overview 2

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 overview 2, 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

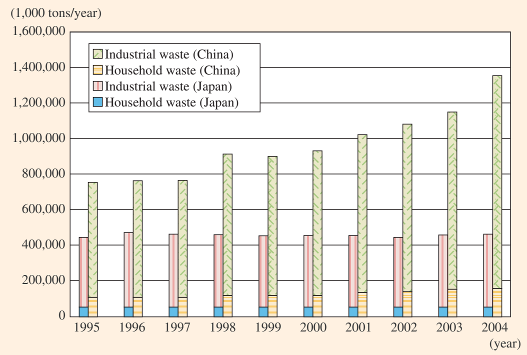
Global growth in economies and populations, particularly in Asia, has been accompanied by an increase in the amount of waste produced worldwide. The nature of that waste is also proliferating into areas such as medical waste and discarded electrical and electronic products ("E-waste"). Moreover, prices 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.

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.

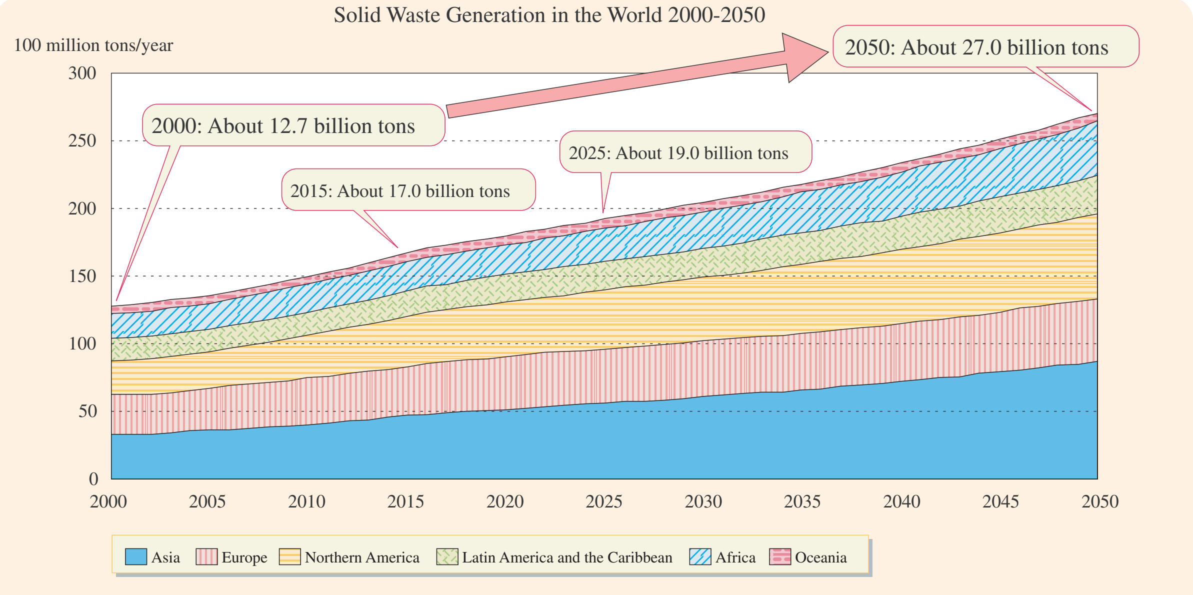
Meanwhile, there have recently been some tragic accidents related to waste management. The Leuwigajah final disposal site in Indonesia, which used to receive waste from Bandung City and surrounding areas, was a landfill site created by damming a river valley. In February 2005, a major disaster occurred 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

Fig. 1-2 Waste generation in China



Source: Chinese data – OECD; Japanese data – Ministry of the Environment

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



Source: Paper by professor Tanaka of Okayama University outlet for waste management, people started to dump their waste at random in the streets.

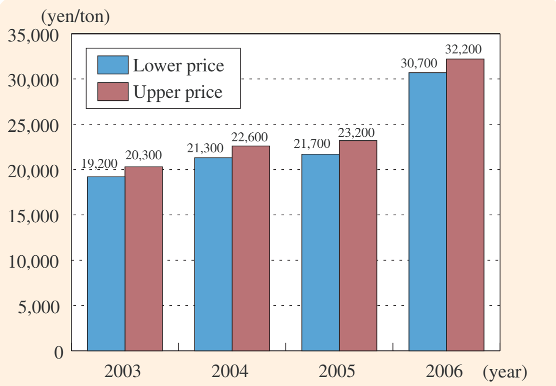
In recent years, meanwhile, the volume of discarded television sets, personal computers, refrigerators and other electrical and electronic products has also increased, and exports or imports of these for recycling or disposal have risen sharply. These discarded electrical and electronic products sometimes 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.

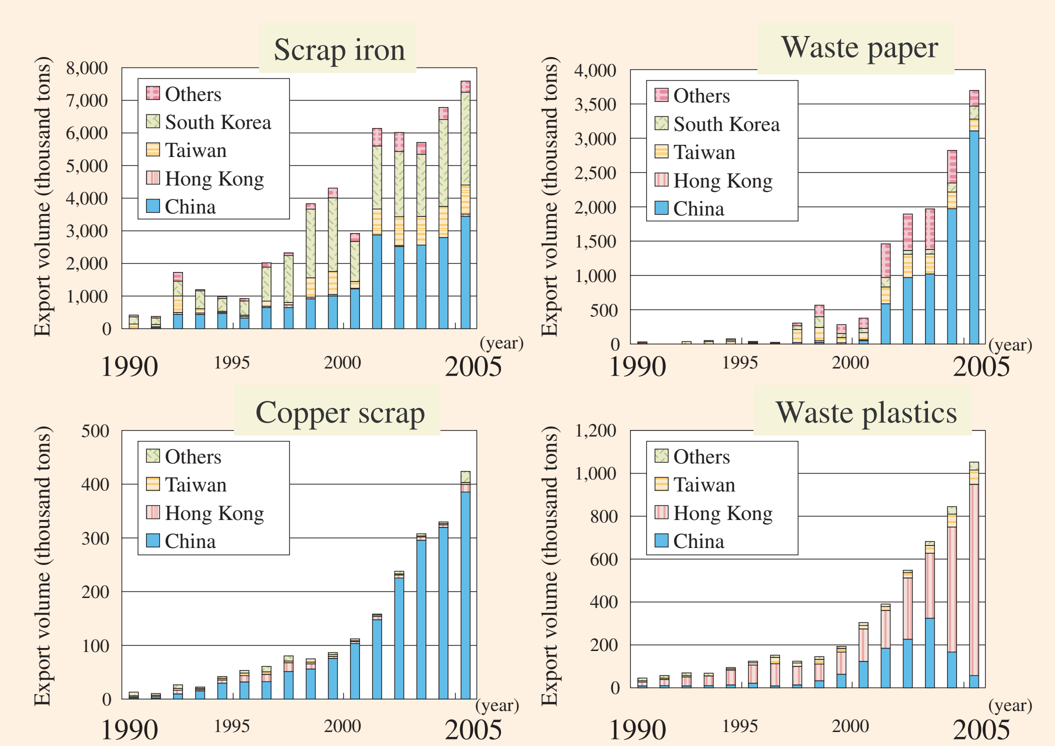
In Japan, exports of recyclable resources to China and other Asian countries are in a growing trend. Trade in recyclable resources that circulate for commercial gain (such as waste plastics) is now handled in the same way as other materials and products. With increased demand for resources associated 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

Fig. 1-3 Trends in scrap iron prices



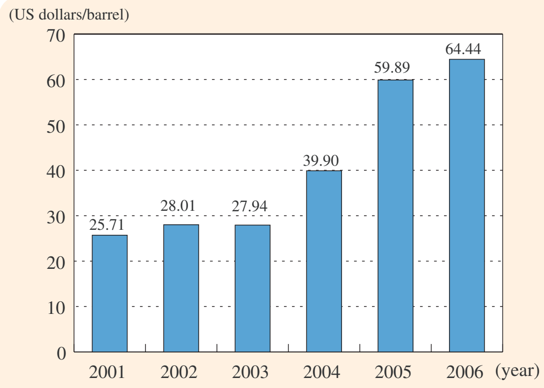
Note: Prices for scrap iron (steel scrap) are based on pre-H2 furnace cash prices in December each year.
Source: Japan Iron and Steel Recycling Institute

Fig. 1-4 Exports of recyclable resources



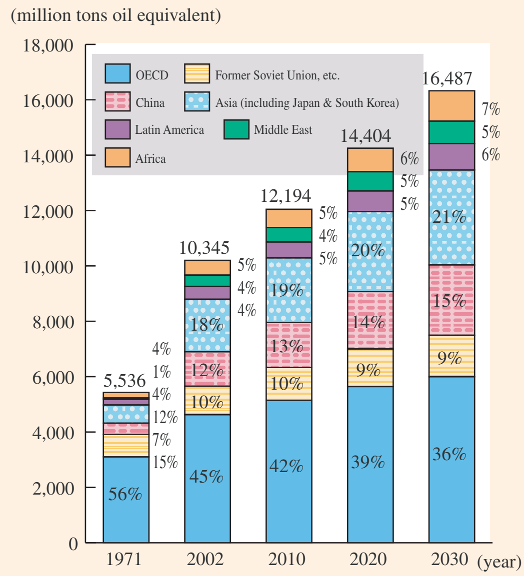
Source: Ministry of Finance Trade Statistics

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



Source: Ministry of Finance “Japan Trade Monthly Tables”

Fig. 1-6 Global prospects for primary energy demand



Source: IEA “World Energy Outlook 2004”

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.

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).

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.

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

Scenes from the Asia 3R promotion conference

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.

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

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		Reduce, reuse
The Food Waste Recycling Law		
2001 PCB Special Measures Law	2001 Ministry of the Environment established	
2002 The End-of-life Vehicle Recycling Law	(Responsibility for the control of waste	
2003 Fundamental Plan for Establishing a Sound Material-cycle Society	transferred to the Ministry of the Environment)	

Source: Ministry of the Environment

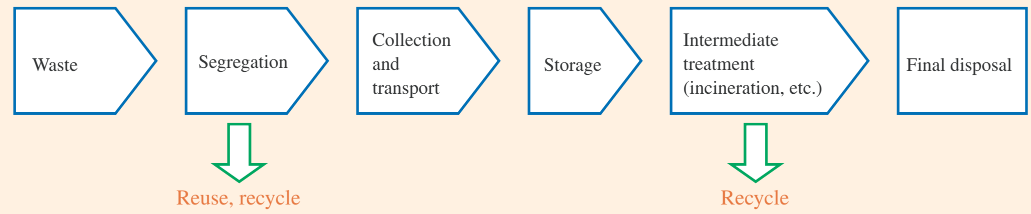
This section outlines various technologies that support the SMS of Japan, for example the following: waste-related technology for improving public health; hazardous substance countermeasure technology for reducing influences on human health and the ecosystem; 3R-related technology for enabling the 3Rs (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

Fig. 2-2 Waste management flow



Source: Ministry of the Environment

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.

(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.

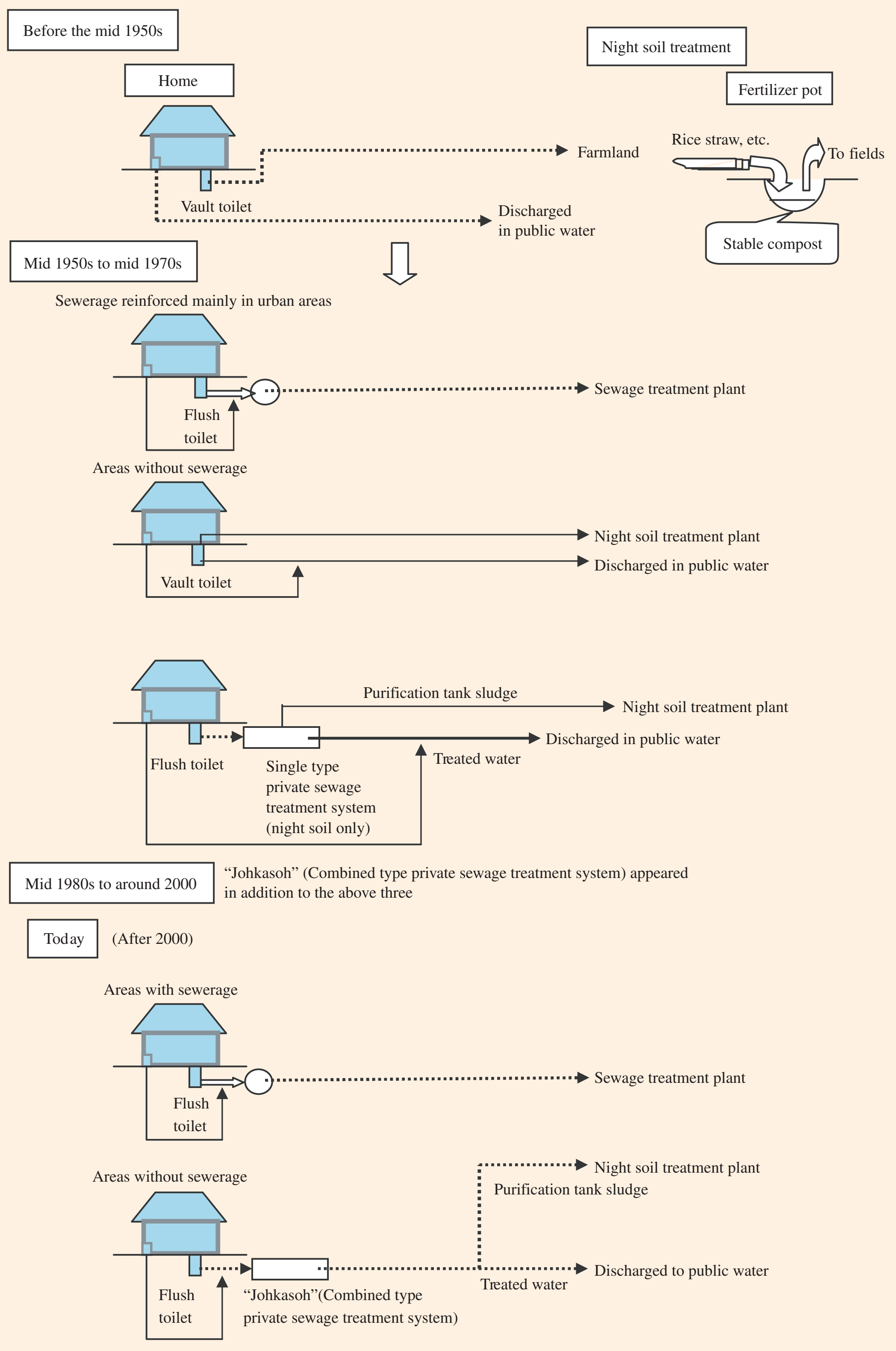
In 1983 the Purification Tank Law, which regulates each stage of purification tank processing, from manufacture through installation to management and maintenance, was enacted to control purification tanks. After that, a pressing need arose for reinforcing measures to be taken against one of the major 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

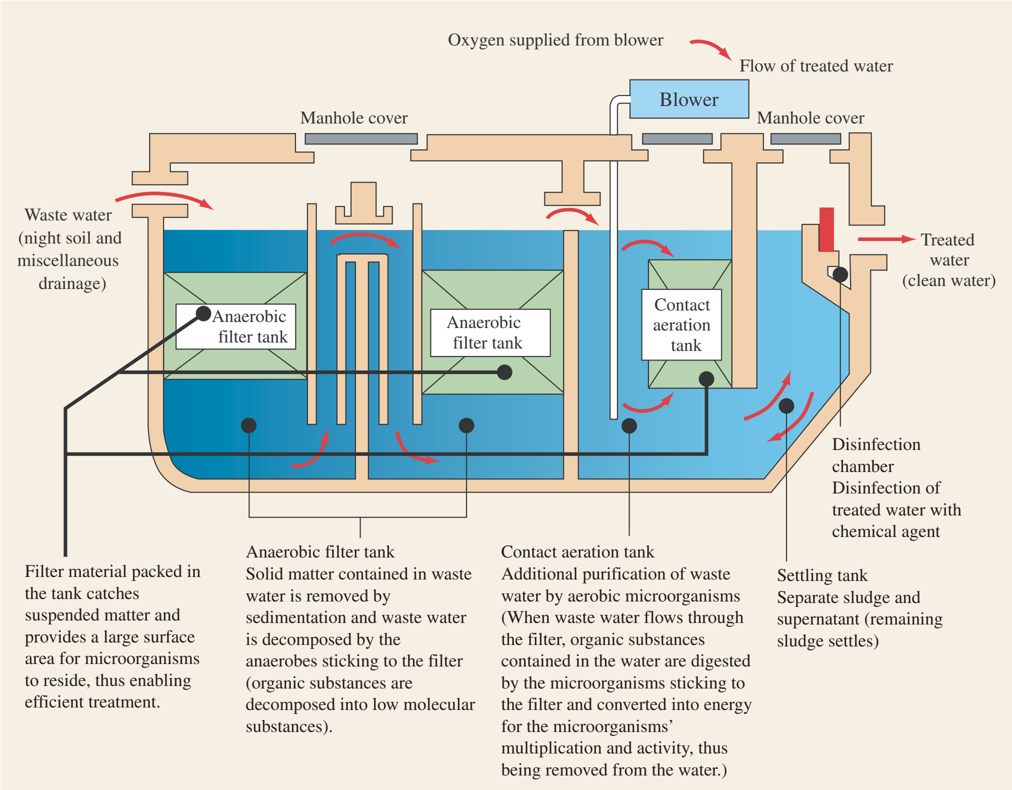


Source: Ministry of the Environment

Column : Treatment of Domestic Wastewater by Japanese - Made “Johkasoh”

”Johkasoh” is “a Purification 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

Mechanical waste collection vehicle (packer car)

Source: HP of the Resource & Waste Recycling Bureau, Yokohama City

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

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

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.

(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.

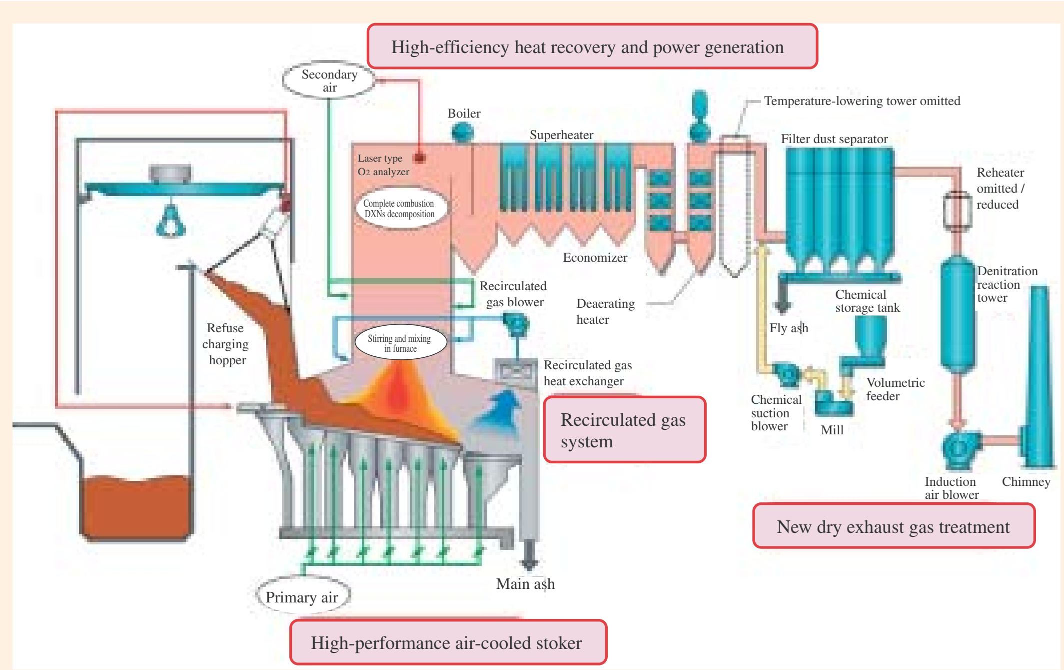
Because the amount and quality of waste generated and the measures required for environmental preservation have changed, incineration technology as a core waste management method has developed accordingly. Because domestic waste in Japan has a comparatively high water content, advanced technology is 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.

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.

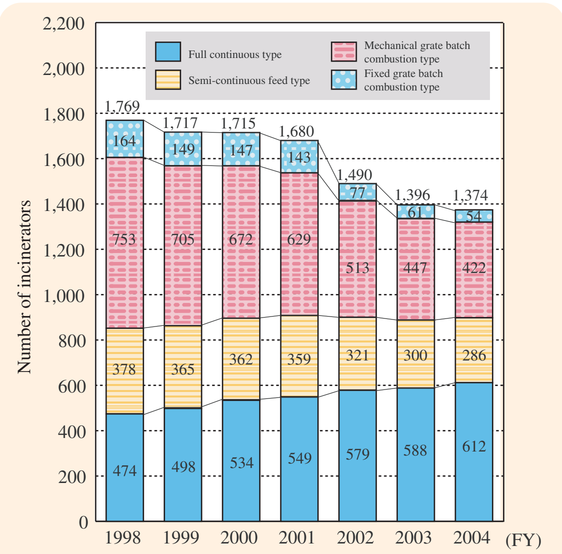
As at the end of 2004, there were 1,374 domestic waste incineration plants in Japan. While the number of plants is decreasing due to the promoted amalgamated treatment of waste as a measure against dioxins, the number of full continuous type incineration plants is increasing. Classified by type, mechanical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

Fig. 2-4 Example of stoker type waste incinerator



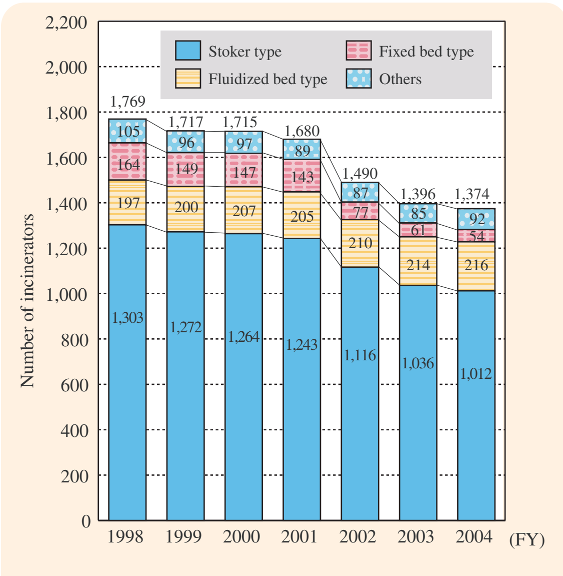
Source: Takuma Co., Ltd.

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



Source: Ministry of the Environment

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



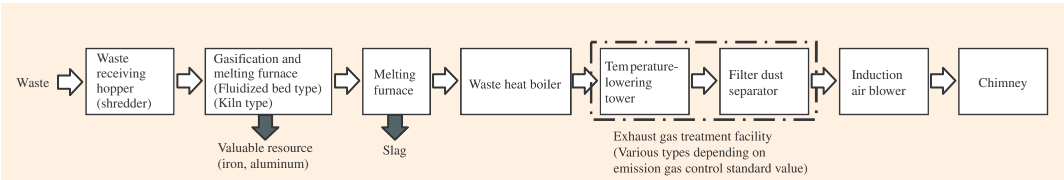
Source: Ministry of the Environment

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).

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.

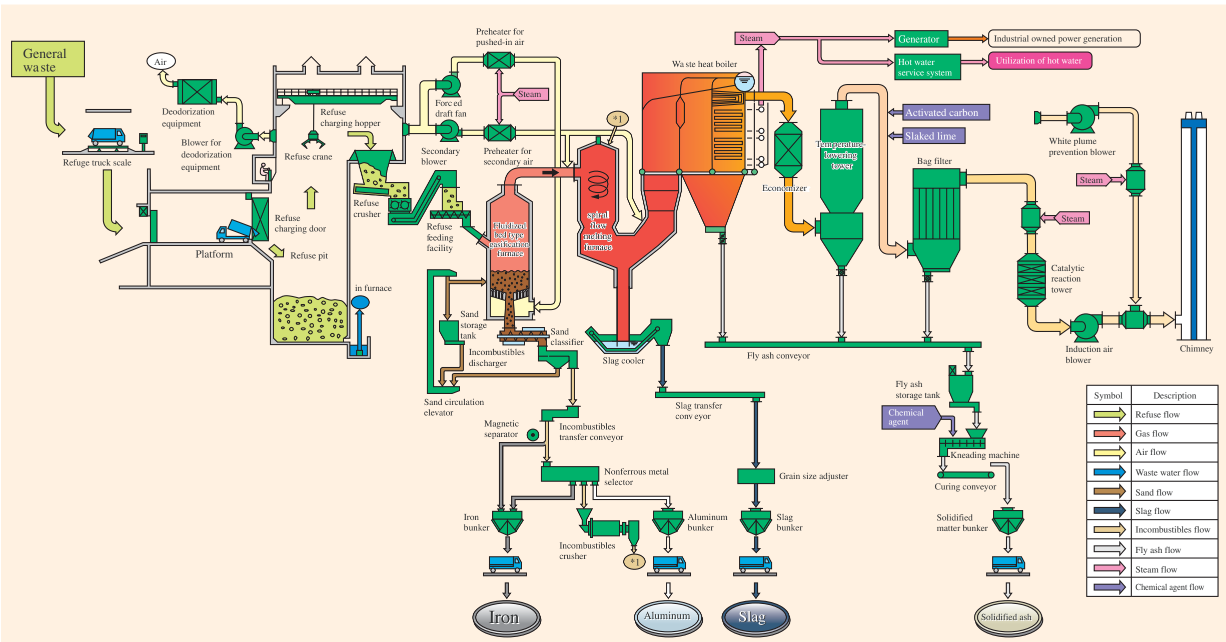
Fluidized bed type gasification and melting furnaces burn part of the waste, which is loaded in a fluidized bed type gasification furnace, together with fluid sand, to partially oxidize the waste and pyrolytically decompose it, utilizing combustion heat. In fluidized bed type gasification furnaces, waste is dried slowly, pyrolytically decomposed and gasified at a comparatively low

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



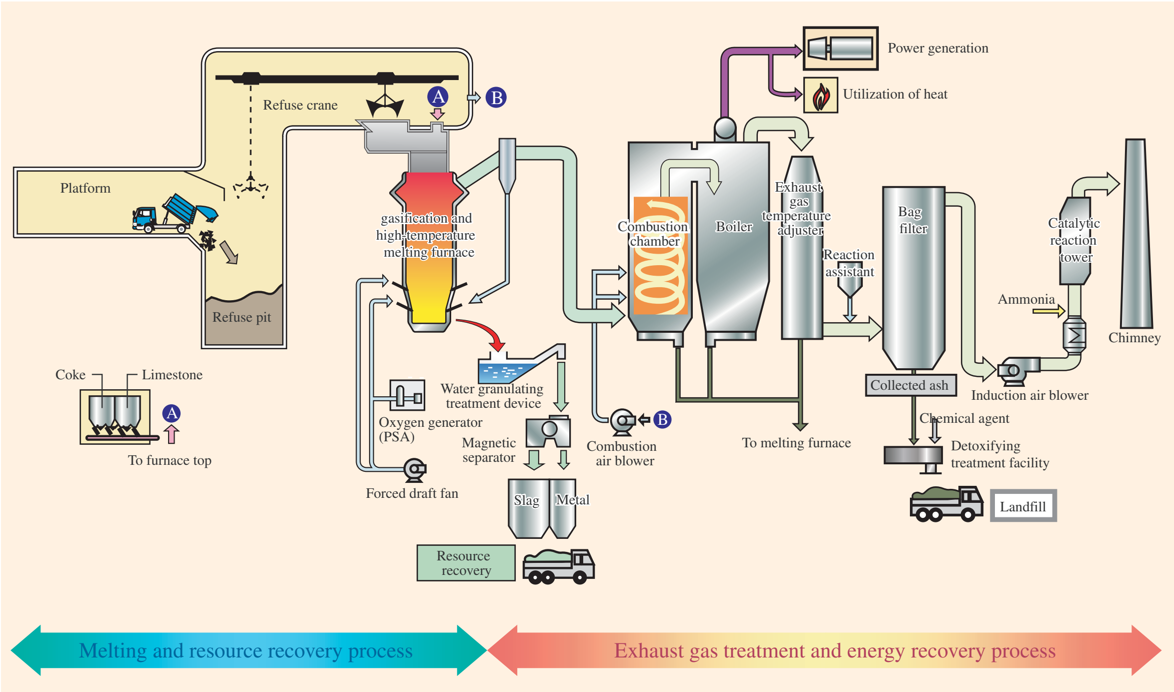
Source: Japan Waste Research Foundation

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



Source: Kobelco Eco-Solutions Co., Ltd.

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



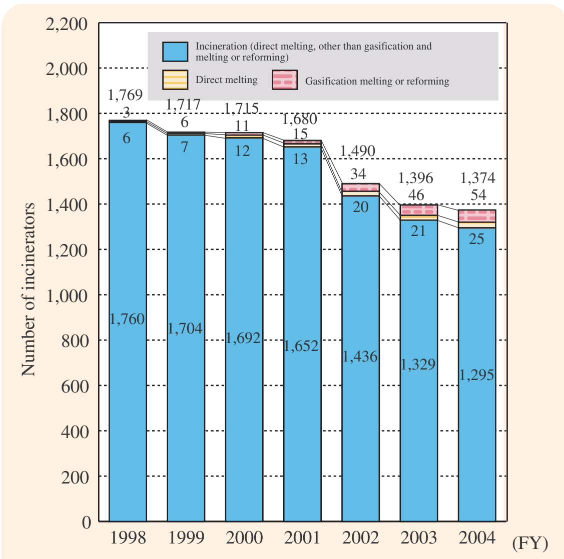
Source: Nippon Steel Engineering Co., Ltd.

temperature of 500 to 600˚C and at a super-low air ratio (Fig. 2-8).

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).

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).

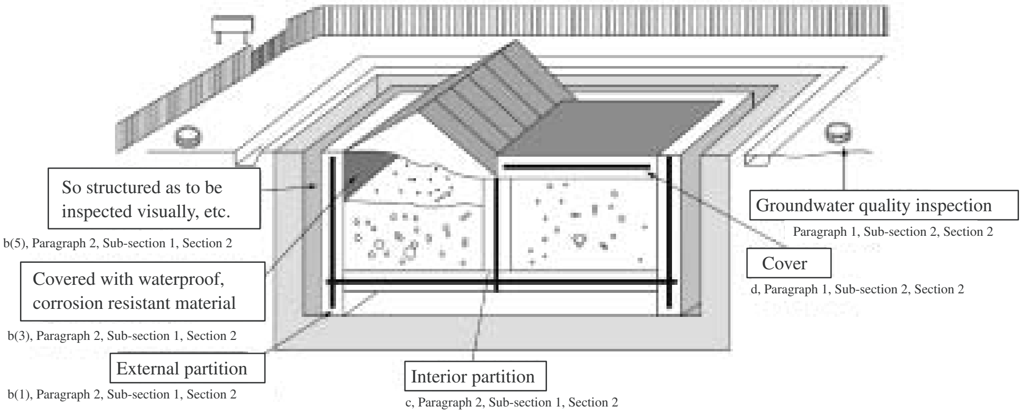
Least controlled landfill sites receive industrial waste that cannot be decomposed, for example, waste plastic which has no hazardous substance, organic matter, etc. adhered to it, waste metal, waste glass, and rubble. Because industrial waste such as waste plastics contains no water and is not decomposable, 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).

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).

Recently, in order to prevent the waste disposed of in landfill sites from contaminating the surrounding environment and thus to

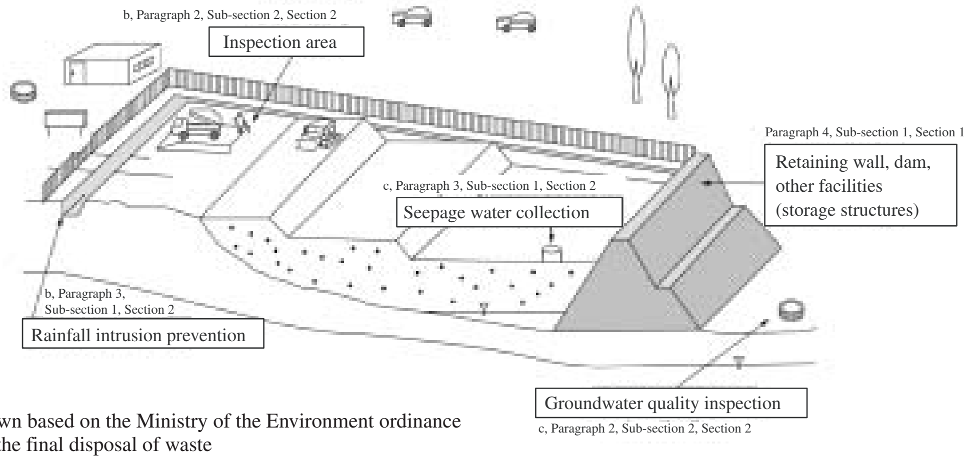
Fig. 2-11 Strictly controlled landfill site



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

Source: Japan Environmental Sanitation Center

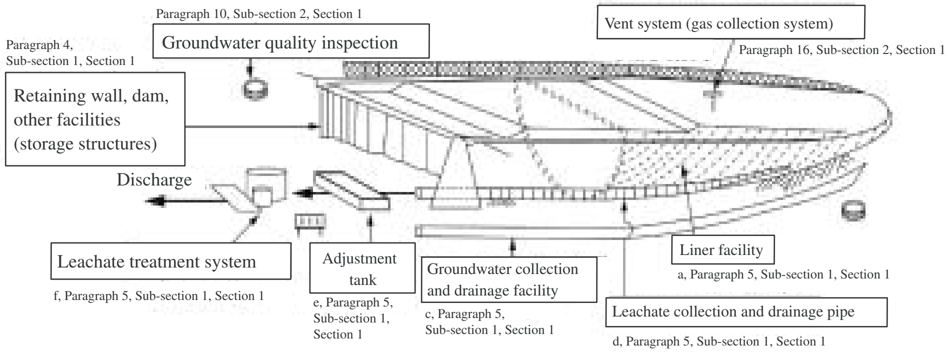
Fig. 2-12 Inert controlled landfill site



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

Source: Japan Environmental Sanitation Center

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

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.

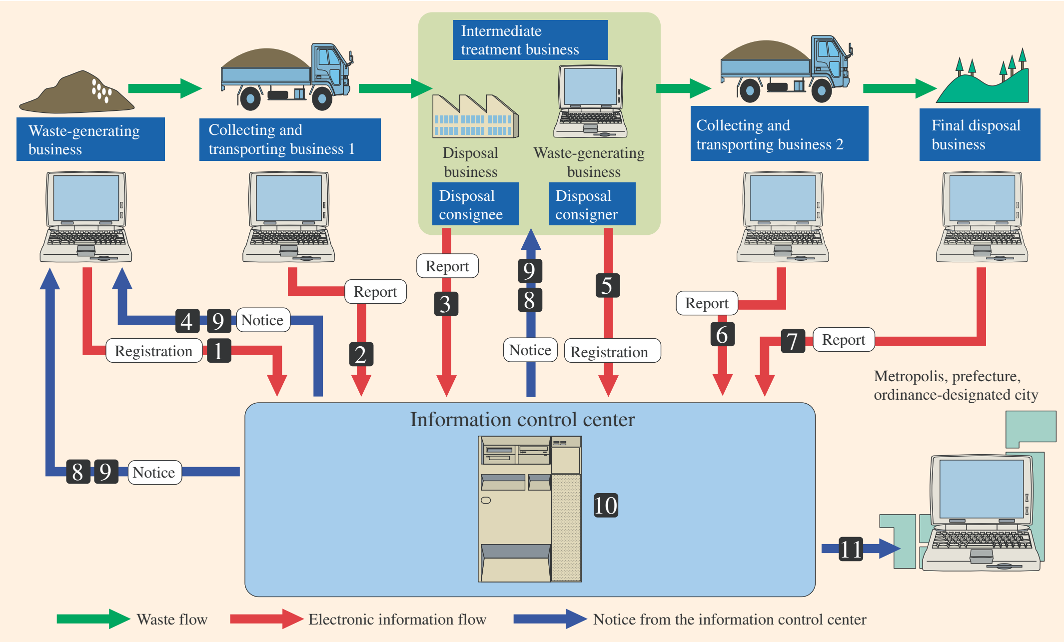
The 1997 revision of the Waste Management Law introduced an electronic manifest system, in addition to the conventional paper manifest. The electronic manifest system not only contributes to rationalizing information management by waste-generating businesses and waste management businesses but also stores 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

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

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).

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.

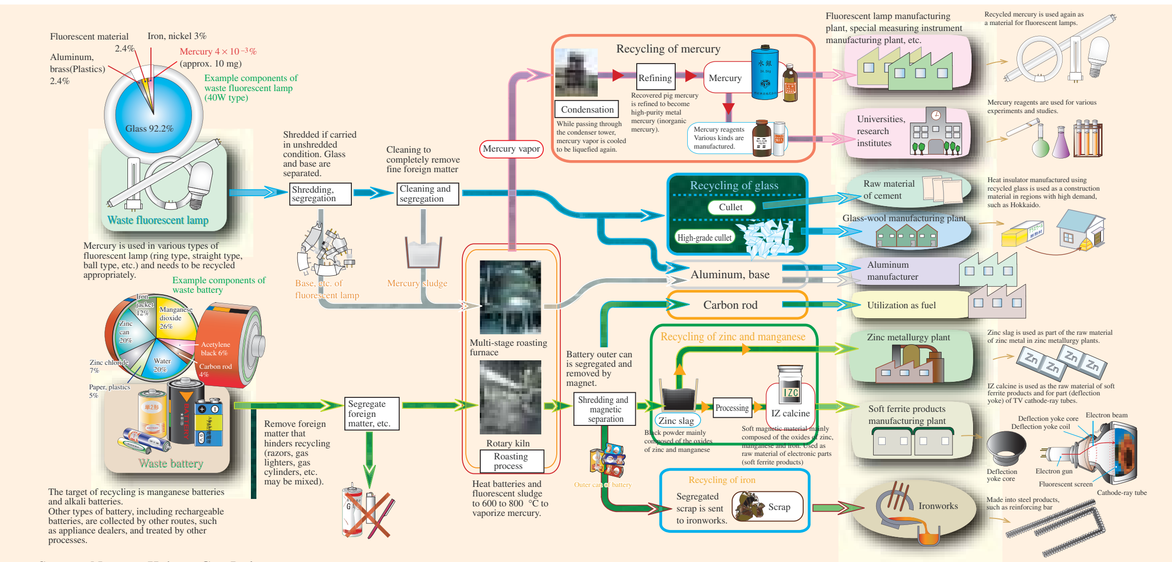
In order to prevent mercury from being dispersed in the environment when waste batteries and fluorescent lamps are disposed of, these are collected for recycling. Many local authorities participated in the Liaison Meeting for the Amalgamated Treatment of Waste Batteries, etc. of the Japan Waste Management Association to cooperate in

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

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

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).

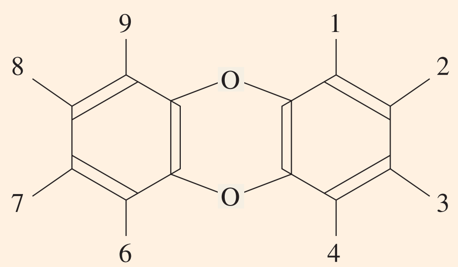
Waste fluorescent bulbs are shredded in the course of their disposal so that mercury will not be dispersed in the environment and are separated into glass, aluminum base parts, fluorescent material and sludge, which contains mercury. Glass and aluminum parts are recycled as valuable resources while the 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).

(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).

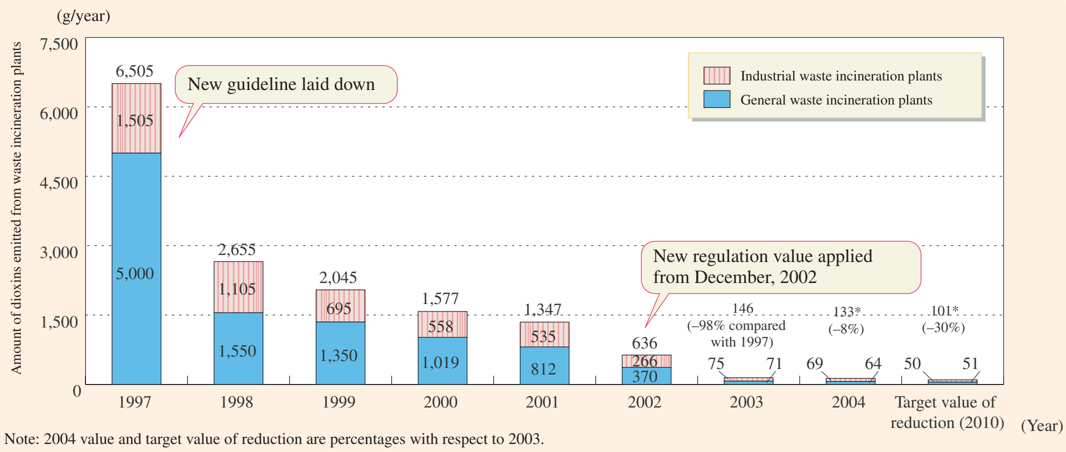
As measures against dioxins, in 1990 the Japanese government laid down guidelines for preventing the generation of dioxins related to waste incinerating facilities (the old guidelines), which were revised in 1997 as new guidelines. According to these guidelines, measures have been taken to control waste 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

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



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

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

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).

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

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 CO_2 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.

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.

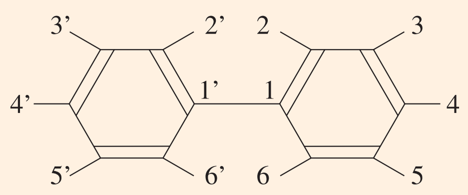
(3) PCB

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.

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).

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



Note: Chlorine atom is bound to the numbered section.

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

Table 2-3 PCB treatment methods

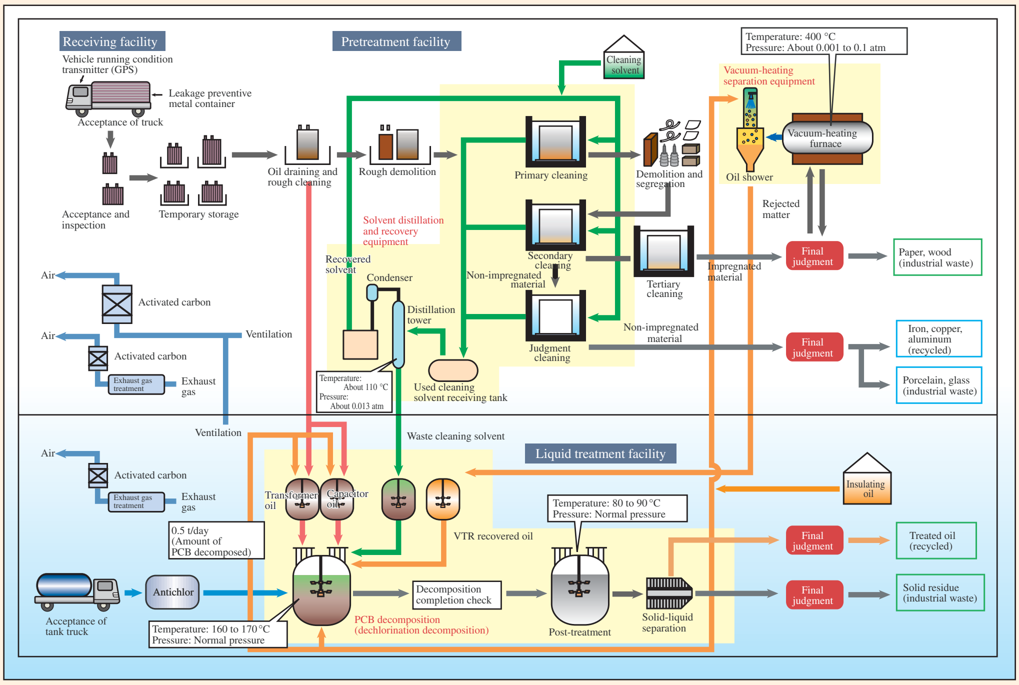
Name	Method	Features
High-temperature incineration	PCB is made into fine droplets to be sprayed in a furnace and incinerated.	Cost-effective method but combustion gas is generated by incineration.
Dechlorination decomposition	Sufficiently mixed with chemicals, etc. to be decomposed by dechlorination 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

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



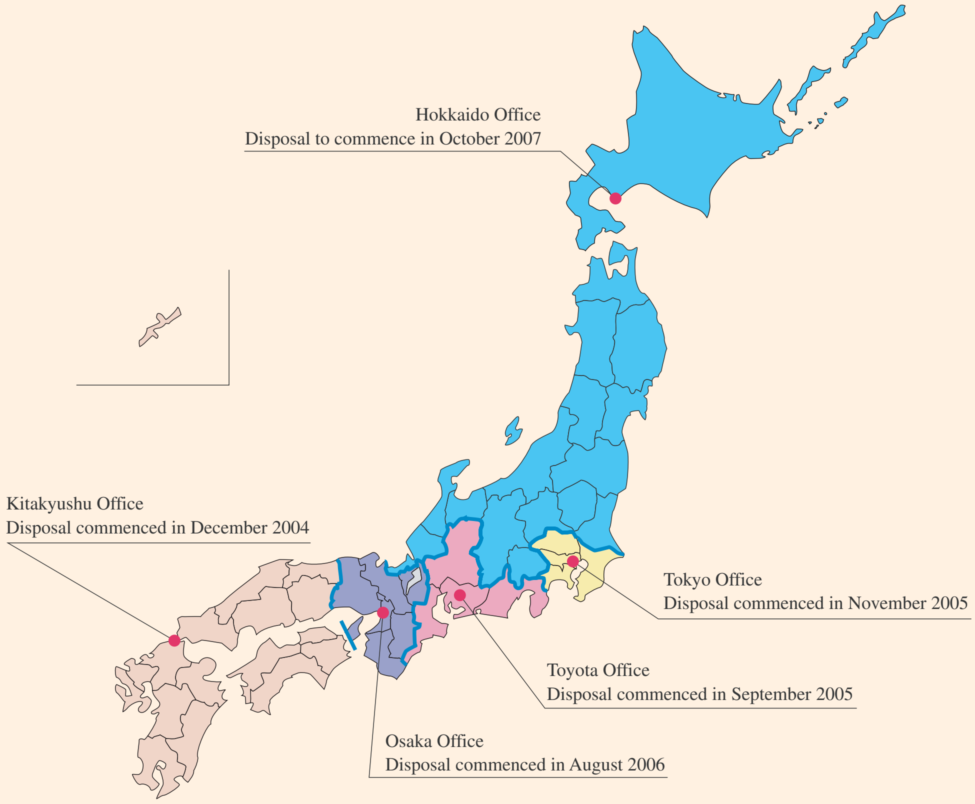
Source: Japan Environmental Safety Corporation

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

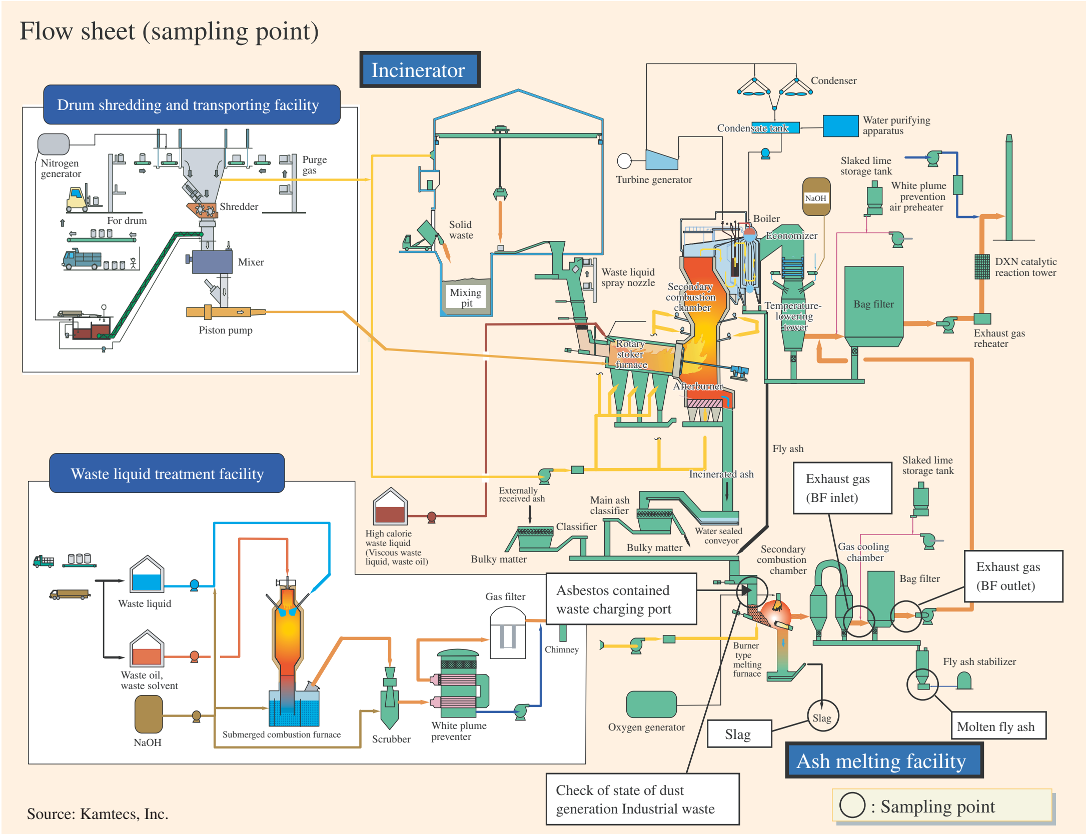
Because of its excellent heat resistance, etc., asbestos has been used in many products, including construction materials. But it is now regarded as a cause of pneumoconiosis, lung cancer, mesothelioma, etc., so the production, use, etc. of asbestos and products containing it have been prohibited. The 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



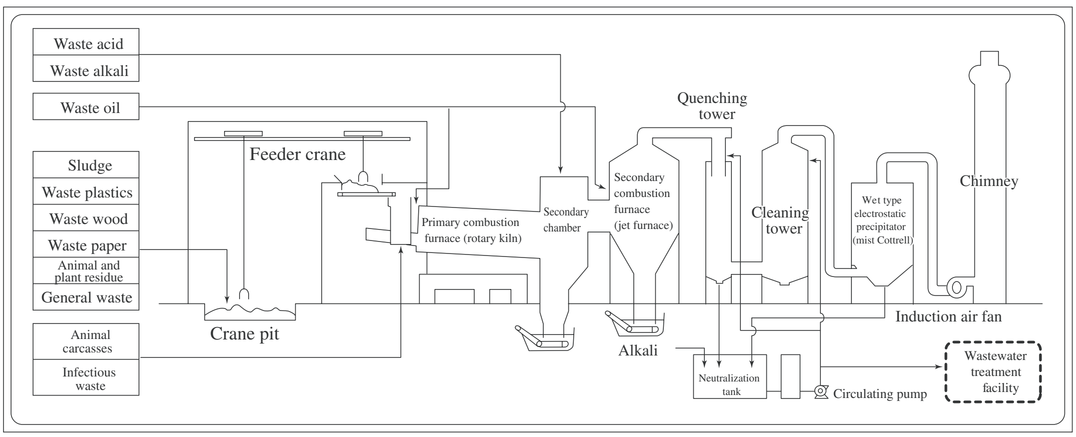
Source: Kamtecs, Inc.

(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.

Fig. 2-22 Incineration treatment flow



Source: Kureha Ecology Management Co., Ltd.

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).

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.

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

Source: Toshiba Corporation

Erasing device for erasable toner

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.

(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.

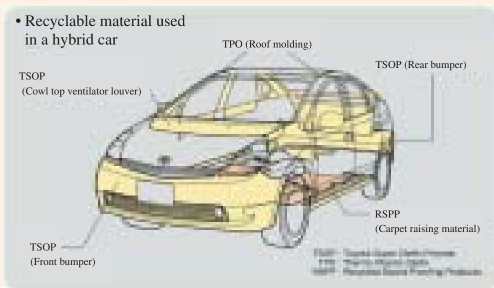
Of such techniques, the ease of decomposition reduces the labor and time for decomposing used products and contributes to their reuse and recycling.

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)

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

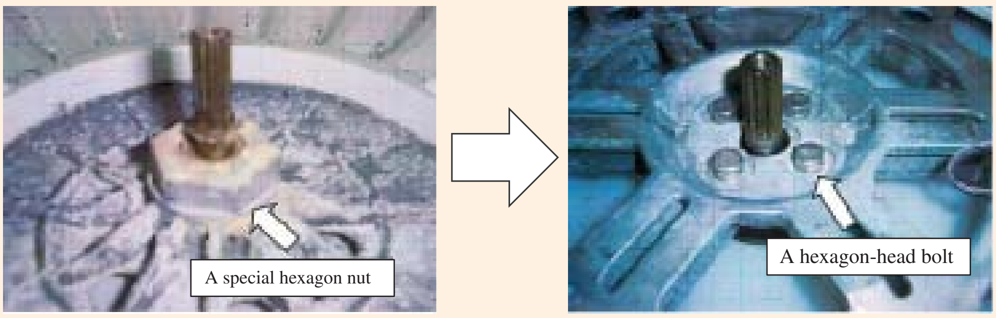
Fig. 2-24 Environment-conscious design of a hybrid car



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

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

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)

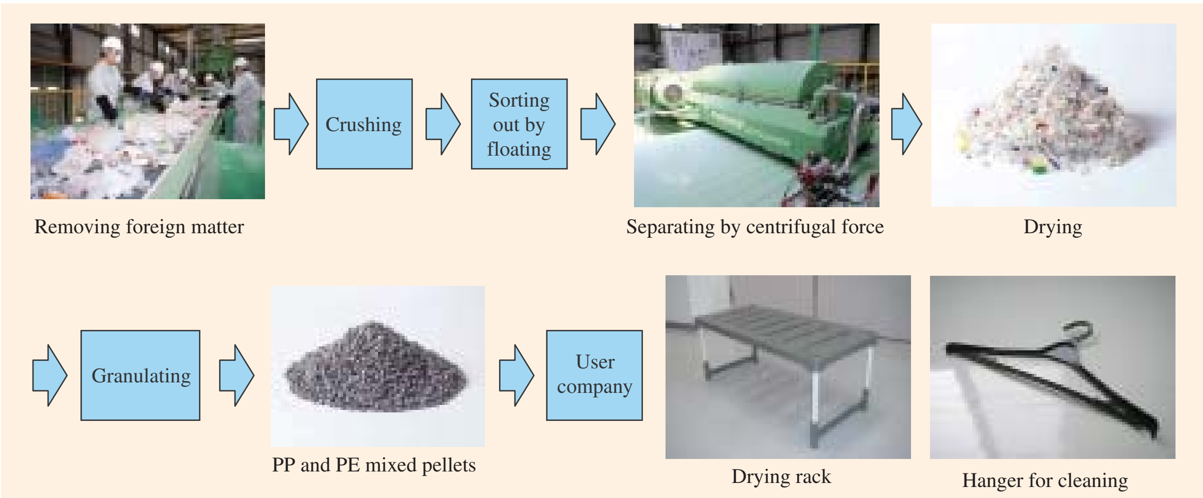
(3) Wastes to resources: material recycling technologies

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

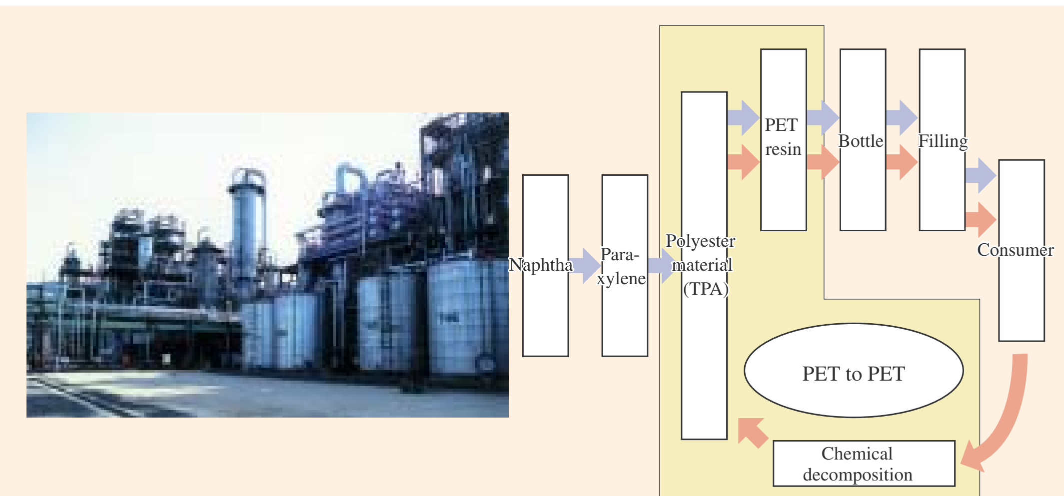
The Law for the Promotion of Sorted Collection and Recycling of Containers and Packaging (hereinafter referred to as “the Container and Packaging Recycling Law”) defines containers and packagings as “containers and packagings for commercial goods (including such container or packaging for which money 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,

Fig. 2-25 Material recycling of waste plastics



Source: Hiroshima Recycle Center Co., Ltd.

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



Source: Teijin Fibers Co., Ltd

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)

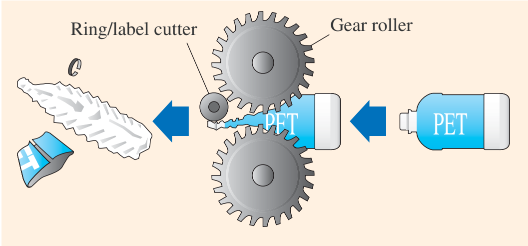
On the other hand, waste containers and packagings and waste PET bottles are recycled into textile products such as working clothes and carpet, sheet products, such as egg packs, and containers for cup noodles, hangers, and planters. A technology to make PET bottles from waste PET bottles has also been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

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)

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)

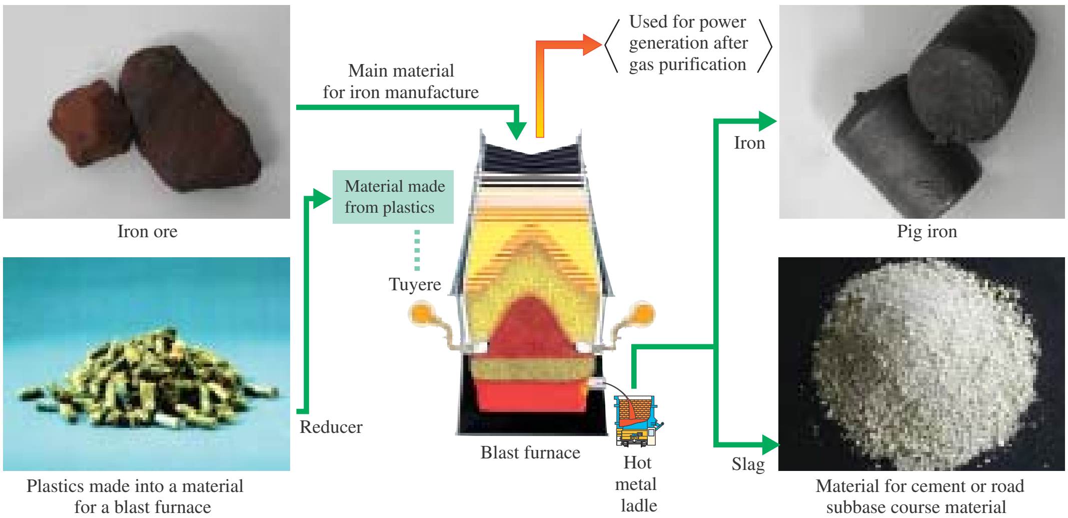
For a coke furnace, there is also technology to thermally decompose waste plastics and reuse them as resources. This technology involves heating waste plastics in a closed chamber, called a carbonizing chamber, in a coke furnace without oxygen at about 1,200˚C, thus generating hydrocarbon oils (light oils and tar) and coke furnace gases (hydrogen, methane, etc.) from the hot gases

Fig. 2-27 PET-bottle bulk reducer



Source: Meiwa Kousakusyo Corporation

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

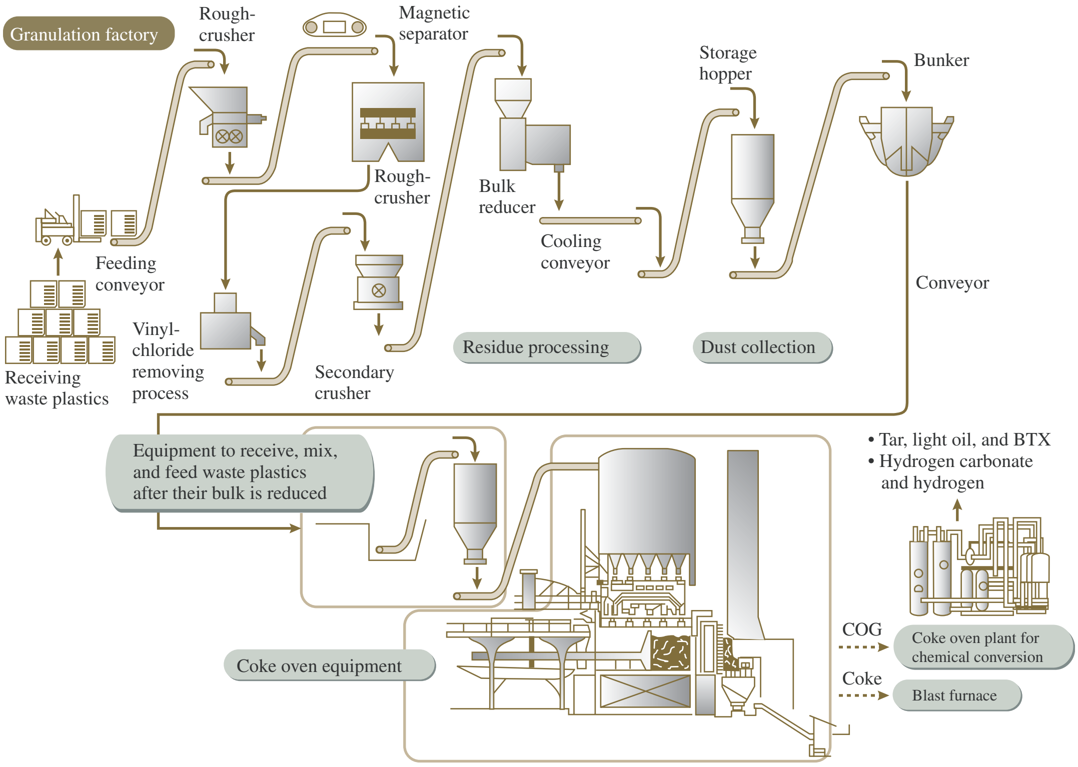


Source: JFE Steel Corporation

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)

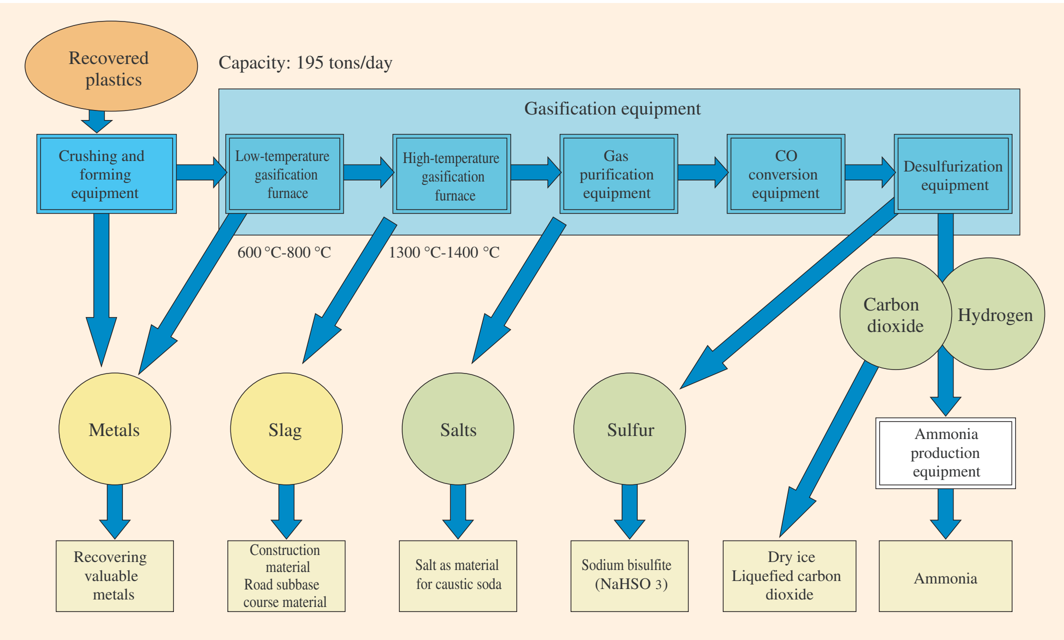
In the chemical industry, a technology to thermally decompose waste plastics into gases for materials contributes to the saving of fossil fuels such as coal and oil. Specifically, in a waste-plastic gasification process, waste plastics are processed into intermediate

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



Source: Nippon Steel Corporation

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



Source: Showa Denko K.K.

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)

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

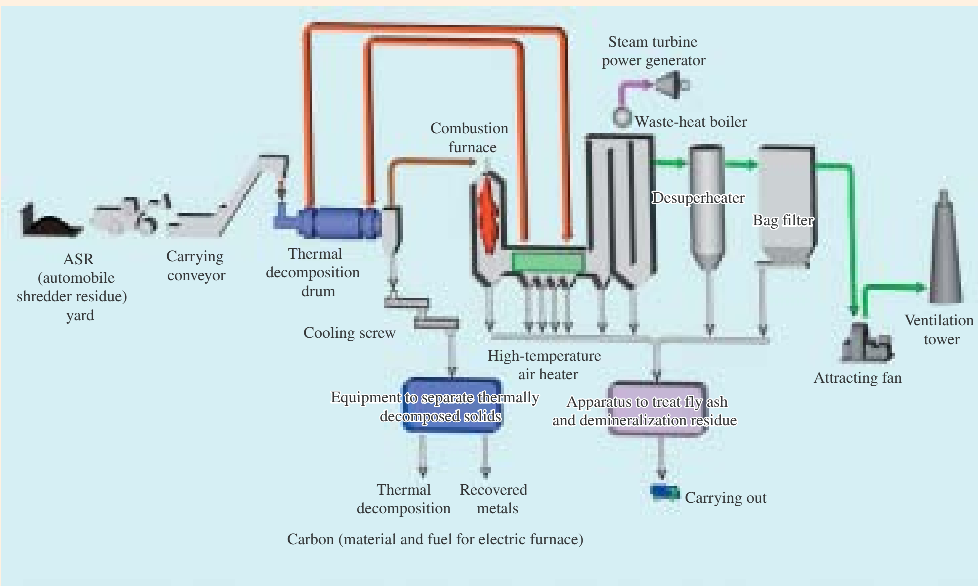
The automobile industry, which is also called a comprehensive industry, produces automobiles using various materials such as metals, glass, and plastics. End-of-life vehicles have conventionally been recycled or disposed of by companies specializing in dismantling or crushing. Nowadays they are recycled 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

Fig. 2-31 Recycling aluminum wheels

Recovering aluminum wheels　　Melting　　Suspension parts

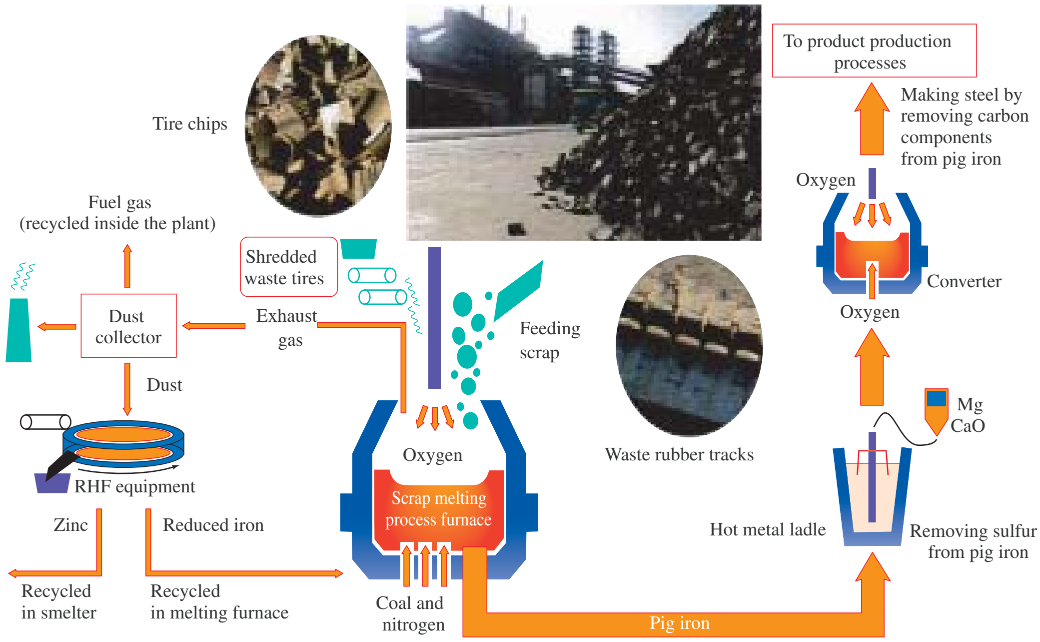
Source: Nissan Motor Co., Ltd.

Fig. 2-32 Technology for carbonizing automobile shredder residue



Source: Mitsui Engineering & Shipbuilding Co., Ltd.

Fig. 2-33 Flow of processing waste tires



Source: Nippon Steel Corporation

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)

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 450˚C 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)

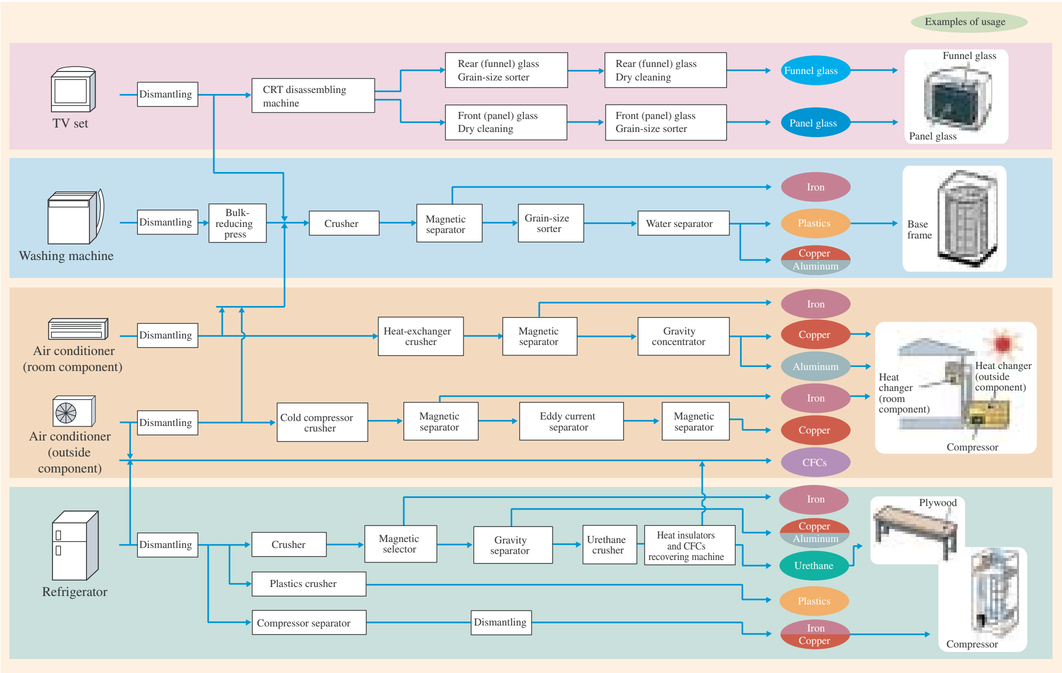
About 100 million tires, or one million by weight, are discarded every year. Typical examples of waste tire recycling include using them as a firing fuel in cement production, as a material for cement, and as a source of thermal energy. In addition, in steel plants, technology to convert them into a 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)

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)

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. 2-34 Flow of recycling home appliances

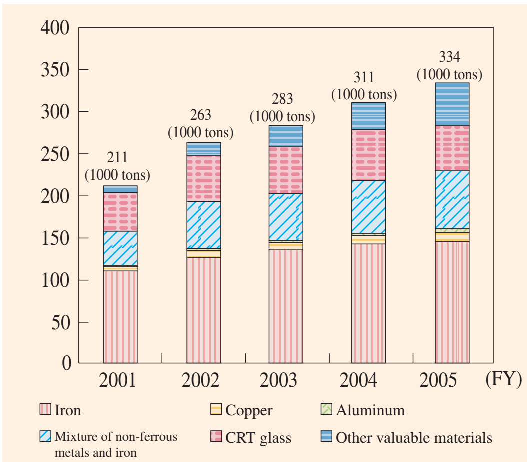


Source: Matsushita Eco Technology Center

Fig. 2-35 Case of closed recycling

Source: Sharp Corporation

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,

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

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

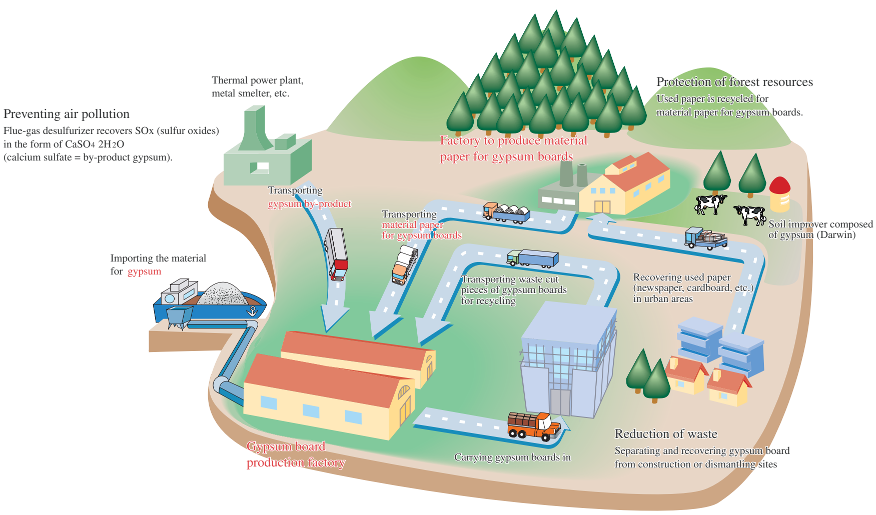
Column : History of Recycling Gypsum

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.

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.

e) Recycling food waste

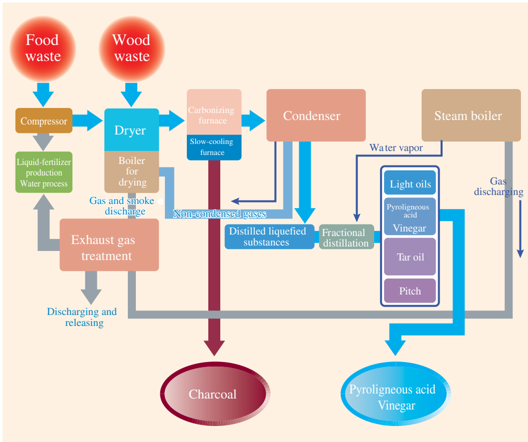
Food waste is the residues derived from animals or plants leftover during the processes of production, distribution, and consumption. Specifically they are processing residues produced in the food production process, unsold and disposed food products, food leftover after consumption, and cooking garbage. 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 60˚C 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)

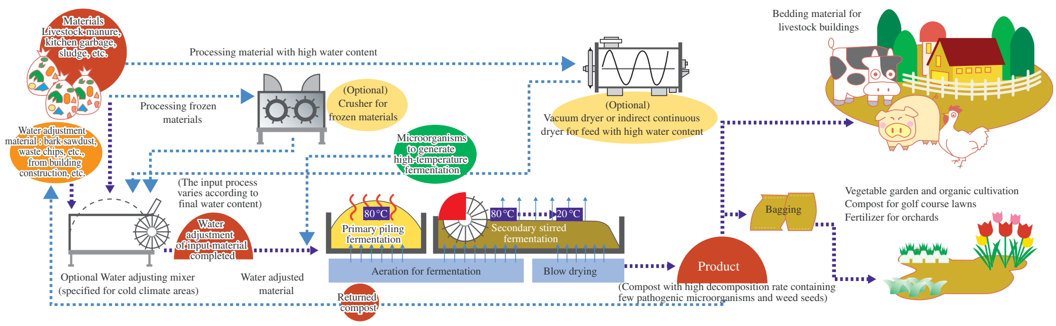
Recently technology to make kitchen garbage or wood waste (residues in the agricultural process) into resources, such as fuels, by carbonizing, liquefying, and distilling has been put into practical use. (Fig. 2-38)

Fig. 2-38 Food and wood waste recycling project



Source: Kansai Saishigen Network Co., Ltd

Fig. 2-37 Composting facilities

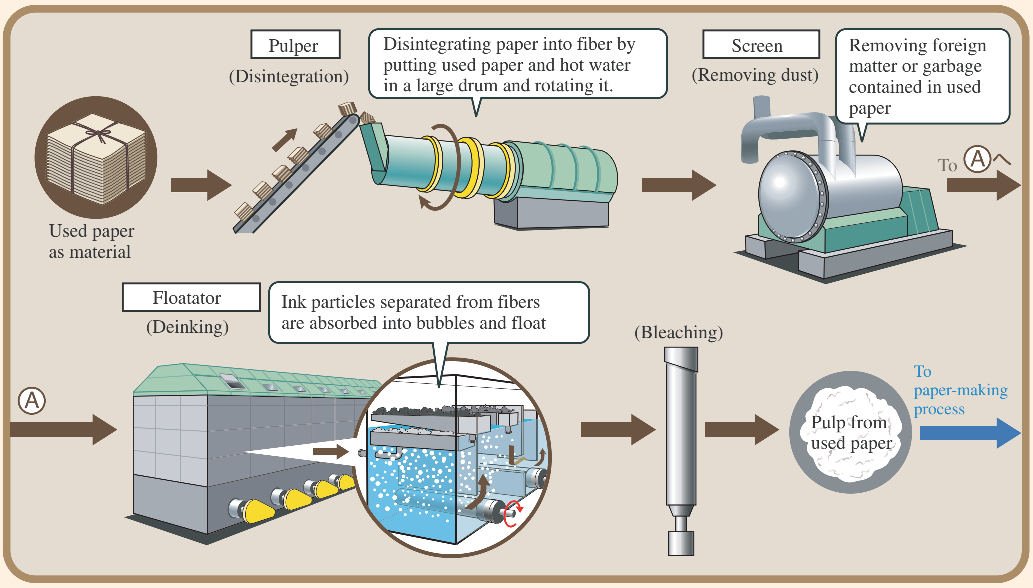


Source: JFE Environmental Solutions Corporation

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

Fig. 2-39 Paper-recycled pulp production process



Source: Oji Paper Co., Ltd.

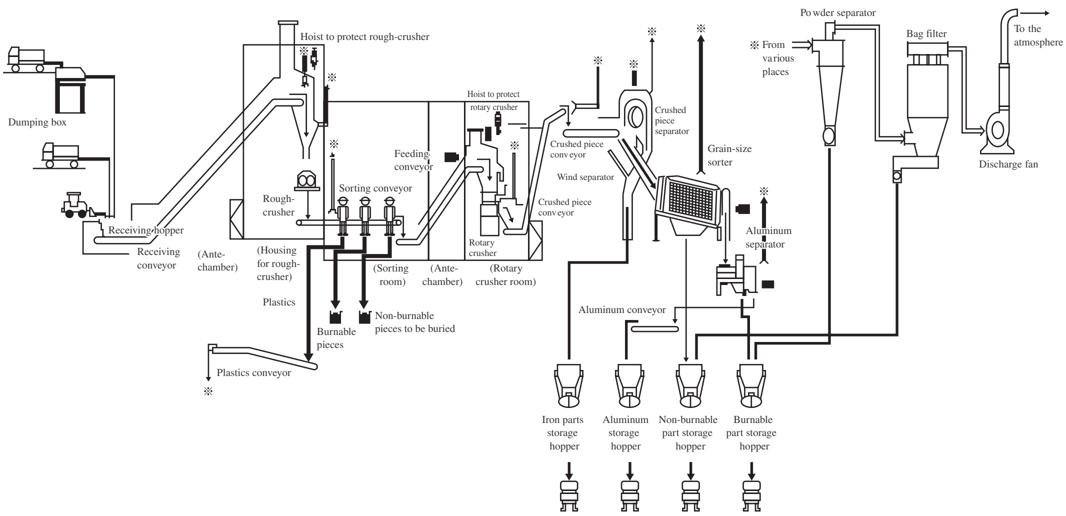
used paper is used as a material for paper manufacturing on the basis of its advantage in formability, it is also now being used to create other paper products.

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)

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)

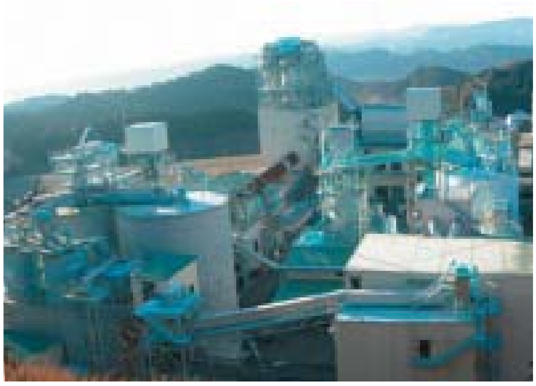
Fig. 2-40 Facility for crushing and sorting large-size discarded articles



Source: Kubota Corporation

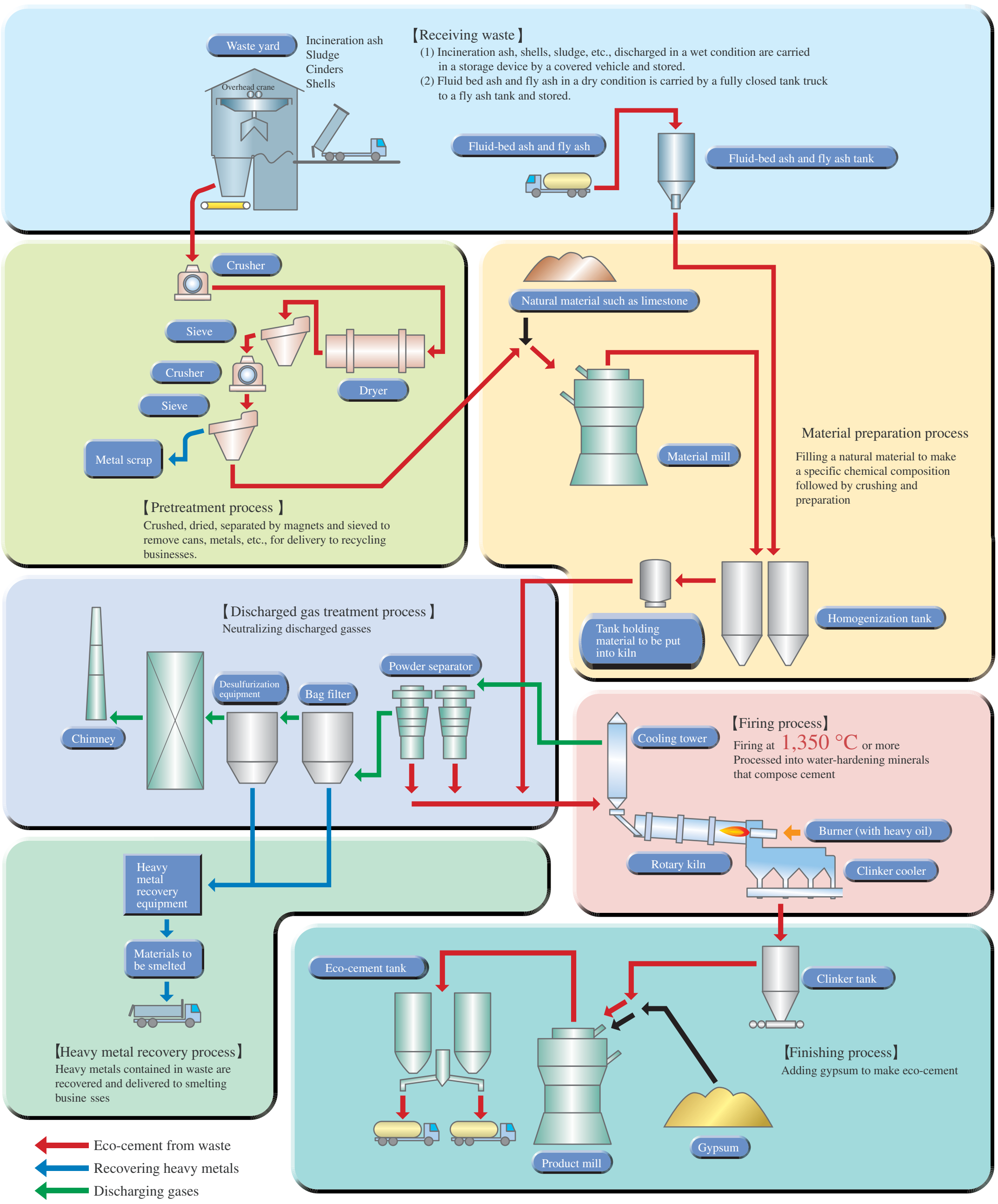
h) Recycling incineration ash

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.



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

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)

(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.

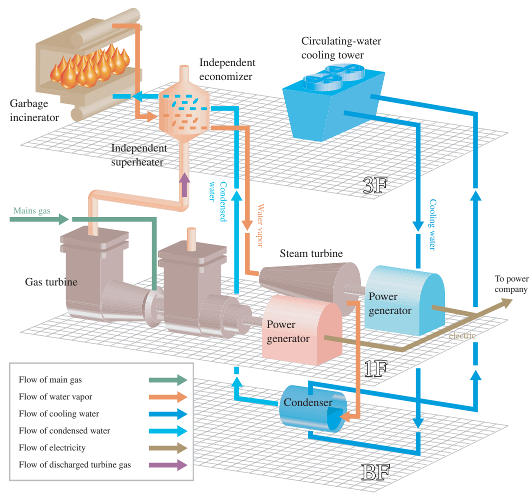
Today, the reduction of emission of greenhouse-effect gases such as CO_2 is an important issue related to controlling global warning. Thermal recycling converts thermal energy produced by waste incineration into electric power and other forms of energy. Since it replaces fossil fuels it reduces CO_2 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)

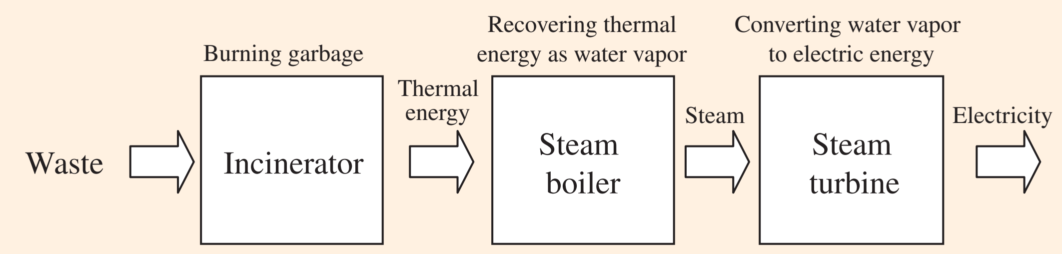
Waste may contain plastics or vinyl chloride, which produce hydrogen chloride when incinerated. Along with hydrogen chloride, iron chloride and alkali iron sulfate is produced on the surface of metals, which decomposes with dust on the surface. The metal surfaces subsequently rapidly corrode when the 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

Fig. 2-43 Example of super waste power generation



Source: Kitakyushu City

Fig. 2-42 Outline of waste power generation



Source: Ministry of the Environment

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)

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)

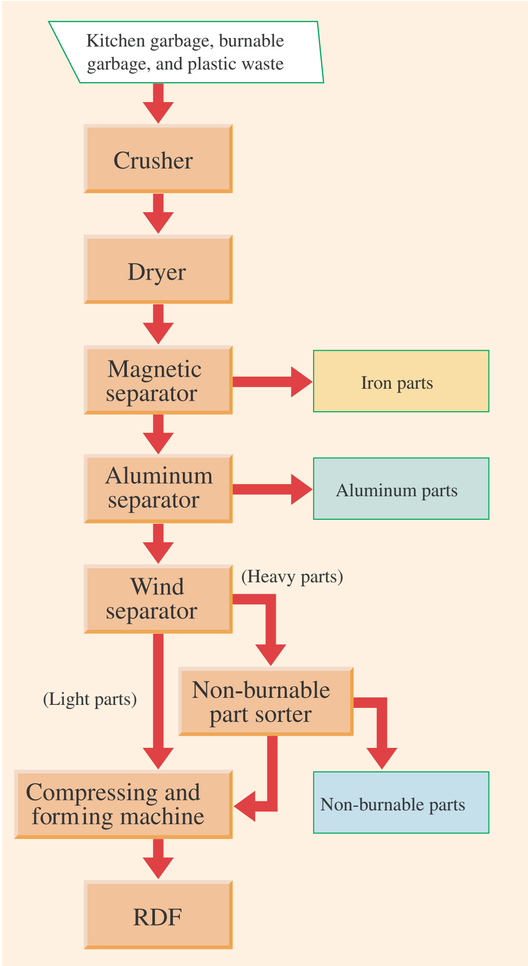
Small-scale garbage incineration plants cannot economically implement heat recovery individually. Thus, some small-scale garbage treatment plants process garbage into burnable solid fuel, and the fuel is collected at a dedicated power generation plant. This solid fuel is called RDF (refuse derived fuel). 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)

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

Fig. 2-44 Flow of RPF production



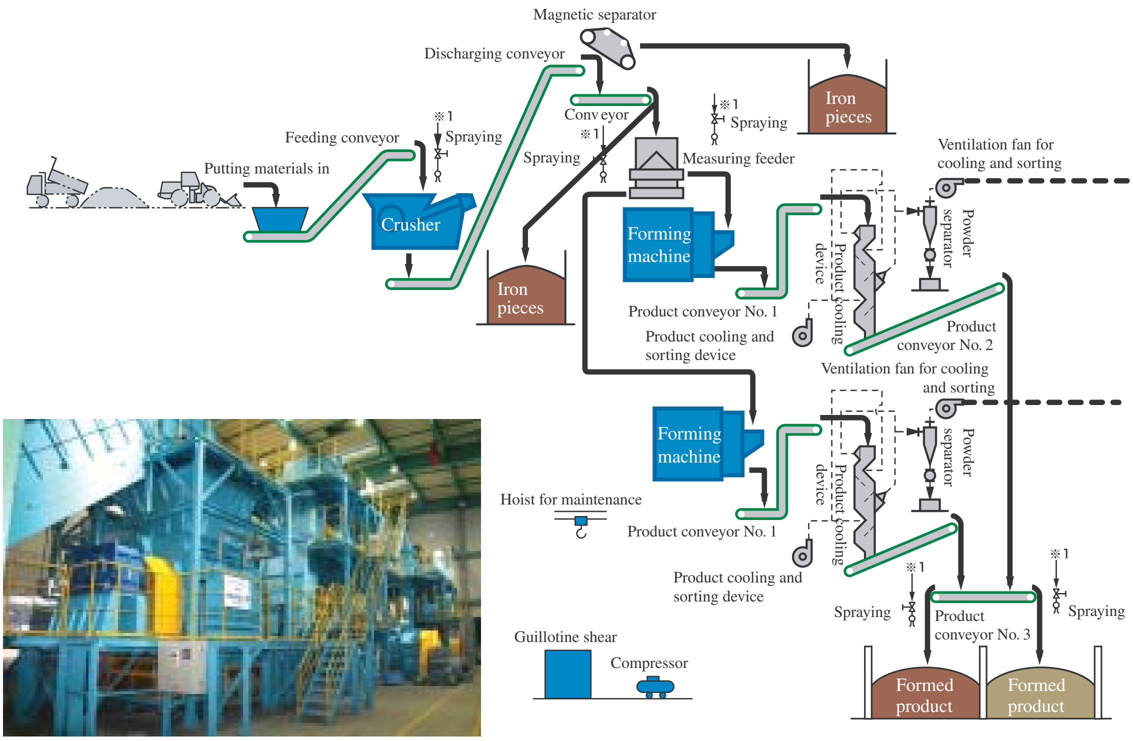
Source: Takuma Co., Ltd.

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

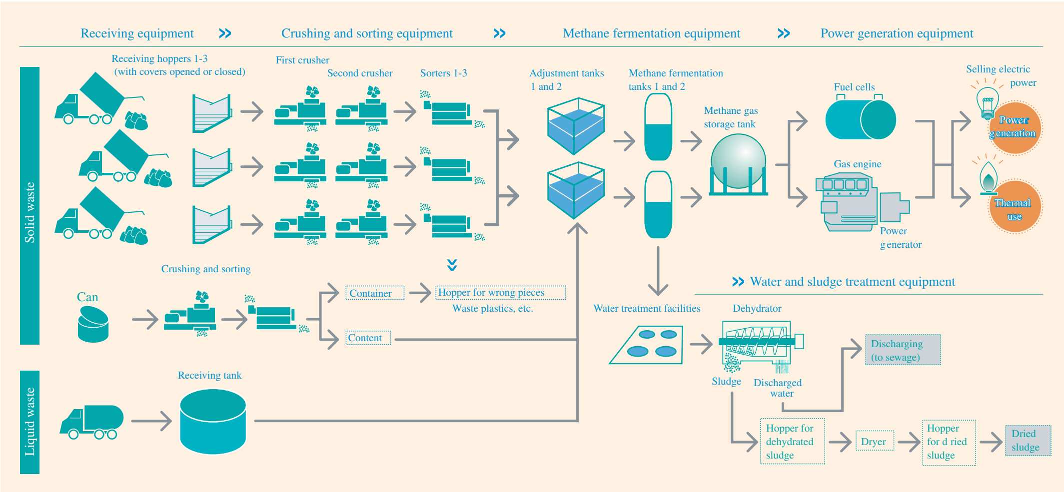
Source: Japan RPF Association Inc.

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.

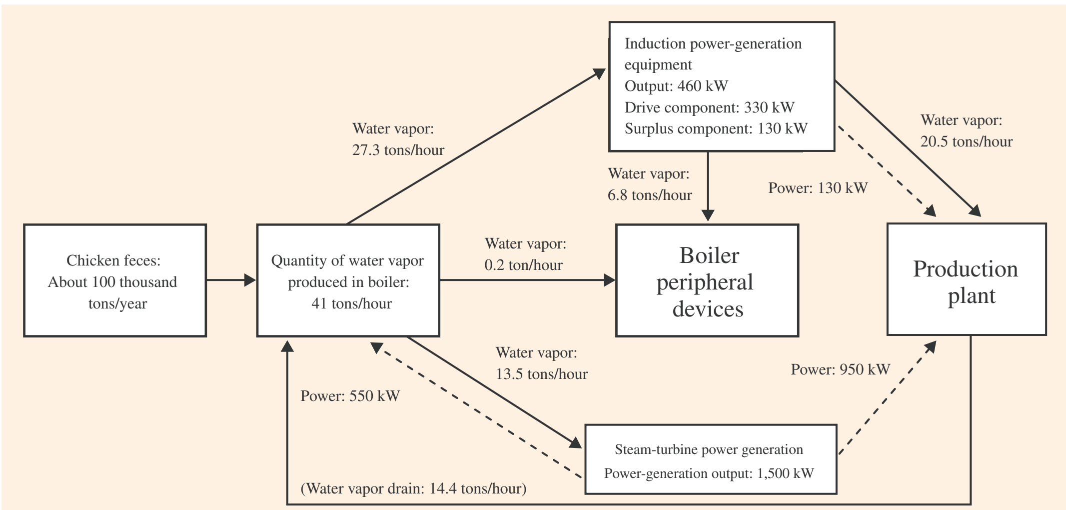
About 50% (100,000 tons annually) of the chicken feces produced all over the prefecture is collected and incinerated at the plant. Water vapor produced in the boiler is used as a heat source in fertilizer production processes as well as for power generation. Incineration ash is granulated into fertilizer.

Source: NANGOKUKOSAN Co., Ltd.

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)

Diagram of chicken feces boiler



Source: NANGOKUKOSAN Co., Ltd.

f) Biodiesel fuel

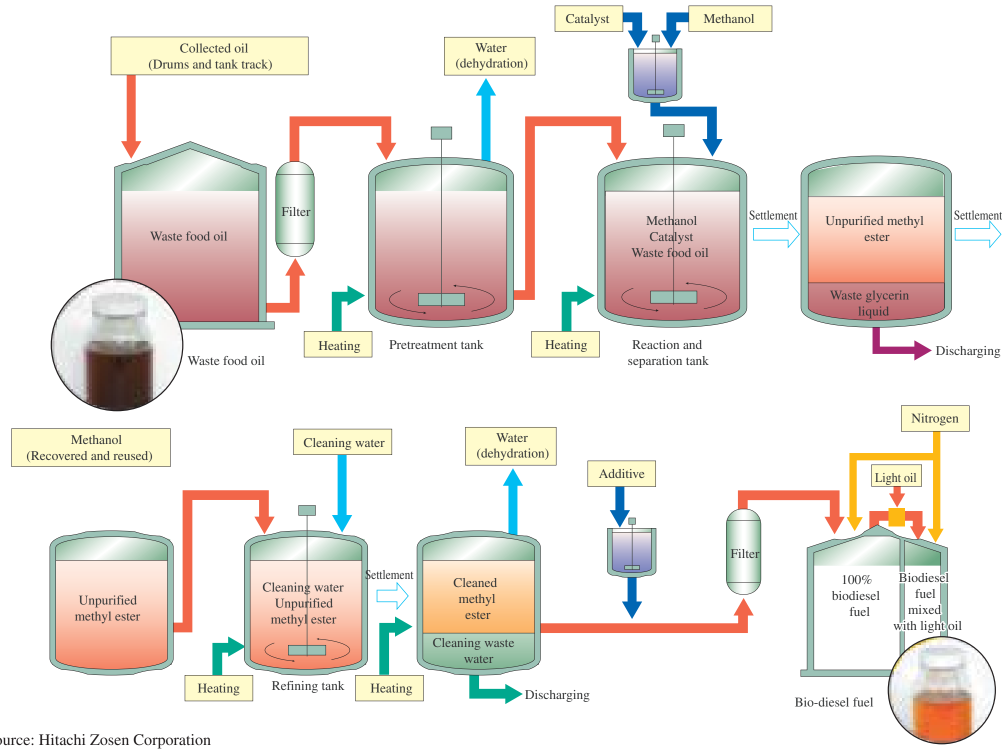
Biodiesel fuel (BDF) can be substituted for light oil and used in automobile diesel engines. It is made from biomass materials such as waste food oil. BDF has low sulfur oxide content, so the exhaust contains low concentrations of sulfur oxides. Since it is an oxygen-containing fuel it promotes engine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

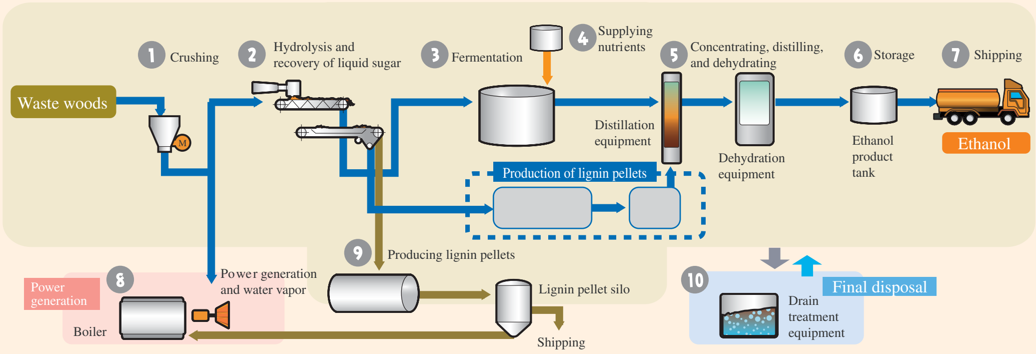


Source: Hitachi Zosen Corporation

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)

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)

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

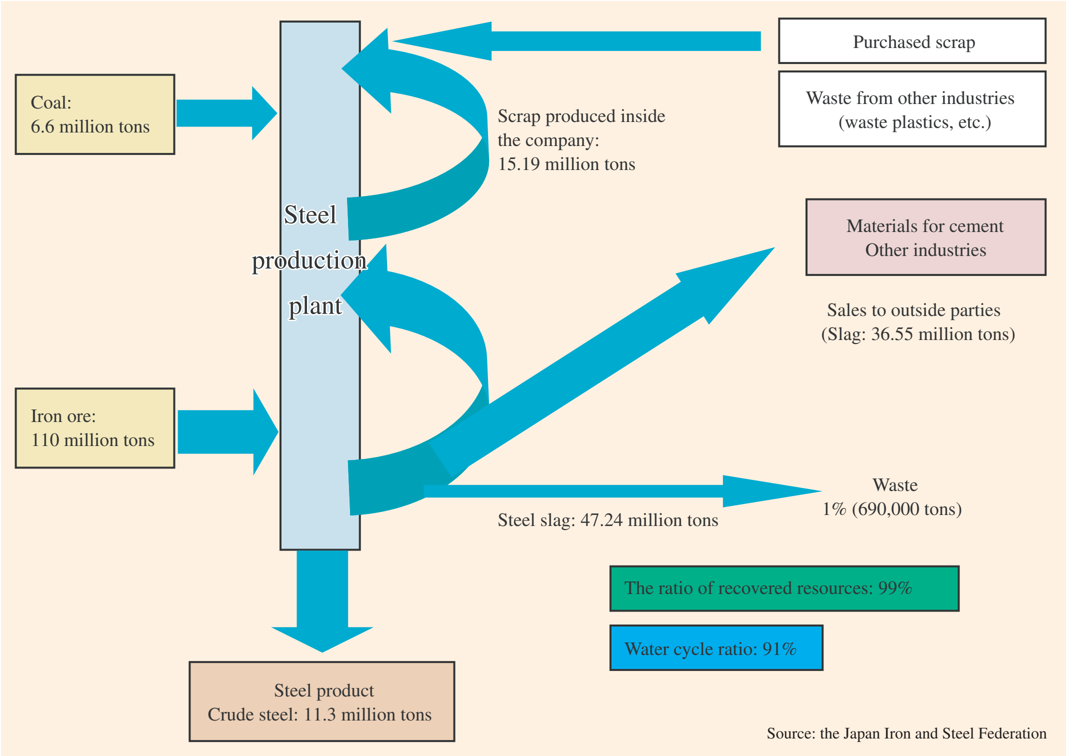
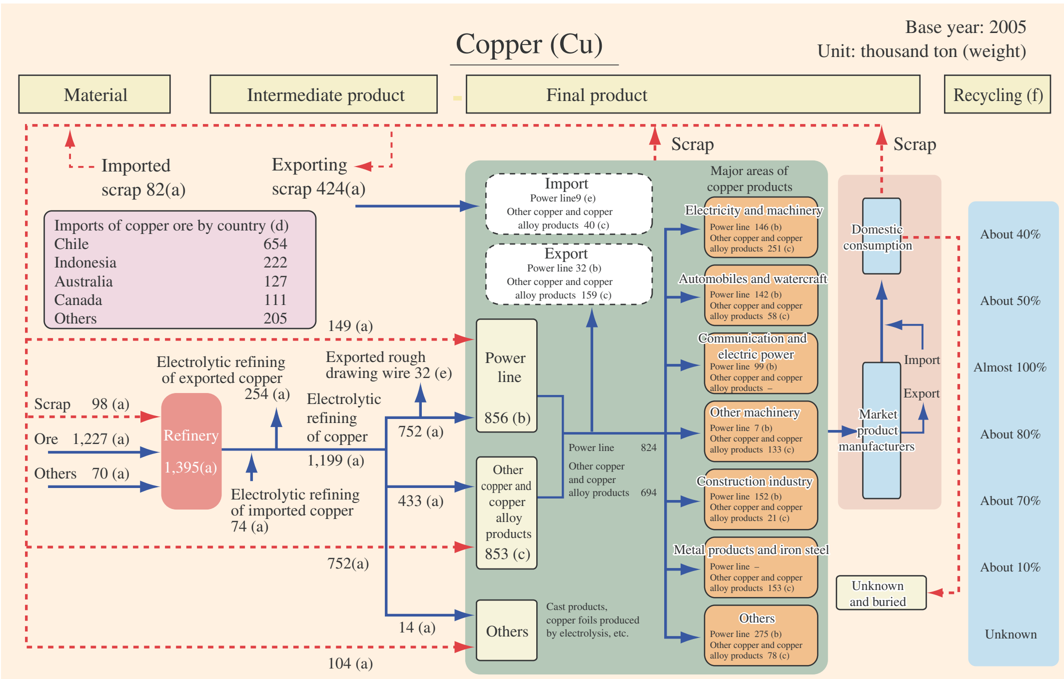


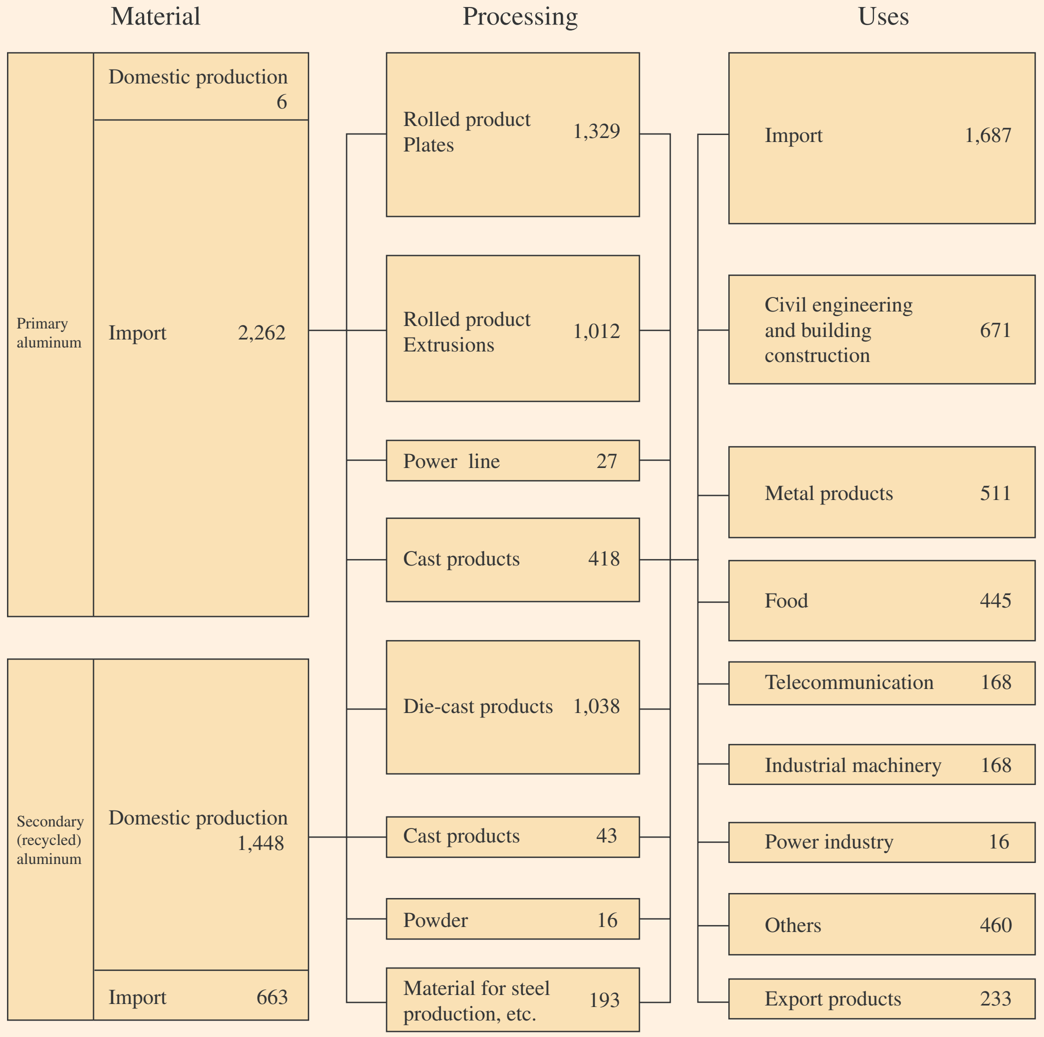
Fig. 2-50 Material flow of copper



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

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

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.

(2) Rare metals and heavy metals

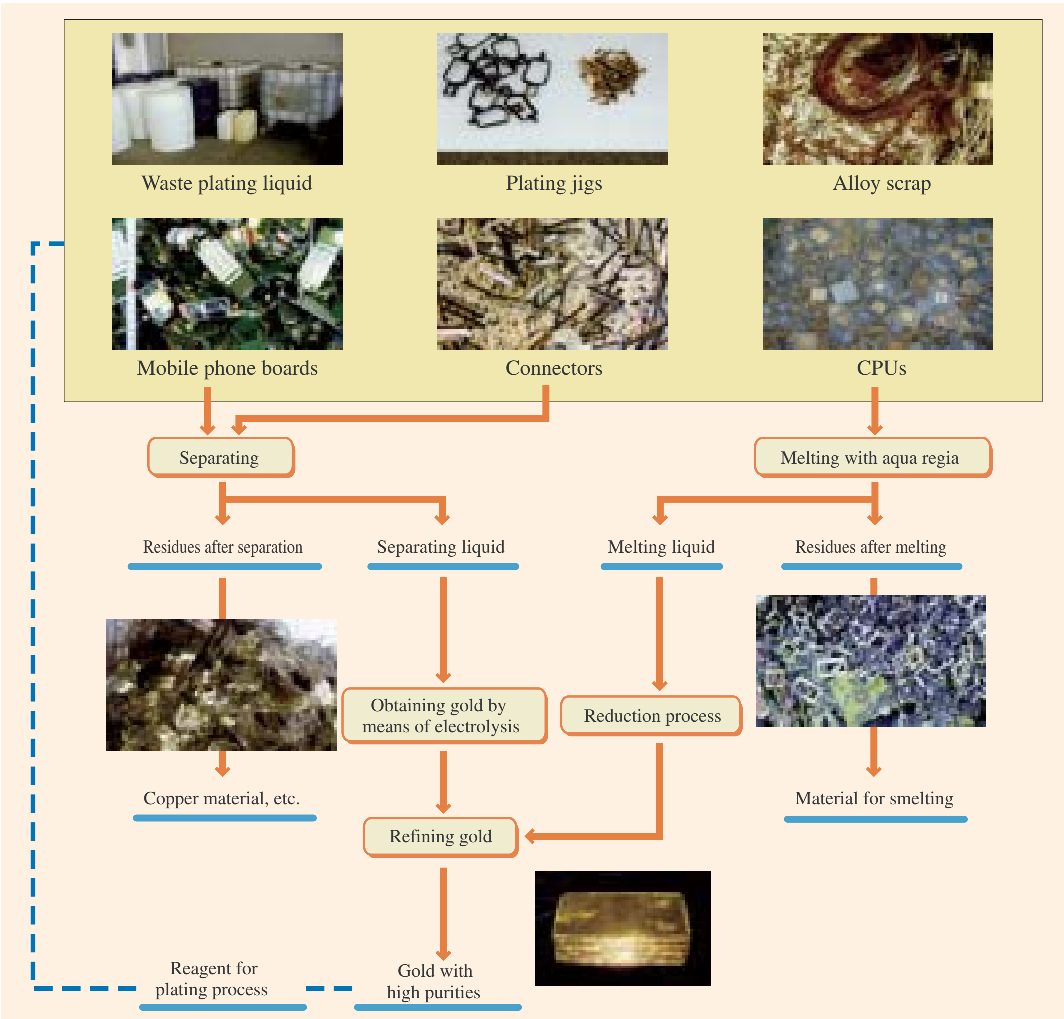
While gold and silver have traditionally been used as ornaments, rare metals such as platinum and indium are used in the fields of cutting-edge technologies. For example, platinum is used as a purification catalyst for automobile exhausts; molybdenum and vanadium are industrial catalysts for oil refineries 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)

There are also technologies where shredder dust produced from automobiles and discarded home appliances and copper-containing

Factory that recovers rare metals and heavy metals from shredding dust

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

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

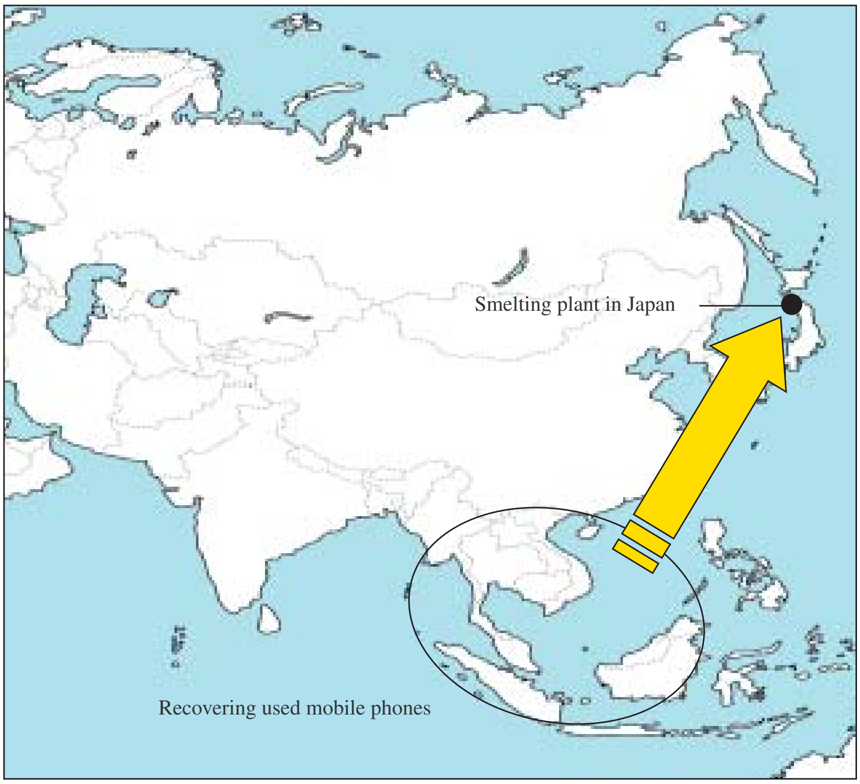


Source: DOWA Eco-System Co., Ltd.

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

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.

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

Molten slag Source: Okayama City

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.

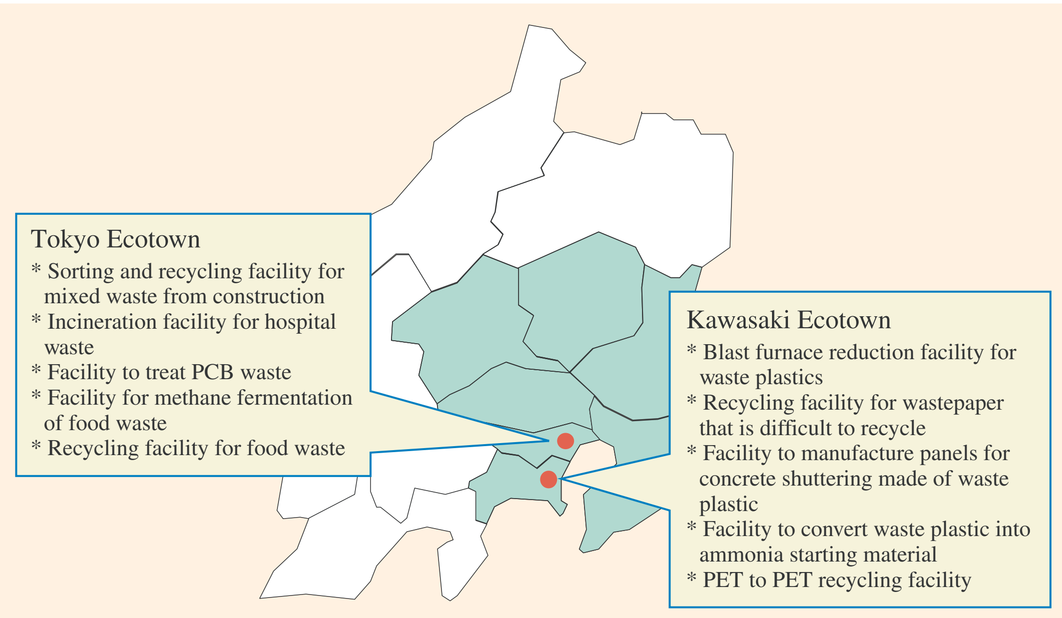
4. Ecotowns, etc.

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).

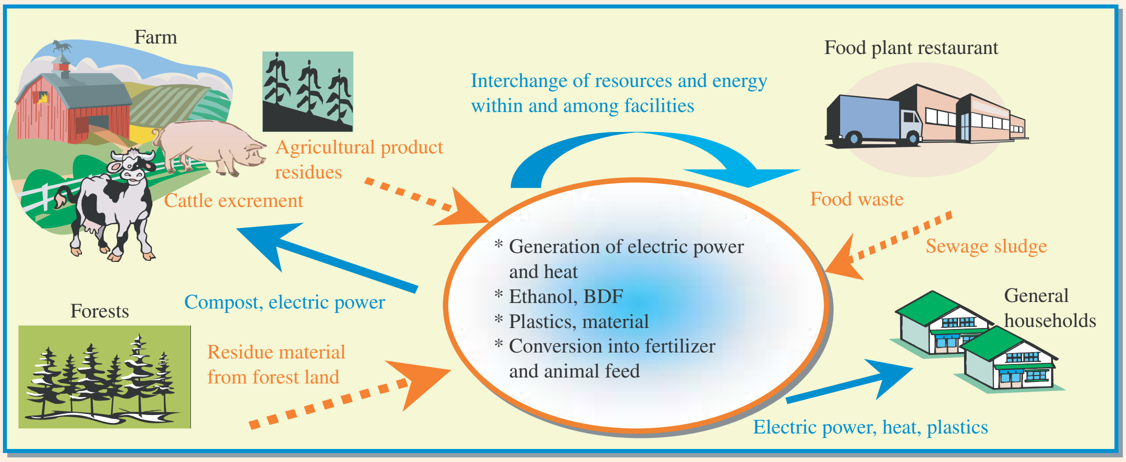
Kitakyushu Eco-Town Source: Kitakyushu City

Fig. 3-1 Tokyo Super Ecotown / Kawasaki Ecotown



Source: Ministry of the Environment

Fig. 3-2 Biomass towns



Source: Ministry of Agriculture, Forestry and Fisheries

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.

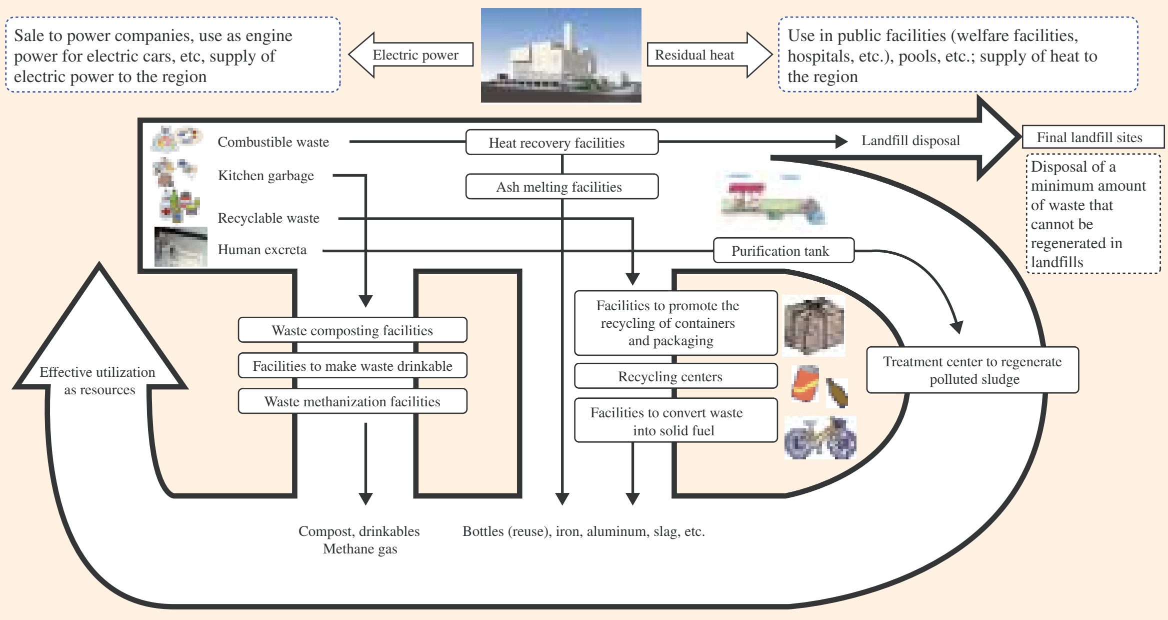
With cities, towns and villages playing a central role, an overall plan for using regional biomass, the "Biomass Town Concept", is being developed. As of March 31, 2007, 90 cities, town and villages have announced this concept. In these biomass towns, resources from cattle excrement or food waste, etc. 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).

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).

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.

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



Source: Ministry of the Environment

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.

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.

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

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

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

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.

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.

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

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.

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.

Part 2: Current Issues in Environmental Conservation and Formation of a Sound Material-Cycle Society, and Government Measures thereon

The following chapters from the White Paper on the Environment and the Sound Material-Cycle Society 2007 explain the current status of our efforts to establish environmentally sound resource cycles and the policy measures implemented during FY2006 for environmental conservation and the formation of a sound material-cycle society.

Chapter 1. Conservation of the Earth's Environment
Chapter 2. Conservation of the Atmospheric Environment
Chapter 3. Conservation of the Water, Soil, and Ground Environments
Chapter 4. Measures and Policies on the Material Circulation, including Waste and Recycling Measures
Chapter 5. Measures and Policies on the Assessment and Control of Environmental Risk of Chemical Substances.
Chapter 6. Conservation of the Natural Environment and Promoting Contact with Nature
Chapter 7. Basis of Various Measures, and Measures Facilitating the Participation of Various Actors and International Cooperation

1. Conservation of the Earth's Environment

(1) Global warming

Along with the expansion of human activities, massive, growing amounts of greenhouse gases such as carbon dioxide and methane are emitted into the atmosphere. In recent years, the greenhouse effect intensified by such increased emissions is threatening to cause excessive global warming.

According to the Working Group I contribution to the Fourth Assessment Report of the IPCC (Intergovernmental Panel on Climate Change), the global average surface temperature increased 0.74ºC [0.56ºC to 0.92 C] (1906 to 2005), and the total 20th-century global average sea level rise is estimated to be 17 [12 to 22] cm.

The report states that, "Warming of the climate system is unequivocal." and "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentration."

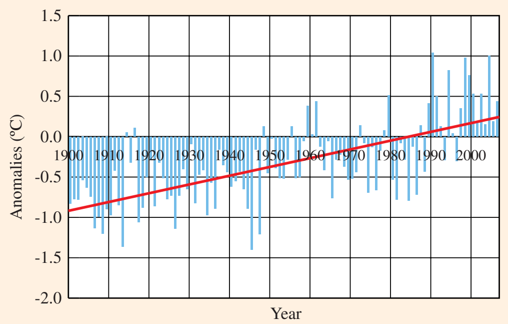
Based on multiple emission scenarios, with certain assumptions on worldwide economic growth, population, technological innovation, economic/energy structures and some other trends, the Report also makes estimates, that the projected average global

Table 5-1: Impacts of Global Warming Observed in Recent Years

Indicator	Observed changes
Global average surface temperature	· 100-year linear trend (1906 to 2005) of 0.74ºC · The linear warming trend over the last 50 years is nearly twice that for the last 100 years. · Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850) · Average arctic temperatures increased at almost twice the global average rate in the past 100 years.
Global mean sea level	· The total 20th-century rise is estimated to be 0.17m. · The rate is about 3.1mm/year over 1993 to 2003
Hot days/heat waves	More frequent
Cold night/frost	Less frequent
Heavy precipitation events	More frequent
Drought	More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics
Glaciers and snow cover	Mountain glaciers and snow cover have declined on average in both hemispheres.

Source: Compiled by the Ministry of the Environment based on *the report of Working Group I of the IPCC Fourth Assessment Report.*

Figure 5-1-1: Annual Surface Temperature Anomalies in Japan



Note 1: The data is based on monthly mean temperatures data in Abashiri, Nemuro, Suttsu, Yamagata, Ishinomaki, Fushiki (Takaoka City), Nagano, Mito, Iida, Choshi, Sakai, Hamada, Hikone, Miyazaki, Tadotsu, Naze and Ishigakijima
Note 2:An anomaly is deviation from normal (1971-2000 average of the 17 stations).
Note 3:A red line indicates a long-term trend.
Compiled by the Ministry of the Environment and based on the Japan Meteorological Agency data

surface temperature will increase by 1.1ºC to 6.4ºC at 2090-2099 relative to 1980-1999.

In addition, the Report states that the global warming tends to reduce land and ocean uptake of atmospheric carbon dioxide, increasing the fraction of anthropogenic emissions that remains in the atmosphere, along with a projection the climate-carbon cycle feedback induce more global average warming. And increasing atmospheric carbon dioxide concentrations will lead to increasing acidification of the ocean. Projections based on the report give reduction in the average global surface ocean pH between 0.14 to 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times.

In Japan, the average temperature has risen by approximately 1ºC during the 20th Century. Climate change will have significant impacts on ecosystems, agriculture, social infrastructure, and human health, possibly leading to drastic lifestyle changes.

To address this problem, the 3rd Conference of the Parties (COP3) to the UN Framework Convention on Climate Change (UNFCCC) (held in Kyoto in 1997) adopted the Kyoto Protocol which entered into force in February 2005. The Kyoto Protocol set reduction targets for the greenhouse gases emissions of developed countries in the commitment period from 2008 to 2012. The targets for the greenhouse gases emissions are based on the 1990 emissions level. Japan is obliged to reduce its greenhouse gas emissions by 6%.

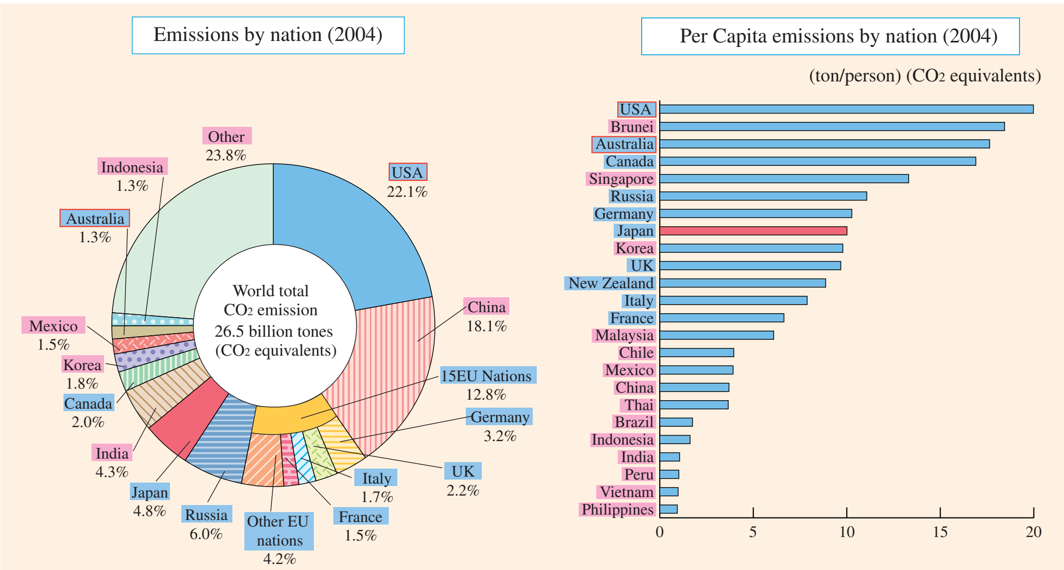
Also, during the twelfth session of the Conference of the Parties to the Convention (COP) and the second Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (COP/MOP2) both held in Nairobi, Kenya in November 2006, the parties agreed to hold the second review of the Kyoto Protocol at the time of the COP/MOP4 in 2008, and a work schedule for the review was also agreed upon.

Japan produces approximately 5% of the total world CO_2 emissions, which is the 4th largest in the world after the U.S.A. (about 23%), China (about 16%) and Russia (about 6%). Developed nations produce larger CO_2 emissions per capita than developing nations.

Japan emitted 1,360 million tons* of greenhouse gases (hereinafter, figures marked with * represent data for CO_2 equivalents) in FY2006, which was 7.8% higher than the total emissions of the base year (1,261 million tons*) as stipulated in the Kyoto Protocol. Japan's greenhouse gas emissions were 0.2% lower than the preceding year. Compared to the base year level (1990 in principle), a breakdown by sectors shows that the emissions of greenhouse gases for the industrial sector had decreased by 5.5%, while that of the transport sector had increased by 18.1%, the commercial and other sectors had increased by 44.6%, and the residential sector had increased by 36.7%.

The Kyoto Protocol Achievement Plan, which was adopted by the Cabinet in April 2005, contains about sixty items of measures that collectively aim to attain the target of a 6% reduction in accordance with the Protocol and also support our continuous long-term efforts of reducing GHG emissions. In July 2006, the progress of those measures was assessed, and it was pointed out that

Figure 5-1-2: CO_2 Emissions and Per Capita CO_2 Emissions by Nation



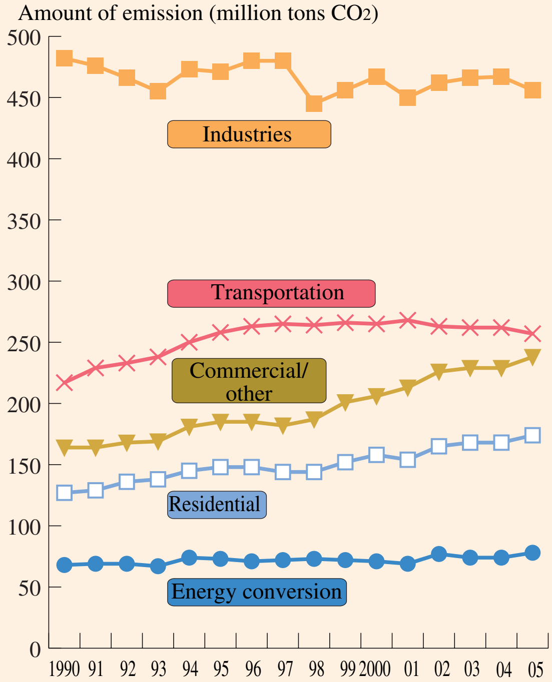
Obligation of greenhouse gases reduction during the first commitment period (2008-2012) of major CO_2 emitting nations based on the Kyoto Protocol

…… Not Obligatory

…… Obligatory (Note: Nations in [red-outlined box] have not ratified the Kyoto Protocol.)

Compiled by the Ministry of the Environment based on the Institute of Energy Economics, Japan, *Handbook of Energy & Economic Statistics in Japan 2007.*

Figure 5-1-3: Changes in Energy-Originated Carbon Dioxide of Respective Sectors and the 2010 targets.



Sector	FY1990	the rate change	FY2005	the reduction rate to the aim	Standard aim in FY2010 (*)
Industries	482	-5.5% ↘	456	-4.3% ↘	435
Transportation	217	18.1% ↗	257	-3.1% ↘	250
Commercial /other	164	44.6% ↗	238	-44.1% ↘	165
Residential	127	36.7% ↗	174	-29.2% ↘	137
Energy conversion	68	15.7% ↗	78	-14.0% ↘	69

(*) It is necessary to conduct a detailed review and adjustment as to numerical estimates based on the inventory of green gas emissions and removals, since the estimated amount of emissions as of the base year (1990 in principle), which was figured out at the time that the Kyoto Protocol Target Achievement Plan was established, is not consistent with today's estimates.
Source: Ministry of the Environment

further acceleration of the implementation of the measures would be necessary to ensure the thorough fulfillment of the Plan, although overall achievements through the implementation of the measures were positively evaluated at the same time.

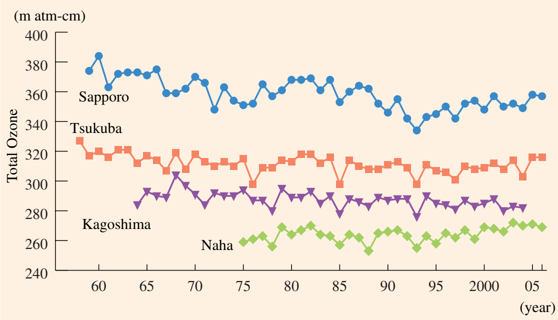
(2) Depletion of the ozone layer

CFCs, halons and some other substances are found to have been depleting the ozone layer. There is concern that depletion of ozone layer may increase the amount of harmful ultraviolet radiation reaching the earth, leading to increased damage to human health such as skin cancer and cataracts, as well as hindered growth of plants and plankton.

The ozone layer has been depleted, in particular in the 1980s, over the whole globe, except for the tropical areas. The total ozone over Japan also decreased, especially in the 1980s, but it has remained constant or slightly increased since the 1990s.

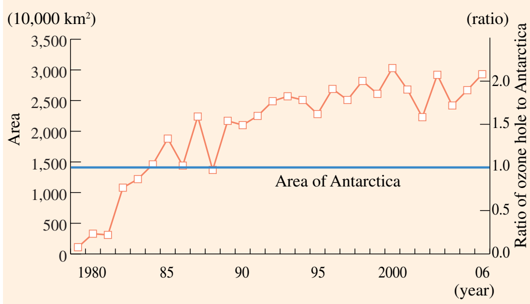
In 2006, the area of the ozone hole over Antarctica was found to be one of the largest. At present, no downward trend of the ozone hole area can be observed. The ozone layer over Antarctica is still in critical condition. Japan has controlled the production of ozone-depleting substances, in accordance with the Law Concerning the Protection of the Ozone Layer through the Control of Specified Substances and Other Measures. In Japan, recovery and destruction of fluorocarbons from end-of-life products are required by the Law for the Recycling of Specified Kinds of Home Appliances, the Law for Ensuring the Implementation of Recovery and Destruction of Fluorocarbons in Specified Products and the Law for the Recycling

Figure 5-1-4: Changes in the Annual Average of Total Ozone over Japan



Source: Japan Meteorological Agency, *Report of Ozone Layer Observation in 2006*

Figure 5-1-5: Changes in the Size of Ozone Hole over Antarctica



Source: Japan Meteorological Agency, *Report of Ozone Layer Observation in 2006* of End-of-Life Vehicles. For the purpose of ensuring the recovery of fluorocarbons from commercial refrigerators and air conditioners, the Law for Ensuring the Implementation of Recovery and Destruction of Fluorocarbons in Specified Products was amended in June 2006.

(3) Acid deposition and dust and sandstorms (DSS)

Acid deposition can produce various effects on the environment and living creatures such as trees or fish by increasing acidity in soil, lake and reservoir water, etc. Buildings, artificial constructions, and cultural assets can be affected by acid deposition.

Japan has also had almost the same level of acid deposition as the Western nations that have suffered some damage. However, it is still unclear how acid deposition will impact on ecosystems in Japan. The affects of acid deposition may become apparent in the future, if Japan's acid deposition remains at the current level.

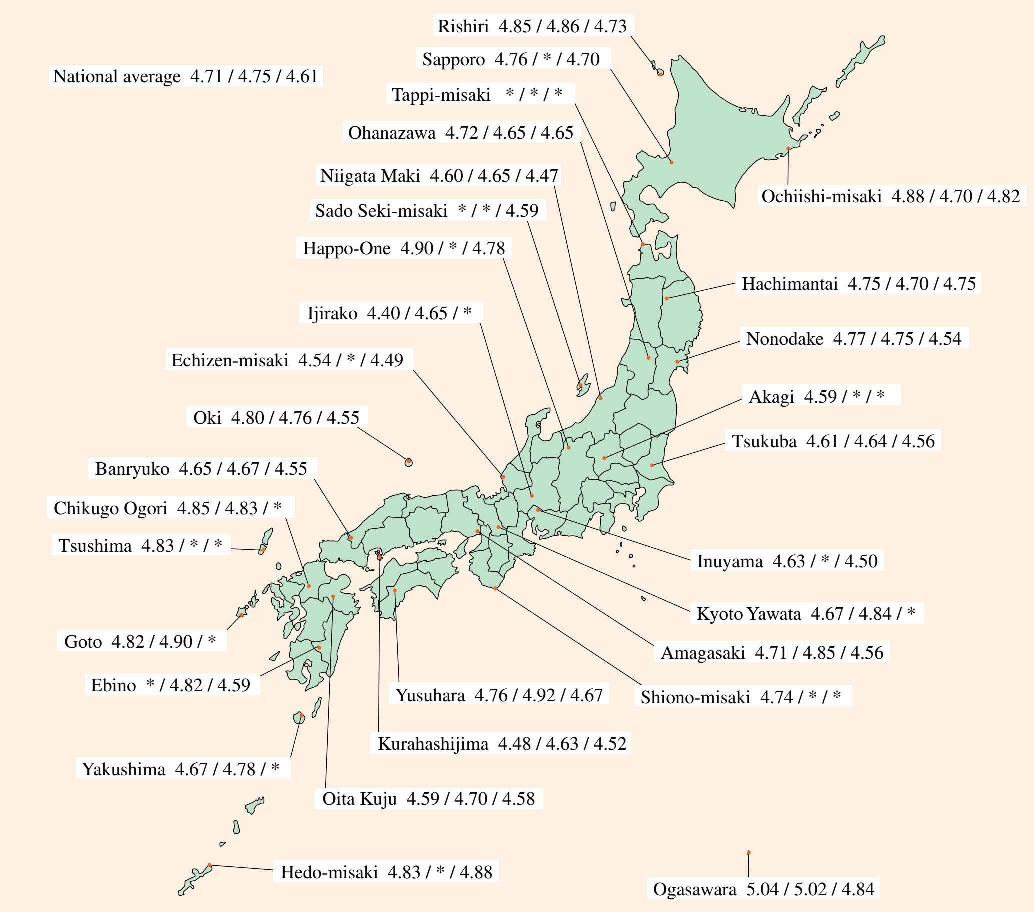
The Acid Deposition Monitoring Network in East Asia (EANET) became fully operational in FY2001. It is aiming to identify the state of acid deposition and its impacts on East Asia and to establish the framework for a regional cooperative approach to acid deposition problems.

In Japan, long-term monitoring of acid deposition is carried out to detect its effects as early as possible and to forecast its effects in the future.

In recent years, the dust and sandstorms (DSS) that blow over from China and Mongolia have increased their scale, and China,

Figure 5-1-6: Levels of pH in Precipitation

FY2003 average / FY2004 average / FY2005 average



Asterisk (*) represents invalid annual average data.
Notes:1. Annual average data stands for weighted average precipitation.
2. For the Akagi area, annual averages cannot be calculated in years when heavy snowfall prevents data collection.
Source: Data from the Ministry of the Environment

the Republic of Korea, Japan and other nations share a common interest in dealing with such enlarged DSS. In Japan, the government has introduced the high-level LIDAR (light detection and ranging) system to monitor DSS. In addition, China, Mongolia, Korea, Japan, the United Nations Environment Programme (UNEP), and some other international organizations are working together to explore effective measures to deal with DSS in the future.

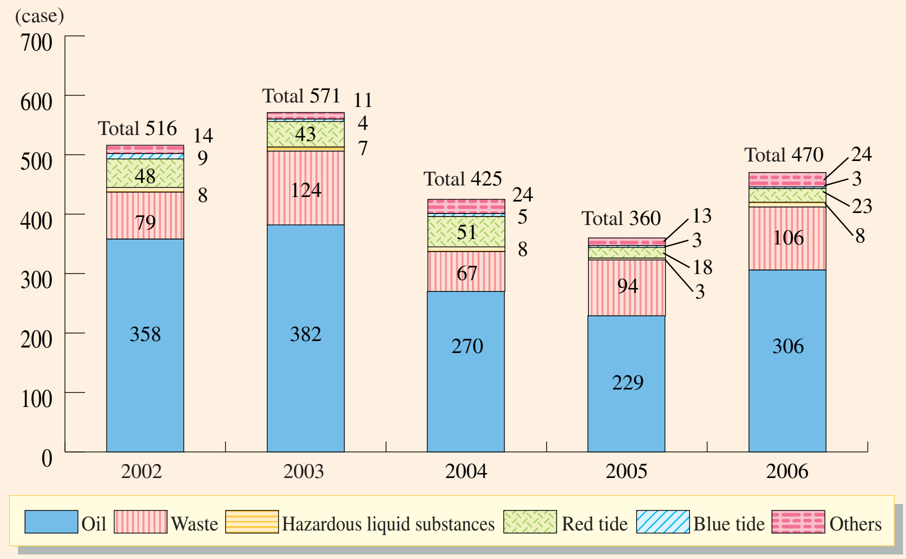
(4) Marine environment

For conservation of the marine environment, Japan is a state party to the London Convention, which regulates ocean dumping from vessels, and to the MARPOL 73/78 Convention, which prevents marine pollution caused by ships. In response to these conventions, Japan has taken domestic measures to prevent marine pollution.

In order to assess and monitor the conditions of the marine environment, Japan conducts marine environment monitoring programs, to systematically collect comprehensive data on water quality, bottom sediments, and aquatic organisms.

In terms of marine pollution caused by oil, waste and red tides, 470 cases were identified in 2006, an increase of 110 cases from the 2005 level.

Figure 5-1-7: Changes in the Number of Marine Pollution Cases Identified



Note: "Others" include factory effluent.
Source: Japan Coast Guard

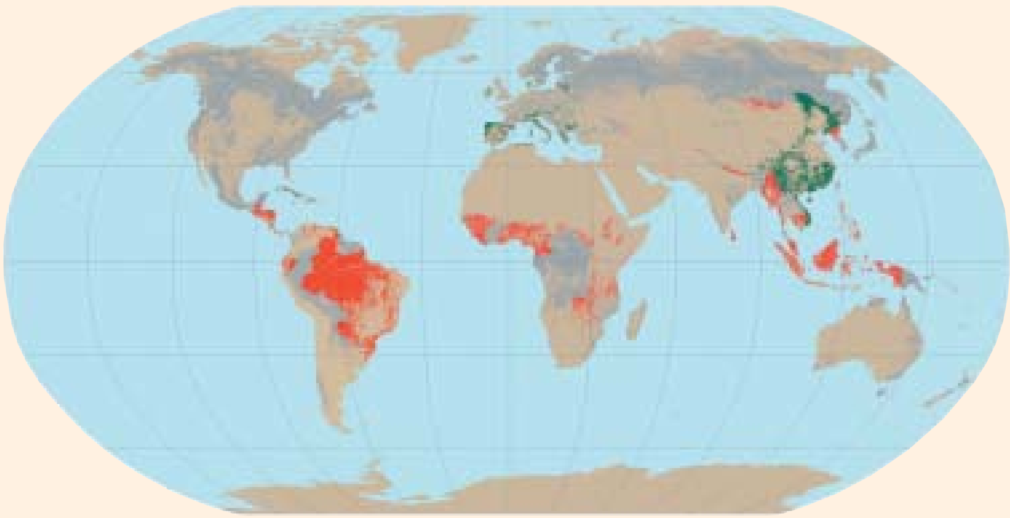
In response to the conclusion of the OPRC-HNS Protocol (Protocol on Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances), which is going to enter into force in June 2007, the Marine Pollution and Disaster Prevention Law has been partially revised, and the National Plan on Preparedness and Response to Emergency Pollution Incidents by Oil or Other Hazardous Substances" has been newly established. Also, the High-level Inter-ministry Meeting on Marine Litter was organized to enhance control over drifting refuse and abandoned wastes washed seashore, and in March 2007 the conference released to the public a report on the current status, policy measures to be implemented by the national government and necessary efforts in the future regarding this issue.

(5) Forest and desertification

The world's forests now occupy approximately 30% of the earth's surface, having decreased about 7.32 million hectares per year on average from 2000 to 2005. Particularly, African, South American, and Southeast Asian from Asian region forests, where the tropical forests are located, have suffered a significant reduction in their size.

This significant reduction is caused by changes in land use to farmlands from forests, an increase in non-traditional, migratory slash-and-burn agriculture, overharvesting of firewood and charcoal, as well as illegal logging. In an effort to tackle this problem, the 41st session of the International Tropical Timber Organization (ITTO) adopted projects and actions to promote sustainable management of tropical forests.

Figure 5-1-8: Changing Rate in the size of World Forests per a year (2000-2005)



Note: The percentage represents the data on a net basis (offsetting forest shrinkage by forest growth)
Source: Compiled by the Ministry of the Environment based on the FAO, *"Global Forest Resources Assessment 2005."*

About one-quarter of all land areas in the world and about 1 billion people, accounting for one-sixth of the world's population, are affected by desertification. As background of this problem, there are factors such as poverty and population growth in developing nations. Therefore, international efforts are being made under the UN Convention to Combat Desertification (UNCCD).

2. Conservation of the Atmospheric Environment

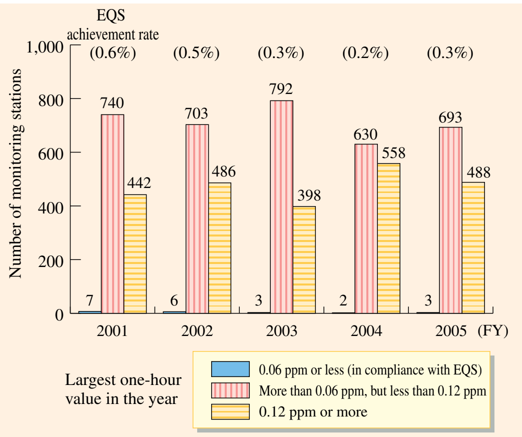
(1) Photochemical oxidant

Photochemical oxidants are the cause of photochemical smog, which causes eye and throat irritation and respiratory distress. In almost all regions throughout Japan, photochemical oxidants still exceed the environmental quality standard (EQS) (a one-hour value of 0.06 ppm or less).

As one of the measures to combat photochemical oxidants, VOC-emitting firms have been required to submit notification of their VOC-emitting plants and comply with the emission criteria since April 2006. In accordance with the Air Pollution Control Law, Japan's regulatory authority has put in place tighter restrictions on VOC emitted from automobiles.

Through the Atmospheric Environmental Regional Observation System (nickname: Soramame-kun), the government collects on a real-time basis the nationwide atmospheric environment data measured at a prefectural level as well as the photochemical oxidant warning data , and makes these data available on the Internet.

Figure 5-2-1: Changes in the Number of Monitoring Stations by Photochemical Oxidant Concentration Level (AAPMSs and RAPMSs) (FY2001–2005)

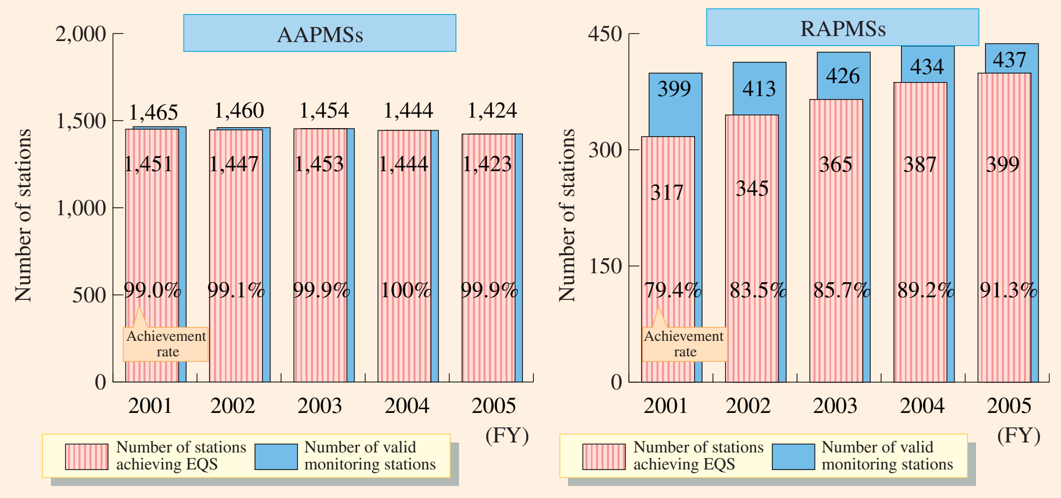


Source: Compiled from the Ministry of the Environment, *FY2005 Report on the State of Air Pollution.*

(2) Nitrogen oxide

Nitrogen oxide (NOx) is generated mainly from stationary sources (such as factories) and mobile sources (such as motor vehicles). NOx contributes to photochemical oxidants, suspended particulate matter, and acid deposition. High concentrations of Nitrogen dioxide (NO_2) may have a negative impact on health by causing irritation to the respiratory organs.

Figure 5-2-2: Changes in Achievement of NO_2-related EQS (FY2001-2005)



Source: Compiled from the Ministry of the Environment, *FY2005 Report on the State of Air Pollution*

Compared to the previous year, the achievement rates for the NO_2-related EQSs were slightly improved in the roadside air pollution monitoring stations (RAPMSs) in FY2005. The achievement rate of the ambient air pollution monitoring stations (AAPMSs) was 99.9%, and that of the roadside air pollution monitoring stations (RAPMSs) was 91.3%.

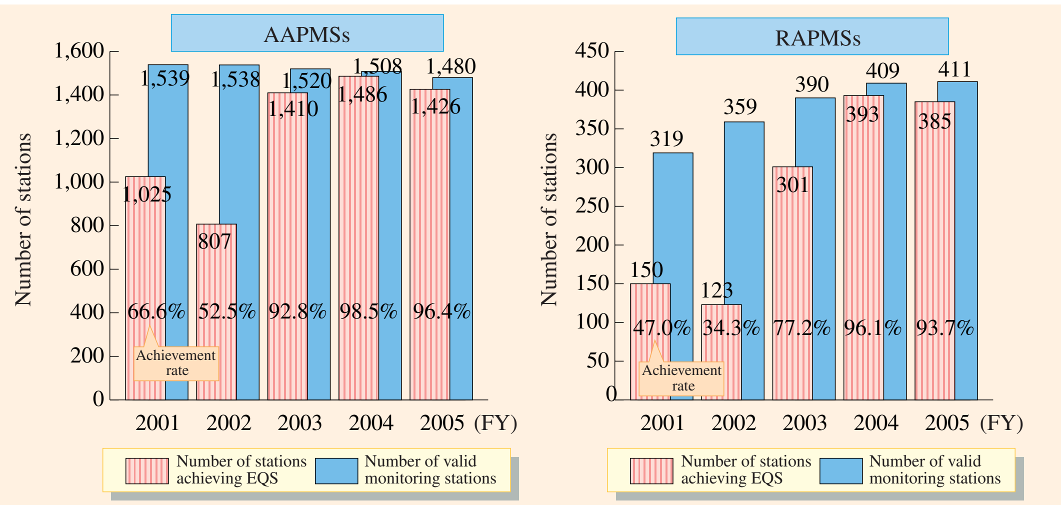
Source: Compiled from the Ministry of the Environment, FY2005 Report on the State of Air Pollution

(3) Suspended particulate matter (SPM)

Suspended particulate matter (SPM), which floats in the air and has a diameter of 10µm or less, is classified into primary particles and secondary particles. Primary particles include soot and dust from factories, diesel exhaust particles (DEP) generated from diesel vehicles, and soil particles dispersed in the air. Secondary particles are formed in the atmosphere from gaseous substances such as nitrogen oxides (NOx). Because SPM is of a minute size, it stays in the air for a long time. An accumulation of SPM in high concentrations in the lungs or the trachea can have damaging effects on the respiratory system.

Regarding the current status of our efforts to satisfy the environmental quality standards (EQS) related to SPM, the achievement rate measured in the FY2005 was slightly lower than that of the previous year, both for ambient air-pollution monitoring stations (AAPMS) and roadside air-pollution monitoring stations (RAPMS).

Figure 5-2-3: Changes in Achievement of SPM-related EQS (FY2001-2005)



Source: Compiled from the Ministry of the Environment, *FY2005 Report on the State of Air Pollution*

In addition, experts are carrying out research on fine particulate matter with a diameter of 2.5µm or less and diesel exhaust particles because analysts recently pointed out that these substances can have an adverse affect on human health.

(4) Hazardous air pollutants

Various hazardous air pollutant, though low in concentration, have been detected in the atmosphere, raising concerns about the health effects of long-term exposure.

In terms of the four substances that have EQSs in place, benzene's observed value improved in FY2005, with 3.9% of monitoring stations recording data exceeding the EQS. As for the other three substances, all monitoring stations recorded data better than the applicable EQSs.

In order to mitigate the health risk attributable to hazardous air pollutants, guideline values of chloroform, 1,2-dichloroethane and 1,3-butadiene were newly established in FY2006 to join the four existing designated substances.

(5) Measures against asbestos

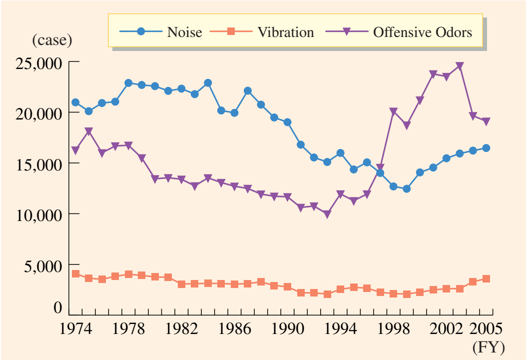
The Air Pollution Control Law provides a work standard for demolition and other works of fireproof buildings of certain sizes using spray-applied asbestos. In March 2006, this Law was partially revised to expand the scope of restricted construction materials and also to abolish the building-size exemptions applied to small-sized buildings, with the aim of strengthening the measures to prevent asbestos dispersal into the atmosphere and expand applications of the measures. Also, starting from October 2006, regulations on demolition and other works of the said buildings have expanded to newly bind equipment, fixtures, etc. in addition to buildings.

(6) Noise, vibration, and offensive odors

The number of complaints about noise and vibration has been gradually increasing over several years to 16,470 and 3,599 in FY2005. There were 19,114 complaints about offensive odors in FY2005, a decrease for the second consecutive year.

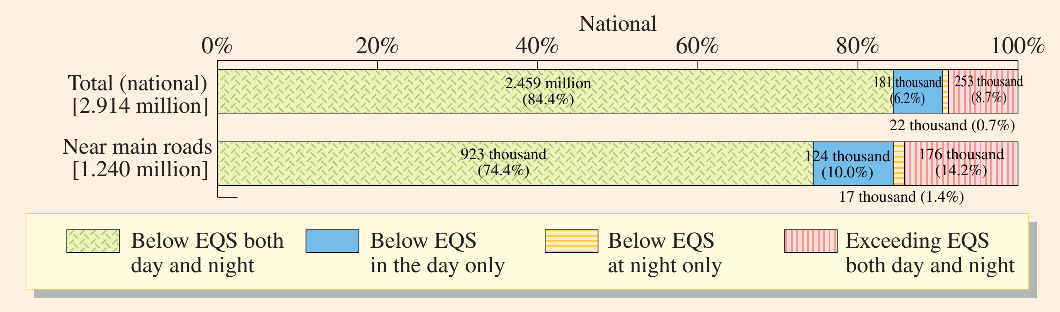
Out of the 2,914 thousand noise observation points (households) in residential areas nationwide, 456 thousand households (16%) exceeded the EQS either at day or night in FY2005. Out of the 1,240 thousand observation points (households) facing a main road, 317 thousand households (26%) exceeded the EQS either at day or night. With regard to aircraft noise, 73% of the observation points were within the EQSs satisfactory level in FY2005.

Figure 5-2-4: Changes in the Number of Complaints against Noise, Vibration, and Offensive Odors (FY1974–2005)



Compiled from the Ministry of the Environment, *Survey on the Enforcement Status of the Noise Regulation Law, Survey on the Enforcement Status of the Vibration Regulation Law*, and *Survey on the Enforcement Status of the Offensive Odor Control Law*

Figure 5-2-5: Attainment of the EQS for Road-Facing Areas



Notes:1. The figures in parenthesis represent the number of households surveyed.
2. The total households may not correspond to the number of households surveyed due to rounding.
Source: Ministry of the Environment

(7) Urban heat island phenomenon

"The heat island phenomenon" means that the air temperature at the city center is higher than that of the surrounding non-urban areas. This phenomenon results in an increase in the number of nights in which the minimum temperature is above 25 degree centigrade in summer. The increase in temperature by waste heat from air conditioners causes more demand for air conditioning and energy use.

According to the "Outline of the Policy Framework to Reduce Urban Heat Island Effects," the government has promoted four major pillars of countermeasures against the heat island phenomenon: reduction of anthropogenic heat emission, improvement of the urban surface, improvement of urban structures, and improvement of lifestyles.

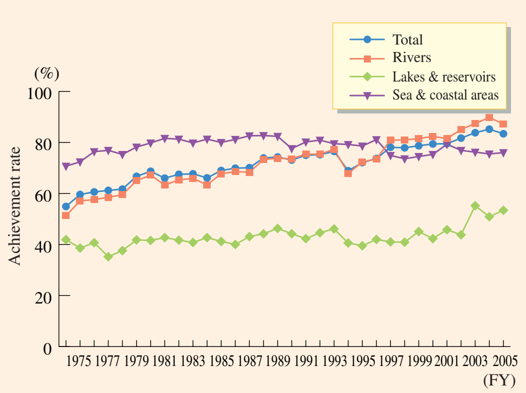
The government has also promoted the research and observation of the heat island phenomenon and its impact on the environment.

3. Conservation of the Water, Soil, and Ground Environment

(1) Water environment

According to the Results of FY2005 Measurement of Water Quality in Public Waters, the achievement level of the EQS for the protection of human health from substances, such as cadmium, was 99.1%. Standards set for protecting the living environment were achieved at slightly lower rates. The BOD (or COD) level is an EQS for the conservation of the living environment and is a typical

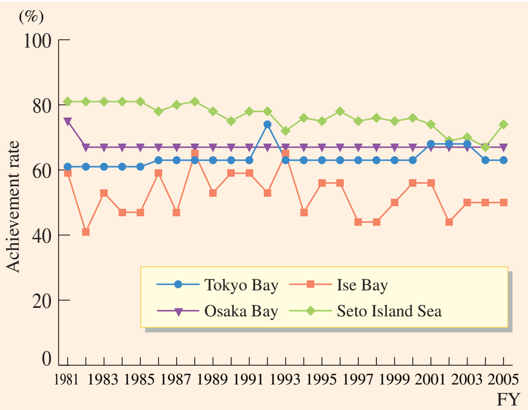
Figure 5-3-1: Trends in EQS Achievement Rate (BOD or COD)



Notes: 1. BOD used for rivers, while COD used for lakes/reservoirs, and sea/coastal areas.
2. Achievement rate (%) = (no. of water areas achieving EQS/no. of designated water areas)×100

Source: Ministry of the Environment, *Results of FY2005 Measurement of Water Quality in Public Waters*

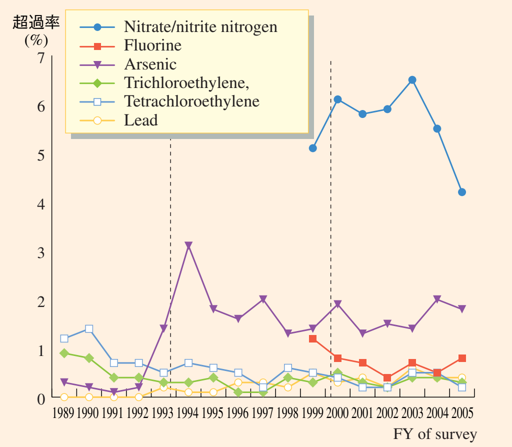
Figure 5-3-2: Trends in EQS Achievement Rate (COD) in Three Coastal Regions



Note: Ise Bay includes Mikawa Bay, and Seto Inland Sea excludes Osaka Bay

Source: Ministry of the Environment, *Results of FY2005 Measurement of Water Quality in Public Waters*

Figure 5-3-3: Percentage of the Groundwater Monitored which Exceeded the EQS



Notes: 1. The survey teams monitor different sets of wells every year. (They do not necessarily collect data on the same wells every year.)
2. Until the EQSs for groundwater were established in 1997, the Assessment Standards had been used to evaluate groundwater quality. (The Assessment Standard for Arsenic was revised from "0.05 mg/L or less" to "0.01 mg/L or less" in 1993.)
3. The EQS for nitrate/nitrite nitrogen, fluorine, and boron were established items in 1999.
4. The data contained in the chart is limited to those of the substances with relatively high rate of the data which exceeded the EQS.

Source: Ministry of the Environment, Results of FY2005 *Monitoring Survey of Groundwater Quality* water-quality indicator for organic contamination. Its EQS achievement level remained at 83.4%. By water area, the achievement levels were 87.2% for rivers, 53.4% for lakes and reservoirs, and 76.0% for sea areas. In particular, achievement rates for enclosed water areas, such as lakes, reservoirs, inner bays, and inland seas were still low. In terms of COD, the achievement rates were 63.2% for Tokyo Bay, 50.0% for Ise Bay, and 73.5% for the Seto Inland Sea.

Regarding measures for lakes and reservoirs, the revised Law concerning Special Measures for the Conservation of Lake Water Quality came into force in April 2006. Also, the measures for addressing the issue of pollutant loads attributable to non-point pollution sources in farmlands, urban areas, etc. have been deliberated and the deliberation results are reflected in the report, "The Basic Policy on Basin Areas for the Improvement of Water Quality of Lakes and Reservoirs." In addition, the sixth Basic Policy for Area-wide Total Pollutant Load Control has been established to promote further improvement of the water environment of enclosed water areas, wherein targets are set to be attained by FY2009.

According to the FY2005 Monitoring Survey of Groundwater Quality, 6.3% of the wells monitored exceeded the EQS (of one or more substances). Specifically, 4.2% of the total did not meet the EQS for nitrate-nitrogen or nitrite-nitrogen. Most of the wells were supposed to be polluted by farmland fertilization, livestock excreta, or domestic wastewater. Appropriate measures to prevent the pollution are necessary for the conservation of groundwater.

The "Inter-Ministry/Agency Coordination Committee for Building Sound Water Cycle" is pushing ahead with policy actions to provide a healthy water cycle by holding information/opinion exchange sessions, encouraging research activities, and serving as a coordinator of policy actions.

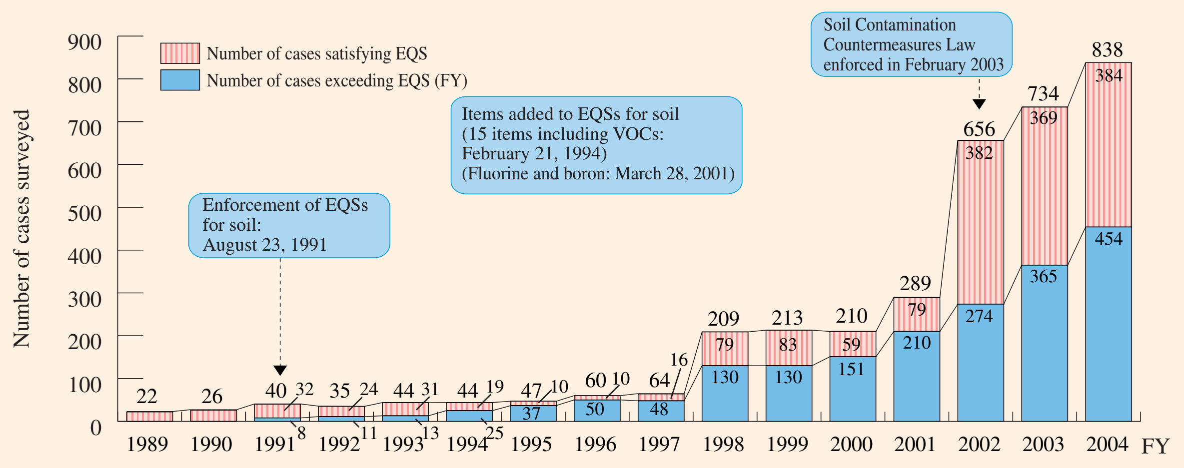
(2) Soil contamination

Once soil is contaminated, it accumulates hazardous substances, perpetuating the state of pollution.

A larger number of soil contamination cases have been identified in urban areas as a result of redevelopment projects at former factory sites. In FY2004, the regulatory authority acknowledged 454 cases that exceed the EQS for Soil Contamination or Soil Contamination Countermeasures Law.

In order to address such soil contamination, the Ministry of the Environment is pushing ahead with appropriate countermeasures on soil contamination in accordance with the Soil Contamination Countermeasures Law, and conducted a survey, with the intention of establishing more comprehensive EQS that would regulate extensively of pollutants and exposure paths.

Figure 5-3-4: Number of Soil Contamination Cases Identified by Fiscal Year



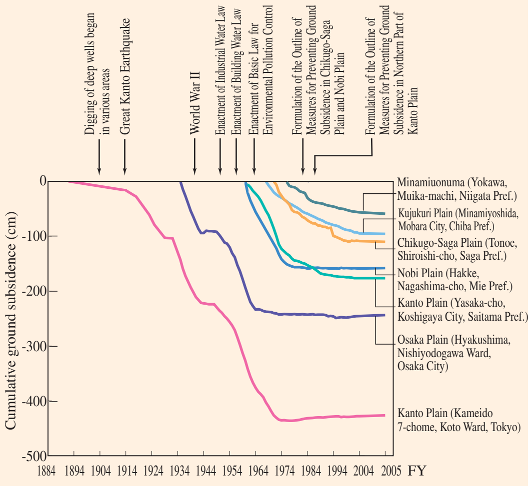
Source: Ministry of the Environment, *Overview of the Survey Result on Survey and Measures and State of Responses for Soil Contamination in FY2004*

(3) Ground subsidence

Ground subsidence is caused by excessive pumping of groundwater, which lowers the level of the groundwater and shrinks the clay layer. As of FY2005, 61 areas in 37 prefectures suffered ground subsidence. Restrictions on the pumping of groundwater and other measures have mitigated ground subsidence in Tokyo's 23 wards, Osaka City, and Nagoya City, where remarkable ground subsidence had occurred in the past.

However, ground subsidence still occurred in certain areas such as the South Uwonuma plain in Niigata Prefecture. Some areas that are lower than sea level due to ground subsidence may face the danger of huge damages caused by high tides or floods. For this reason, besides imposing restrictions on the pumping of groundwater, measures are being taken to deal with high tides and to build facilities to protect the coastline.

Figure 5-3-5: Changes in Ground Subsidence in Selected Areas



Source: Ministry of the Environment, *Overview of Ground Subsidence in Japan in FY2005*

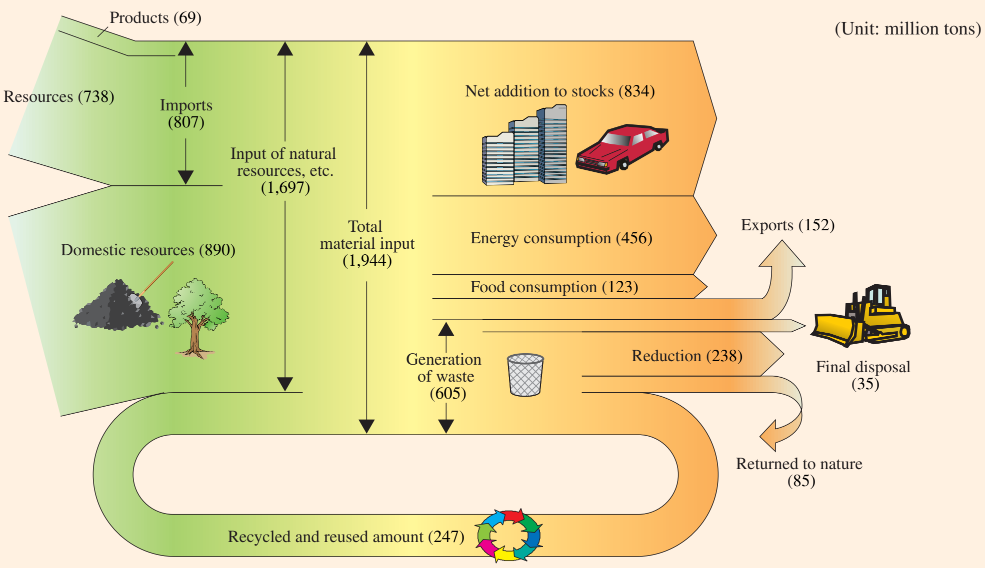
4. Measures and Policies on the Material Circulation, including Waste and Recycling Measures

(1) Material flow in our country

In order to build a Sound Material-Cycle Society, it is important to understand, first and foremost, the current status of how much we collect, consume and discard resources.

An overview of the Material flow in our country as of FY2004 shows that the Total material input this year was 1.94 billion tons, about half (or 830 million tons) of which was stored in the form of buildings or social infrastructure. It is also shown that 150 million tons were exported to other countries in the form of products, etc., 460 million tons were converted to energy, and 610 million tons became wastes, etc. Of those wastes, 250 million tons were recycled, which accounts for only 12.7% of the Total material input. This data indicates that the issues of waste treatment, recycling and global warming come from structural and

Figure 5-4-1: Material Flow in Japan (FY2004)



Note: The total output is greater than the total input due to water-intake, etc.
Source: Ministry of the Environment

fundamental problems of our society.

The Fundamental Plan for Establishing a Sound Material-Cycle Society, adopted by the Cabinet in March 2003, sets numerical targets of "input," "recycling" and "output," which respectively represent major indicators of the Material flow, with the aim of visualizing an appropriate structure of the policy measures necessary to be implemented for reducing, reusing, recycling and disposal, and ensuring appropriate waste disposal respectively so as to ensure the well-balanced implementation of those measures for the formation of a Sound Material-Cycle Society.

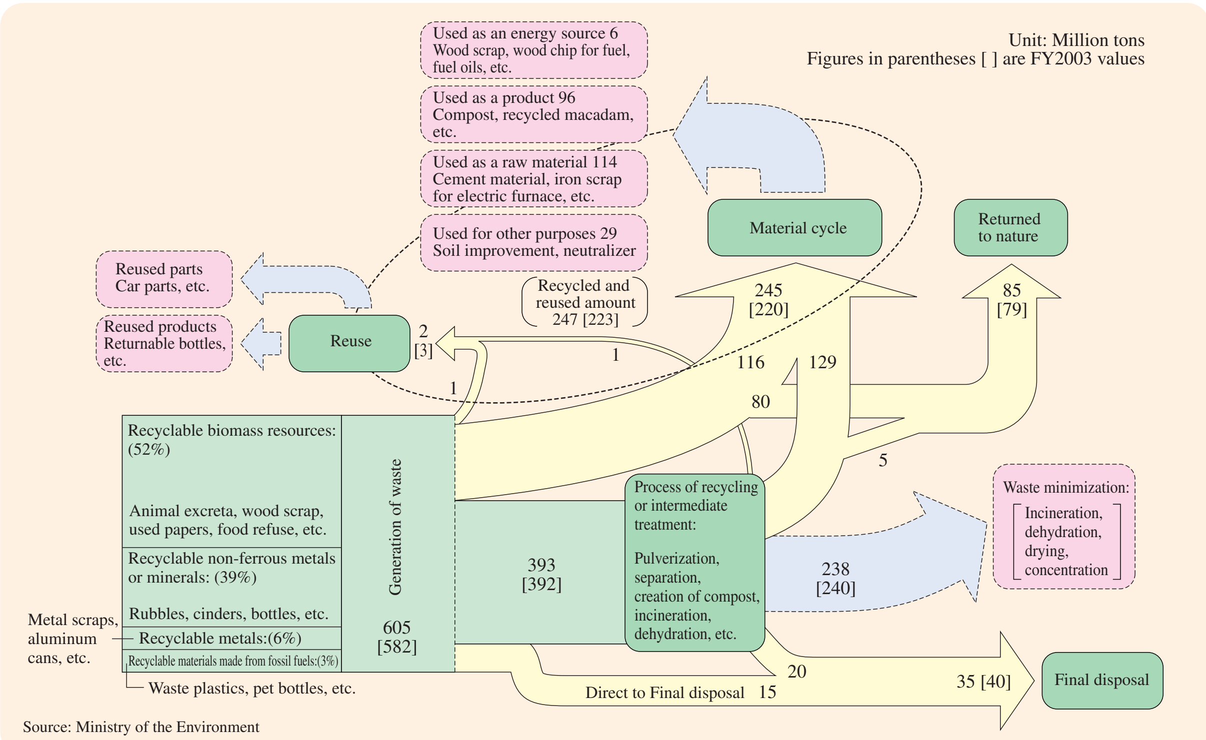
Table5-4: Targets to be Achieved by FY2010

Indicators	Resource productivity	Recycle/ reuse rate	Final disposal volume
Targets	About 390,000 yen per ton	About 14%	About 28 million tons

- **Resource productivity (=GDP/Input of natural resources, etc.)**
  This indicator represents the performance of how resources efficiently produce benefits.
- **Recycle/reuse rate (=Recycled and reused amount /(Recycled and reused amount + Input of natural resources, etc.)**
  This indicator represents the proportion of how much of input resources are recycled or reused.
- **Final disposal volume**
  This indicator represents the volume of wastes that go to landfills, and needs to be closely watched due to the current situation of the impending shortage of final waste disposal site.

The results of the third assessment of the progress of the Fundamental Plan for Establishing a Sound Material-Cycle Society show that "Resource productivity" was about 336,000 yen per ton during FY2004, up 60% from FY1990 from about 210,000 yen per ton and up 20% from FY2000 from about 280,000 yen per ton. The "recycling/reuse rate" during FY2004 was about 12.7%, up about 70% from FY1990 from about 8% and up about 30% from FY2000 from about 10%. The "Final disposal volume" during FY2004 was about 35 million tons, down about 69% from FY1990 from about 110 million tons and down about 38% from FY2000 from about 56 million tons.

Figure5-4-2: Flow of Resource Recycling in Japan (FY2004)



Source: Ministry of the Environment

Thus, the indicators of the Material flow have been showing satisfactory values overall in recent years. If this tendency can be maintained, it is highly possible to achieve the targets by FY2010 as planned. However, we also see many undesirable statuses in the Material flow at present, including the high levels of “Total material input” and “Input of natural resources, etc.,” imbalance between input (resources, products, etc.) and output and the low level of “Recycled and reused amount.” In order for us to correct those undesirable statuses to accomplish the above-mentioned targets of the respective indicators, it is important to promote our 3R efforts.

Regarding the present status of our efforts of recycling and reuse (as of FY2004), a total of 605 million tons of wastes were generated annually, of which 247 millions entered into a material cycle including reuse and recycling, and 238 million tons were through waste-minimization procedures, including incineration and dehydration. Of the total amount recycled or reused, 2 million tons were reused, in the form of the reuse of returnable bottles for beer, milk, etc., the reuse of tires and other.

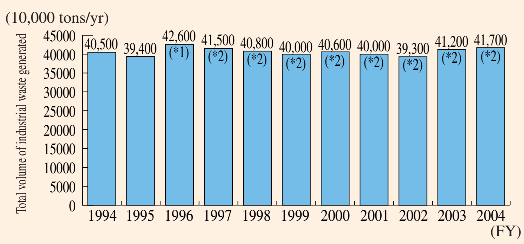
(2) Current status of wastes generation

Since FY1989, Japan has been generating municipal solid waste at an annual volume of approximately 50 million tons or more. These annual volumes of municipal solid waste have been showing a continuous downward trend since FY2000. In FY2004, of all municipal solid waste, direct incineration accounted for 77.5%, while recycling accounted for 19.0%. The final volume disposed of at landfill sites was 8.09 million tons, a decrease of 360,000 tons from the previous year.

The total volume of industrial waste generated in Japan has also remained steady over the last few years. The volume was approximately 417 million tons in FY2004, up 1.3% from the previous fiscal year. Approximately 26 million tons was registered as final disposal volume in FY2004, registering a decrease of about 4 million tons from the previous fiscal year.

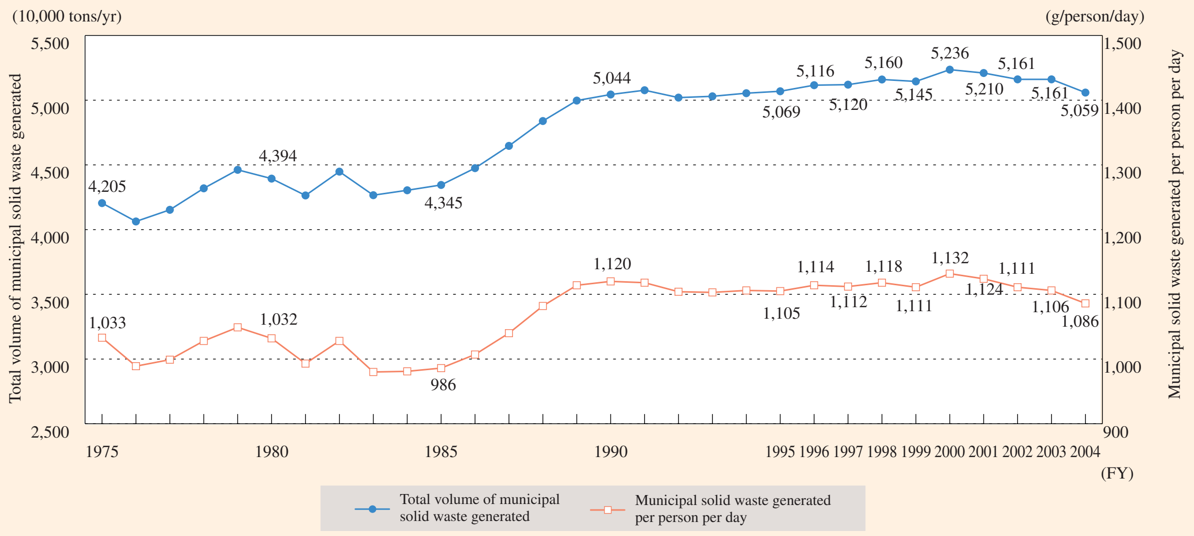
Nationally there is a lack of disposal capacity, with final disposal

Figure 5-4-3: Changes in the Volume of Industrial Waste Generated



Notes: (*1) The 1996 data indicate the waste volume in FY1996, as defined in the “Target of Waste Reduction” (government decision, September 28, 1999). In the “Target of Waste Reduction,” the government aims to achieve its targets at the latest in FY2010 based on the “Basic Policy for Dioxin Measures,” which was decided by the Ministerial Meeting on Anti-Dioxin Measures.
(*2) The amount of waste from FY1997 onward was calculated using the same calculation approach as *1 above.
Source: Compiled from the Ministry of the Environment, *State of the Generation and Treatment of Industrial Waste*

Figure 5-4-4: Changes in Total Volume of Municipal Solid Wastes and Waste Volume Generated per Person per Day

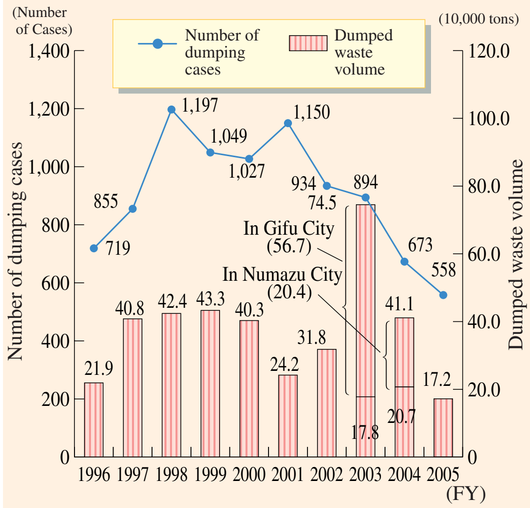


Notes: “Total volume of municipal solid waste generated” = “volume of wastes collected” + “volume of wastes directly brought in” + “self disposal volume” In accordance with the Waste Management and Public Cleansing Law, the government setup “Basic Guidelines for the Comprehensive and Systematic Promotion of Waste Reduction Measures and Other Appropriate Treatments.” According to these Basic Guidelines, total volume of municipal solid waste is defined as “total volume of municipal solid waste generated” less “self disposal volume” plus “recyclable waste volume collectible by groups.” The amount of municipal solid wastes (as defined above) stood at 53,380,000 tons in FY2004.
Source: Ministry of the Environment

sites having an average capacity of only another 7.2 years as of April 2005.

In FY2005 there were 558 cases of illegal dumping of industrial waste in Japan, continuing the downward trend of the consecutive two years.

Figure 5-4-5: Trend of Illegal Dumping Cases and Illegally Dumped Waste Volume



Notes: 1. The chart above illustrates illegal dumping of industrial wastes (at least10 tons per case) identified by prefectures or cities with public health offices. (However, cases that involve specially controlled industrial waste are all included in the chart)

2. As shown in the chart above, the illegal dumping case in Gifu City was discovered in FY2003, while that in Numazu City was detected in FY2004. Because waste disposers illegally dumped industrial wastes for several years before that, these two cases were identified as large-scale dumping cases in said years.

Source: Ministry of the Environment, *State of the Illegal Dumping of Industrial Waste*

(3) Legislation and efforts to facilitate the formation of a Sound Material-Cycle Society

To solve these problems, the following measures have been promoted in line with the Fundamental Law for Establishing a Sound Material-Cycle Society: (i) reducing wastes; (ii) reusing end-of-life products and parts; (iii) recycling wastes as raw materials; (iv) recovering heat; and (v) appropriate disposal as final waste. In line with these basic principles, the Waste Management and Public Cleansing Law will be implemented as well as other recycling-related legislation.

In an effort to promote recycling, the Law for the Promotion of Sorted Collection and Recycling of Containers and Packaging was partially revised in June 2006, to introduce new mechanisms. This includes the practice of businesses to financially compensate municipal governments that contributed to the reduction of container or package waste by introducing effective measures or to the efficient recycling of containers and packages by introducing sophisticated methods of sorted collection. In response to this legislation, municipal governments have been promoting collaborative efforts with businesses to reduce container and package waste. For example, municipal governments carry out model projects such as a program to encourage shoppers to use their own bags instead of using stores' plastic bags and promote relevant education and publicity programs, and also enter into voluntary agreements with highly motivated businesses that introduce pioneering programs for facilitating waste reduction.

The Central Environment Council and the Council of Food, Agriculture and Rural Area Policies held meetings to jointly review and discuss existing systems under the Law for Promotion of Recycling and Related Activities for the Treatment of Cyclical Food Resources. Consequently, they submitted a bill, during the 166th Diet session, for the partial amendment of a law that proposes the introduction of strengthened guidance and supervision over food businesses and the expansion of the scope of special exemptions provided for by the Waste Management and Public Cleansing Law to apply to food businesses when their agricultural produce, stock farm products or marine products are using food refuse-originated fertilizers or feeds with the consent of the competent minister.

Also, in order to create an infrastructure that supports a Sound Material-Cycle Society, the improvements of waste-treatment facilities and recycling facilities are underway through the cooperation between the national and local governments and the use of subsidies, etc. designed to promote the formation of a Sound Material-Cycle Society.

In addition, for the purpose of promoting countermeasures against illegal dumping to ensure appropriate waste treatment, the governments have been making efforts to promote the wide utilization of the electronic manifest system, education for industrial waste-management contractors, proper, safe treatment of PCB (polychlorinated biphenyl) and development of toxicity-free treatment of asbestos-contained wastes.

(4) International efforts

As part of efforts to globally promote the 3R initiative, the Asia 3R Conference was held in Tokyo in October 2006. Representatives from China, South Korea, Singapore, etc. got together to share the understanding of the significance of the Asia-wide promotion of 3R efforts and had active policy dialogues for further promotion of the 3R initiative.

5. Measures and Policies on the Assessment and Control of the Environmental Risk of Chemical Substances

To prevent adverse environmental effects from the production, distribution, use, or disposal of the several tens of thousands of chemical substances that are traded in Japan, it is necessary to evaluate and properly address the risk that chemical substances could harm human health and the environment (environmental risks).

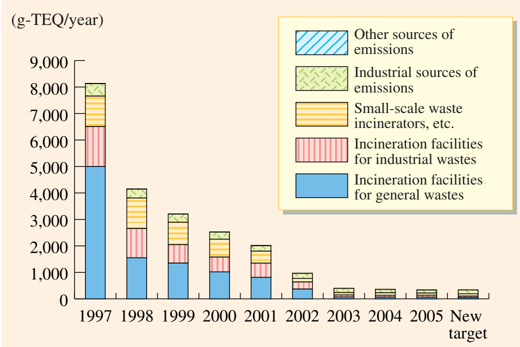
During FY2006, the 5th assessment report was issued, wherein five specific substances were designated as "candidates for detailed assessment," with two for health risk and three for ecological risk.

In accordance with the Chemical Substances Control Law, the government controls new chemical substances that are manufactured or imported based on an evaluation of their biodegradability, bioaccumulation, and toxicity to human, plants and animals.

During FY2006, a total of 503 notifications on the manufacture or import of a new chemical substance were made (of which 219 were of low manufacture or import quantities), and pre-market evaluations were conducted for those notifications.

Japan has also implemented the PRTR (Pollutant Release and Transfer Register) system for chemical substances possibly harmful to human health or ecosystems. Under the PRTR system, businesses identify and report to the government the amount of chemical substances that are released to the environment or transferred as waste materials. The government then aggregates the data from businesses and publishes them together with the estimation of releases that are not reported to the government (e.g. household, transport, small businesses, etc). The fifth aggregate result was published in February 2007.

Figure 5-5-2: Changes over Time of Total Dioxin Emissions



Decrease rate from the year 1997 (%)

	H10	H11	H12	H13	H14	H15	H16	H17
Base year	49.0~ 51.9	60.6~ 62.6	68.8~ 68.9	75.2~ 75.3	87.7~ 88.1	95.1~ 95.2	95.5~ 95.6	95.7~ 95.8

Source: Ministry of the Environment

Figure 5-5-1: Outline of the Law concerning the Evaluation of Chemical Substances and Regulation of Their Manufacture, etc.

☐ The aim of the Law is to prevent toxic chemical substances from the environmental pollutions.
☐ The prevention scheme is structured from two angles: evaluation and regulation.

1. Evaluation

A pre-market evaluation is supposed to be conducted on the production or import of any new chemical substances, for the purpose of evaluating the following:

(1) Biodegradability,
(2) Bio-accumulation, and
(3) Toxicity to humans, animals and plants.

The evaluation is to be conducted rationally, taking into consideration the volume of production or import and the probability of the release to the environment.

2. Regulation

Regulations on the production, import or use are to be implemented according to characteristics of the chemical substance concerned, taking into consideration the results of the pre-market evalution for new chemicals and the assessment for existing chemicals

Category	Regulatory measures
Class 1 Specified Chemical Substances (15 substances including PCB)	· Virtually ban on production, import or use in real terms
Class 2 Specified Chemical Substances (23 substances including trichloroethylene)	· Mandatory notification on planned and actual amounts of production or import · Restriction on the quantity to be produced or imported, as necessary · Required observation of technical guidelines as to treatment
Monitoring chemical substances (Class 1: 28 substances, Class 2: 859 substances, Class 3: 51substances)	· Mandatory notification on actual amounts of production or import · Move to the category "specified chemical substance" according to the results of hazard assessment, risk evaluation, etc.

Note: The number of substances mentioned above is as of the end of March 2007.
Source: Ministry of Health, Labour and Welfare, Ministry of Economy, Trade and Industry and Ministry of the Environment

In 2004, Japan successfully achieved its reduction target for emission of dioxins. The ministry also amended the reduction plan in 2005, with the aim of achieving a 15% reduction from the 2003 level in 2010 at the latest. It is estimated that the total emission of dioxins in 2005 was 13% less than that in 2003.

With regard to policy actions on poison gas bombs in Japan, the government ministries, in line with Cabinet approval on June 6, 2003 and the Cabinet decision on December 16, 2003, are working together to conduct an environment survey and treatment with the intention of preventing possible damage from defunct Imperial Japanese Army/Navy gas bombs. In addition, the Poison Gas Information Center, established by the Ministry of the Environment, collects relevant information on an ongoing basis and distributes such information and general guidance to citizens.

6. Conservation of the Natural Environment and Promoting Contact with Nature

The 4th review on implementation of the National Biodiversity Strategy of Japan was conducted in FY2006, and the results of the review were reported to the Central Environment Council. Since the strategy is supposed to be revised after five years following its establishment, meetings of experts for the review have been held since August 2006 to clarify important points at issue for improving the Strategy.

Figure 5-6-1: Outline of Newly Implemented Policy Actions for Addressing Biodiversity Crisis (Fourth review on implementation of the strategy)

November 2006

Measures for mitigating the biodiversity crises (major new efforts)

Crisis 1 Destruction of ecosystem due to human activity

- Expansion of protected areas (national parks, national wildlife management areas, and protection forests)
  - Expansion of marine parks (13.7ha)
  - New designations as a national wildlife protection area (6 designations)
  - Designation of green corridors (3 locations, 31,000 hectares)
  - Designation of natural habitat conservation area for Hynobius abei, etc.
- Designation of 20 additional wetland sites as Ramsar sites

Crisis 2 Change in the environmental quality of satochi-satoyama

- Launch of discussions on “Measures to Conserve and Improve Rural Resources (Land, Water and Environment)” with the aim of supporting efforts to improve the quality of rural resources and environment (farmland, irrigation water, etc.) and the environment
  Model support programs were carried out in FY2006.
- Establishment of the pilot projects to provide direct support for nonprofit organizations working for conservation or restoration of rural landscapes and the natural environment
- First designation of Important Cultural Landscapes
  - Suigo Area, Nishinoko Wetland and its Cultural Landscape of Omi-hachiman (Shiga Prefecture), the farming village landscape of Ichinoseki-hondera (Iwate Prefecture)
- Implementation of measures to support activities to preserve and utilize cultural landscapes

Crisis 3 Ecosystem disturbance by alien species

- The Invasive Alien Species Act came into force in June 2005, by which a total of 83 species have been designated as invasive alien species and the ban in principle on raising , planting, storing, carrying, importing and transferring of those designated species has been introduced.
  A public announcement on mitigation is to be made for all the designated species.
- Implementation of model control programs for raccoon, largemouth bass, and some other species
- Introduction of new regulations over the release of all animals and plants into special protection zones inside national or quasi-national parks or Wilderness Areas.

Source: Ministry of the Environment

Table 5-6: Threatened Wildlife of Japan (Species Listed in the Red List)

(as of December 2006)

	Taxonomical group	Species assessed	Extinct	Extinct in the wild	Threatened species (total)	Critically endangered + Endangered	Category 1A	Category 1B	Vulnerable	Near threatened	Data deficient	Threatened local population	Total number of species listed
Animals	Mammals	approx. 200	4	0	48	32	12	20	16	16	9	12	89
	Birds	approx. 700	13	1	92	53	21	32	39	18	17	2	143
	Reptiles	98	0	0	31	13	3	10	18	17	5	3	56
	Amphibians	62	0	0	21	10	1	9	11	14	1	0	36
	Brackish water and freshwater fish	approx. 300	3	0	76	58	29	29	18	12	5	12	108
	Insects	approx. 30,000	2	0	171	89			82	161	88	3	425
	Land/freshwater mollusks	approx. 1,000	25	0	251	86			165	201	71	5	553
	Spiders/ crustaceans	approx. 4,200	0	1	56	17			39	40	39	0	136
	Subtotal for animals		47	2	746	358			388	479	234	38	1546
Plants	Vascular plants	approx. 7,000	20	5	1,665	1,044	564	480	621	145	52	—	1,887
	Bryophytes	approx. 1,800	0	0	180	110			70	4	54	—	238
	Algae	approx. 5,500	5	1	41	35			6	24	0	—	71
	Lichen	approx. 1,000	3	0	45	22			23	17	17	—	82
	Fungi	approx. 16,500	27	1	63	53			10	—	—	—	91
Subtotal of plants			55	7	1,994	1,264			730	190	123	—	2,369
Total			102	9	2,740	1,622			1,118	669	357	38	3,915

Notes:1. Data on the assessed animal species (including subspecies) were derived from the Environment Agency, Checklist of Japanese Species of Wildlife 1993, 1995, and 1998.
2. Data on the vascular plants (including subspecies) were gathered by the Japanese Society for Plants Systematics.
3. Data on the species of bryophytes, algae, lichen, and fungi (including subspecies) were derived from Ministry of the Environment surveys.
4. Bars (-) mean incomplete assessment.

The categories are considered as follows:
Extinct: Species that are extinct in Japan
Extinct in the wild: Species that are known only to survive in captivity or in cultivation
Critically endangered + Endangered: Species in danger of extinction
Vulnerable: Species facing increasing danger of extinction
Near threatened: Species with weak foundation for survival
Threatened local population: Population of a species that is isolated in an area and has high possibility of extinction.
Source: Ministry of the Environment

Based on the World Conservation Union (IUNC)-classified Red List of Threatened Species, which shows endangered species at risk of extinction in different ranks, the Japanese government has published the Red Data Book, which is a detailed Japan version covering all endangered species as of FY2006. Also, the review of the listed species was conducted for necessary revisions for four categories, including birds. According to the Red Data Book, reflecting the results of the said review, the ratio of threatened species on the verge of extinction in Japan is slightly more than 30% for reptiles and amphibians, slightly more than 20% for mammals, brackish water or freshwater fish and vascular plants, and slightly more than 10% for birds.

Furthermore, 73 species have been designated as national endangered species of wild fauna and flora pursuant to the Law for the Conservation of Endangered Species of Wild Fauna and Flora, including 4 species of mammals, 39 species of birds, 5 species of insects, and 19 species of plants.

Comprehensive reviews have been conducted over the zoning of park areas as well as park plans of national and quasi-national parks. As a result, an access-control district has been designated for the first time (for Yoshino-Kumano National Park). Also, Kuchinoerabujima Island has been incorporated into the park areas of the Kirishima-Yaku National Park. In addition, nine animal species have been designated as species subject to capturing permission in special zones, for the purpose of strengthening capturing controls.

In accordance with the Invasive Alien Species Act, three species, including Bombus terrestris, have been newly added to the list of designated invasive alien species, resulting in the list now having a total of 83 species.

The Wildlife Protection and Proper Hunting Law has been partially amended to review some hunting regulations. For example, some of the special exemptions as to hunting designated species in temporary hunting prohibited areas have been approved and the hunting license has been reconstituted to divide the license of “netting and trapping” into the “netting” license and the “trapping” license. Also, for the purpose of improving the quality of habitats in wildlife protection areas, institutional development of nature conservation programs has been implemented.

In response to the recent frequent appearances of wild bears in human habitations, the manual for preparedness for appearances of wild bears was published in March 2007, for the purpose of promoting measures to discourage wild bears from coming to human habitations, reduce damages to be caused by wild bears and appropriate management of wild bears.

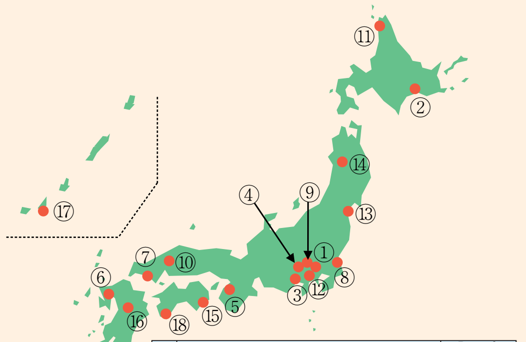
A survey on wild birds was conducted in response to the outbreak of a highly pathogenic avian influenza that started in January 2007. Through the on-site investigation carried out by government staff and specialists as an emergency measure, the inhabitation status of wild birds and the status of their infection with influenza were examined.

Under the Law for the Promotion of Nature Restoration, 18 new Nature Restoration Committees have been established as of the end of March 2007, initiating efforts toward nature restoration.

As part of the efforts to promote international cooperation for securing biodiversity, Japan chaired the International Tropical Marine Ecosystems Management Symposium and the ICRI General Meeting as a host country of the International Coral Reef Initiative (ICRI) in October 2006. Also, to promote further international cooperation in migratory waterbird conservation across the Asia-Pacific region, the Japanese and Australian governments jointly took the initiative to establish Partnership for the East Asian-Australasian Flyway in November 2006. Also, in January 2007, it was approved by the Cabinet that Japan would file its candidacy for host of the 10th Conference of the Parties to the Convention on Biological Diversity.

For the purpose of developing people’s love of nature, their respect for interpersonal relationships and their understanding of the significance of harmonizing with nature, programs to encourage people to communicate with nature have been promoted.

Figure 5-6-2: Locations of the Nature Restoration Committees Nationwide



	Name	Date of establishment
①	Nature Restoration Committee for the Arakawa Taroemon District	H15.7.5
②	Nature Restoration Consulting Committee for Kushiro Marsh	H15.11.15
③	Nature Restoration Committee for Asahata Water Detention Area in the Tomoegawa Basin	H16.1.29
④	Nature Restoration Committee for the Source of Tamagawa River	H16.3.5
⑤	Committee for Nature Conservation and Utilization of the Kounoyama Mountain	H16.5.25
⑥	Nature Restoration Committee for Kashibaru Marsh	H16.7.4
⑦	Nature Restoration Committee for the Fushino River Estuaries and Tidal Flats	H16.8.1
⑧	Nature Restoration Committee for the District of Tamura, Okijuku and Tosaki in the Kasumigaura region	H16.10.31
⑨	Nature Restoration Committee for the Kunugiyama Mountain area	H16.11.6
⑩	Nature Restoration Committee for Yawata Marsh	H16.11.7
⑪	Kami Sarobetsu Nature Restoration Committee	H17.1.19
⑫	Nature Restoration Committee for the Area of Detention Ponds No. 1 and No. 2 of the Nogawa River	H17.3.28
⑬	Nature Restoration Committee for Gamou Tidal Flat	H17.6.19
⑭	Nature Restoration Committee for the Foothills of Mt. Moriyoshi	H17.7.19
⑮	Nature Restoration Committee for Takegashima Marine Park	H17.9.9
⑯	Nature Restoration Committee for Aso Grassland	H17.12.2
⑰	Nature Restoration Committee for Sekisei Lagoon	H18.2.27
⑱	Nature Restoration Committee for Tatsukushi	H18.9.9

Source: Ministry of the Environment

They include national campaigns at natural parks and “Junior Park Ranger” that events for children to give them the opportunity to get many experiences from the park ranger. Also, in order to promote “ecotourism,” the government has continued to carry out the following five promotional policies: Ecotourism Charter, Ecotourism Promotion Manual, Ecotour Comprehensive, Ecotourism Awards and Model Projects. In addition, forums and nationwide seminars have been held.

Recently, people’s interest in hot spring and their needs have been growing and diversified. This trend has invited various emerging issues, including people’s increased claim for correct information on the assay of hot springs. In response to such tendency, a bill for the partial amendment of the Hot Springs Law was submitted to the 166th Diet session. The bill proposes to bind hot spring business operators to periodic evaluations of assay of their hot spring water notify evaluation results to users.

Regarding the welfare and proper management of pets, the fundamental guidelines for breeding, feeding and keeping of experimental animals have been established, and the basic policy for comprehensive promotion of the measures to welfare and proper management of pets has been also established. In addition, for the purpose of promoting the appropriate transfer or return of abandoned or stray animals captured by prefectural governments, etc., the database networking system (internet website for searching for stray animals or pet adoptions) has been launched.

7. Basis of Various Measures, and Measures Facilitating the Participation of Various Actors and International Cooperation

(1) Expenditure for environmental conservation

The total amount of the FY2007 expenditures for environmental conservation is 2.949 trillion yen, down 1.8% or 39.3 billion yen from the previous year’s budget.

Table 5-7-1: List of the Expenditures for Environmental Conservation by Field

(Unit: million yen)

Field	Budget as of FY2006	Budget for FY2007	Increase/ decrease from the previous year
1. Conservation of the geoenvironment	460,130	491,158	31,029
2. Conservation of the atmospheric environment	303,577	279,711	△ 23,866
3. Conservation of the water, soil, and ground environments	818,302	819,504	1,202
4. Measures for appropriate waste treatment and recycling	144,209	132,112	△ 12,097
5. Measures on chemical substances	12,338	9,819	△ 2,518
6. Conservation of the natural environment and promotion of people’s contact with the nature	317,416	285,056	△ 32,360
7. Supporting programs for respective policy measures	78,237	77,575	△ 662
Total	2,134,207	2,094,935	△ 39,272

Note 1: The above figures include special accounts.
2: The figures shown above are exclusive of the budgets which are yet to be allotted to specific programs.
3. The figures by field are all rounded off and therefore do not necessarily add up to the totals.
Source: Ministry of the Environment

(2) Policy measures of the central government

For the purpose of clarifying the direction of Japan’s environmental measures to be implemented inside and outside the country and promoting comprehensive discussions on the “Becoming a Leading Environmental Nation Strategy in the 21st Century: Japan’s Strategy for a Sustainable Society,” which shows guidelines for Japan’s role in the world for the formation of effective international frameworks, the strategy has been organized.

Third Basic Environment Plan, decided upon by the Cabinet in April 2006, explains basic visions of Japan’s environmental measures into the future. It emphasizes the significance of “Integrated Improvements of the Environment, Economy and Society.” The Plan also defines ten policy programs in priority fields, wherein the utilization of actual indicators relevant to respective measures as well as the comprehensive environmental indicators have been determined.

(3) Environmental impact assessment

“Strategic Environmental Assessment (SEA)” is a procedure to weave environmental consideration into policies and plans which provide the framework for respective projects, for the purpose of avoiding,minimizing, or mitigating any possible material adverse impacts of each project on the environment. The Guidelines for the Introduction of Strategic Environmental Assessment have been established, which show common procedures and evaluation methods of SEA for the higher-level plans, those whose location, size, etc. are under consideration.

Also, for the purpose of ensuring appropriate and thorough Environmental Impact Assessment (EIA) implementations, project proponents and local governments have been fully informed of the ministerial ordinances formulated for each type of subjected project revised in FY2006, on the basis of March 2005 revisions made to the Basic Guidelines for EIA.

In accordance with the Environmental Impact Assessment Law, the environmental impact assessment procedures were started for

Table 5-7-2: Status of Environmental Impact Assessment Procedures in Accordance with the Environmental Impact Assessment Law

(As of the end of March 2007)

	Road	Dam, etc	Railway	Airport	Power station	Disposal site	Reclamation	Area development	Total
Procedures started	71 (49)	6 (6)	13 (9)	8 (8)	41 (29)	5 (4)	10 (7)	20 (11)	169 (119)
Underway	22 (22)	3 (3)	1 (0)	1 (1)	9 (9)	2 (2)	3 (2)	5 (4)	45 (42)
Procedures completed	40 (19)	3 (3)	10 (7)	7 (7)	29 (17)	3 (2)	7 (5)	12 (5)	107 (62)
Procedures discontinued	9 (8)	—	2 (2)	—	3 (3)	—	—	3 (2)	17 (15)
Opinion of the Minister of the Environment	44 (23)	3 (3)	10 (7)	7 (7)	31 (19)	—	—	14 (6)	109 (65)

*1: Figures in ( ) show the number of cases conducted under the Law from the start of procedure. When two projects are implemented together, it is counted as one.
*2: The figures include replies without any special comments. The Minister of the Environment is supposed to give opinions only when the national government issues license or other required approval.

Source: Ministry of the Environment

8 projects, and completed for 13 projects in FY2006. Through these procedures, environmental considerations were included in the process of establishing social infrastructure.

(4) Relief programs for victims of Minamata disease and asbestos-caused health damages

a. Minamata disease

The certification of Minamata disease is conducted in accordance with the Law concerning Compensation and Prevention of Pollution-related Health Damages. The total number of certified patients is 2,958 people as of the end of March 2007, of which 897 are alive. Those certified patients receive compensations directly from companies responsible for the disease through compensation agreements.

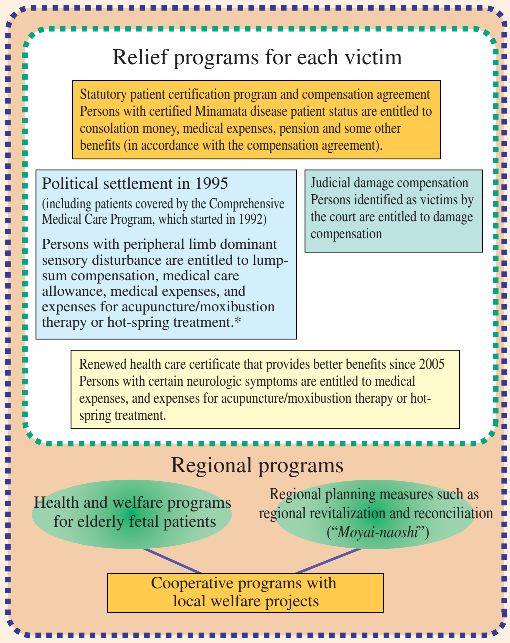
Since FY1992, the Program concerning Comprehensive Measures of Minamata Disease has been carried out, and medical care programs, such as financial compensation of medical care expenses, are being operated under the program. Also, in response to the political settlement of this issue in 1995, the government has resumed to accept applications for benefits under the medical care programs. In May 1996, a total of ten pending lawsuits for state redress were withdrawn. In October 2004, the Supreme Court upheld the Osaka High Court verdict on the Kansai lawsuit, ruling that the government and Kumamoto prefectural government are responsible for the failure to prevent the spread of Minamata disease after January 1960.

In April 2005, prior to the 50th anniversary in 2006 of the official acknowledgement of Minamata disease, the government announced "Future Minamata Disease Countermeasures", which consist of the measure to expand medical care programs, taking into consideration the aging of patients, the measure to assist victims including congenital patients in participating in social activities, and the measure for regional revitalization; and the government has been implementing those measures.

During the meeting for discussion on the Minamata disease issues held in September 2006, the committee presented recommendations including the proposal for the establishment of the risk management scheme for "security of life" and the development of "model areas having advanced environmental and welfare programs."

Also, in response to the increasing number of claims for relief benefits, the project team for the Minamata disease issue was organized within the ruling parties in May 2006, and the team has been promoting deliberations.

Figure 5-7: Outline of Relief Programs for Minamata Disease Victims



Source: Ministry of the Environment
* Medical treatment certificate holders are entitled to these benefits, while health care certificate holders only receive part of the medical expenses as well as expenses for acupuncture/moxibustion therapy or hot-spring treatment.*

Table 5-7-3: Timeline of Key Events related to Minamata Disease

May	1956	Minamata disease was officially acknowledged.
March	1959	Two laws concerning water quality and regulation came into force.
May	1965	Niigata Minamata disease was officially acknowledged.
June	1967	The first lawsuit was filed by Niigata Minamata disease victims. (The plaintiff won the case in September 1971 (final verdict).)
September	1968	The Ministry of Health and Welfare and Technology Agency announced their collective view that Minamata disease was caused by methyl mercury compounds discharged from Chisso Co., Ltd. and Showa Denko Co., Ltd.
June	1969	The first lawsuit of Kumamoto Minamata disease was filed. (The plaintiff won the case in March 1973 (final verdict).)
December	1969	Law concerning the Relief of Pollution-related Health Damage came into force.
July	1973	Compensation agreement was concluded between Chisso and litigation group patients. (Compensation agreement between Showa Denko and patients was concluded in June of the same year.)
September	1974	Law concerning Compensation and Prevention of Pollution-related Health Damages came into force.
November	1991	Central Council for Environmental Pollution Control submitted a report, “Desirable Relief Programs to Be Implemented in the Future for Minamata Disease Patients”.
September	1995	Three ruling parties finalized the report, “Political Settlement of Minamata Disease”. (Final Remedies)
December	1995	“Countermeasures of Minamata Disease” was adopted by the Cabinet.
May	1996	Ten pending lawsuits for state redress were withdrawn (except the Kansai lawsuit).
October	2004	The Supreme Court handed down the final verdict over the Kansai lawsuit. (The final verdict held the national government and Kumamoto prefectural government responsible.)
April	2005	Ministry of the Environment announced “Future Minamata Disease Countermeasures”.
May	2005	40th anniversary of official acknowledgment of Niigata Minamata disease
May	2006	50th anniversary of official acknowledgement of Minamata disease

Source: Ministry of the Environment

b. Asbestos-caused health damages

As of the end of FY2006, the government has received a total of 3,925 applications for relief benefits under the Act on Asbestos Health Damage Relief, of which 2,389 were officially certified for the benefits, 281 were not certified and 387 were withdrawn.

(5) Making progress with environmental education and education for sustainable development

In accordance with the Law concerning the Enhancement of Willingness for Environmental Conservation and Promotion of Environmental Education and the basic policy based on the Law, the program for promoting the utilization of outside human resources, such as specialists from non-profit organizations, has been carried out, where those specialists teach at classes for integrated study at schools. Projects using those outside specialists are to be registered, and the information on those registered projects is released to the public through the Internet. To promote “the United Nations Decade of Education for Sustainable Development,” three key programs in the early stage of the Decade in Japan, including dissemination of the concept of ESD, implementation in communities, and programs at higher education, have been carried out, based on Japan’s Action Plan of the Decade.

(6) Efforts for achieving a more environmentally friendly socioeconomic structure

Another idea is to impose economic costs in an attempt to reduce environmental burdens. Possible policy approaches would include suppressing waste generation as well as controlling carbon dioxide emissions to prevent global warming. To identify appropriate policy approaches, the government conducted a research project to survey and collect data on foreign best practices and examine possible positive effects that these policies would have on environmental conservation or the national economy.

The “Law Concerning the Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities” aims at encouraging a demand shift to eco-friendly goods (goods and services with low environmental loads) by promoting procurement of eco-friendly goods in the public sector (the national government, independent administrative institutes, and public organizations) and actively providing environmental information. In line with these basic policies, the national government and other public sector organizations established their FY2006 eco-friendly goods procurement plans and promoted procurement of eco-friendly goods based on their own plans.

In response to the recent tendency of increased emphasis of corporate social responsibilities in promoting environmental protection, the Meeting for Promoting the Awareness on the issue of Environment and Finance was organized in April 2006, where a report “Toward the Increase of the Environmentally Conscious Money Flow” was issued.

The estimated size of the market and the employment of environmental businesses in Japan as of 2005 is about 44.1 trillion yen and about 1.026 million employees respectively. When other businesses that have the potential to spur consumers' environmentally conscious behaviors, which lead to demand ("environment-induced businesses"), are added to the above, the total market size is about 58.3 trillion yen and the employed population is about 1.372 million.

(7) International policy measures

In an effort to address global environmental issues, the government has been promoting the following: (1) supporting programs for activities of international organizations, (2) involvement in multilateral negotiations for international treaties or protocols, (3) cooperation with other countries, and (4) assistance of developing countries and regions.

◯Measures on Environmental Conservation to be Implemented in FY2007

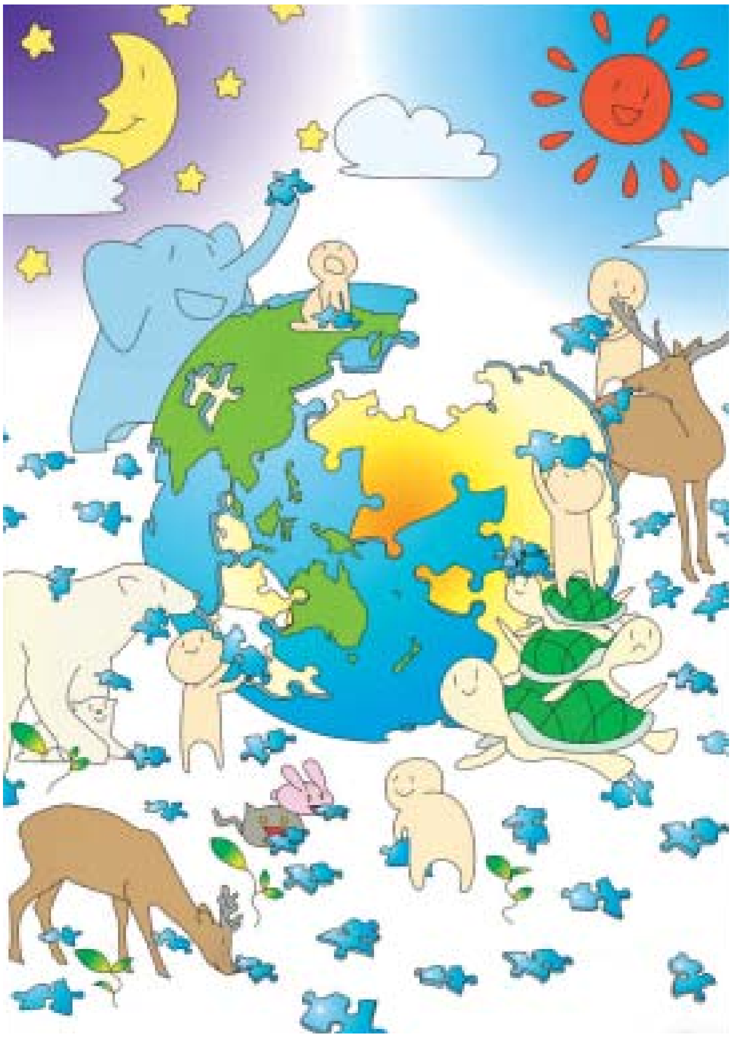
◯Measures on Formation of a Sound Material-Cycle Society to be Implemented in FY2007

The Quality of the Environment in Japan 2006 (White Paper) reports the measures on environmental conservation and formation of a Sound Material-Cycle Society to be implemented in FY2007.

Chapter 1: Conservation of the Earth's Environment
Chapter 2: Conservation of the Atmospheric Environment
Chapter 3: Conservation of the Water, Soil, and Ground Environments
Chapter 4: Measures and Policies Related to the Material Circulation, including Waste and Recycling Measures
Chapter 5: Measures and Policies on the Assessment and Control of Environmental Risk of Chemical Substances
Chapter 6: Conservation of the Natural Environment and Promoting Contact with Nature
Chapter 7: Basis of Various Measures, and Measures Facilitating the Participation of Various Actors and International Cooperation

Stop Global Warming

Team minus 6%



○If you have any opinions and comments regarding this booklet, please contact the following:

○The FY2006 status of the environment/The FY2006 status of the formation of a sound material-cycle society
Overview 1 of Part 1, Sections 1 to 3 and 5 to 7 of Part 2

Environmental Strategy Division
Environmental Policy Bureau
Ministry of the Environment

Tel: +81-3-3581-3351 (ex. 6254) E-mail: hakusho@env.go.jp

○The FY2006 status of the environment/The FY2006 status of the formation of a sound material-cycle society
Overview 2 of Part 1, Section 4 of Part 2

Office of Sound material-cycle society
Waste Management and Recycling Department
Ministry's Secretariat
Ministry of the Environment

Tel: +81-3-3581-3351 (ex. 6819) Email: junkan@env.go.jp

Abridged and Illustrated for Easy Understanding
Annual Report on the Environment and the Sound Material-Cycle Society in Japan 2007
Published by: Ministry of the Environment
Translated by: Ministry of the Environment
Published in October 2007

R100