ENERGY AND ENVIRONMENT

2007–2008

JAPAN'S ELECTRIC POWER INDUSTRY IN THE WORLD

Foreword

Pollution problems first became a social concern in Japan in the 1960s with the development of heavy chemical industries adjacent to urban centers. As countermeasures to these problems, governmental and private organizations took steps to develop anti-pollution measures in their respective fields, by making special efforts to select low-pollution forms of energy when importing primary energy resources. Thanks to these measures, pollution problems have been largely overcome, and today Japan boasts some of the world's most advanced anti-pollution policies. While playing a central role in these developments, the electric power industry gave special priority to the specific environmental concerns of each region. In establishing integrated operations from generation to distribution, careful consideration was given to the characteristics of industries closely related to each region, and the most effective measures within equipment and operation were implemented at any given time. The industry has not only upheld the regulations and standards set by national and municipal governments, but has worked to develop and promote even more stringent anti-pollution measures.

In establishing power supply systems, the industry gives equal consideration to environmental concerns as to supply stability and economical efficiency. When determining the location of a power-generating plant, pertinent environmental impact studies are conducted beforehand, taking into consideration the possible effect on local residents and surrounding land and marine ecosystems. The utmost efforts are made to preserve the natural environment around the plant through tree planting, landscaping and other activities. In addition, the effective use, recycling, management, disposal and reduction of waste materials are actively promoted.

The resolution of global environmental problems requires a combination of international efforts and also activities strongly rooted in each individual community. Hence efforts by the electric power industry must include, in addition to domestic measures, international cooperative efforts such as the transfer of technologies that facilitate efficient energy use and environmental preservation to other developing countries, and the promotion of activities for the reduction of energy and resource consumption and environmental protection. We will implement the above-mentioned activities not only with our industry, but also with our clients and local communities in order to extend these to our society.

This brochure provides information on the activities of Japan's electric power companies which are directed at the reduction of energy and resource consumption, environmental preservation and the problem of global warming. We hope to contribute to the better public understanding of the electric power industry's activities and attitude toward environmental protection.

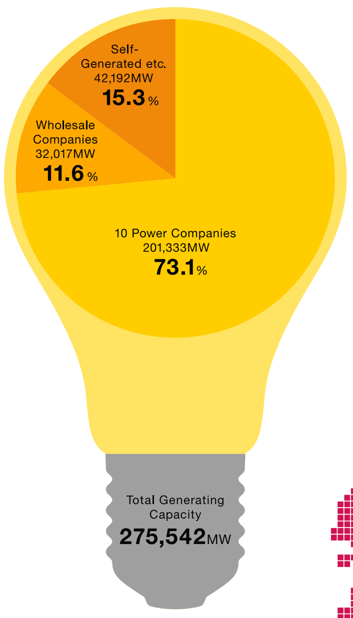
1 Overview of Japan's Electric Power Indu

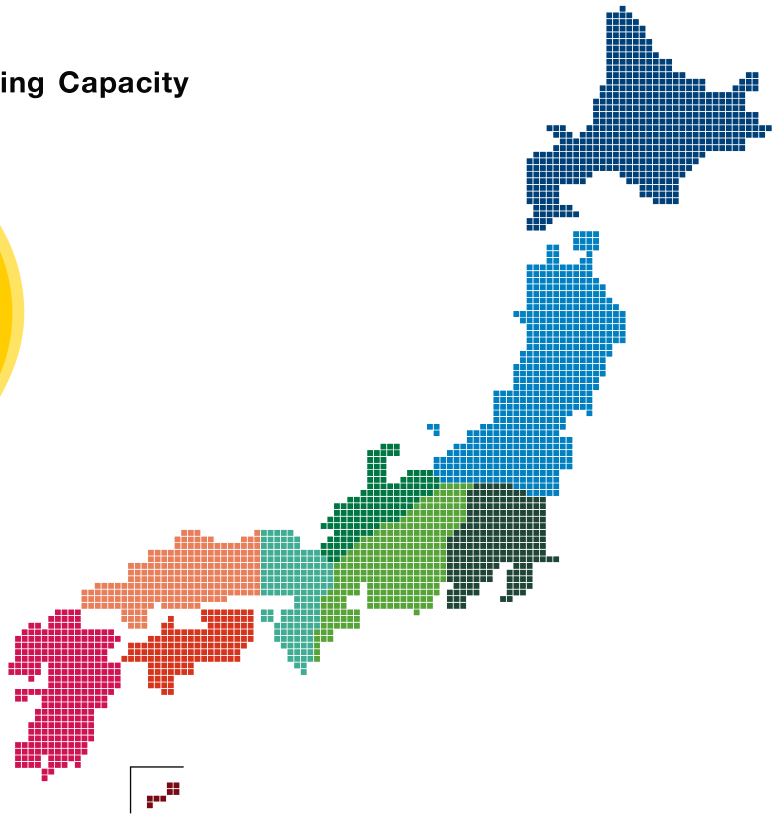
a. Composition of Japan's Electric Power Industry

Japan's electric power industry comprises 10 privately operated power companies representing the regions of Hokkaido, Tohoku, Tokyo, Chubu, Hokuriku, Kansai, Chugoku, Shikoku, Kyushu and Okinawa. Each of these independent companies provides comprehensive power generation, transmission and distribution services. Two additional companies, the Electric Power Development Co., Ltd. and Japan Atomic Power Company, sell power generated at their facilities to the power companies. In addition, there are 31 publicly managed corporations which are municipally owned and operated to provide wholesale supplies to electric power companies, 10 cooperative thermal power stations established by the electric industry and major power consumers to sell power to investment companies, and several small-scale power companies.

Following the introduction of the competition doctrine in the electric power generation business by an amendment to the Electricity Utility Industry Law, the partial liberalization of retail sales of generated power has been in force since March 2000. After the range of the liberalization was extended to more than 500kW in April 2004, it was extended to all high-voltage users, including small-scale plants, from April 2005. As of August 2007, 22 specific-scale power operators have entered the market to conduct retail sales of electric power in the liberalized sector by using the transmission lines of power companies.

Japan's Power Generating Capacity
(as of end of fiscal 2006)





Outline of 10 Major Japanese Power Companies Fiscal 2006

Source: Japan Electric Utilities Handbook

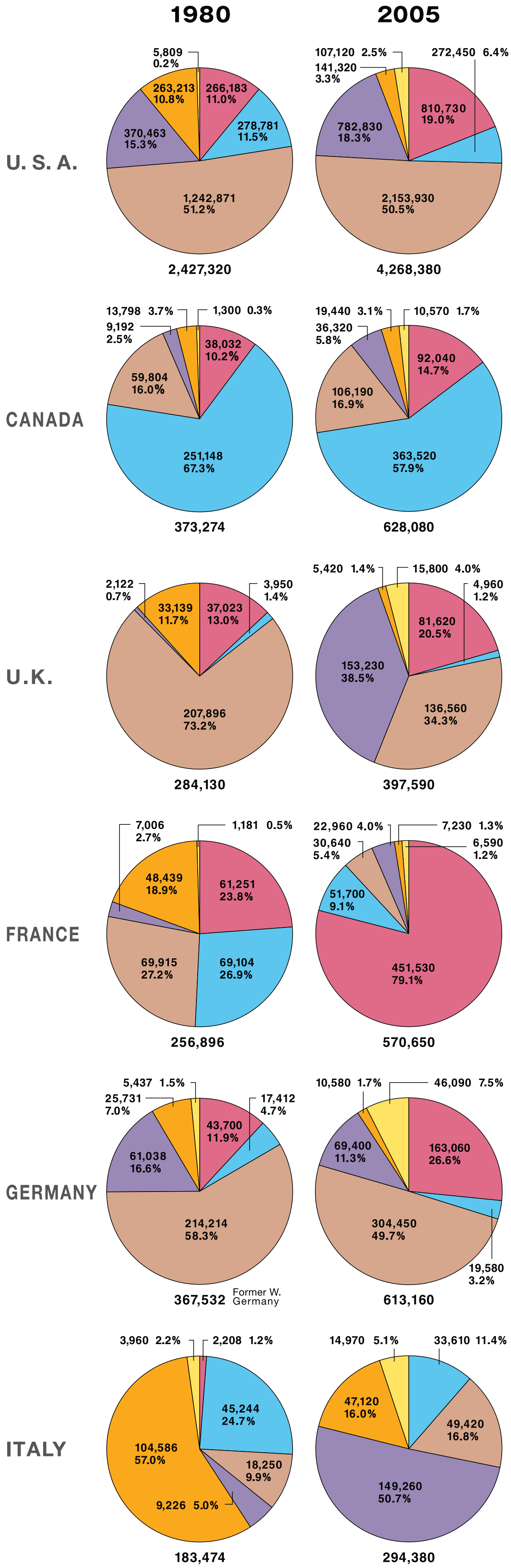
	Capital (billions of yen)	Maximum Electricity Demand (MW)	Power Sold (x 1-million kWh)	Sales (billions of yen)	Employees	Power Generating Capacity (MW)				
						Hydro	Thermal	Nuclear	Wind	Total
Hokkaido Electric Power Co.	114	5,461	31,512	535	5,794	1,231	4,115	1,158	—	6,505
Tohoku Electric Power Co.	251	14,761	80,950	1,541	12,148	2,414	11,453	3,274	—	17,141
Tokyo Electric Power Co.	676	58,058	287,622	4,952	38,111	8,993	35,533	17,308	1	61,835
Chubu Electric Power Co.	431	26,967	132,687	2,086	15,973	5,220	22,369	4,884	—	32,473
Hokuriku Electric Power Co.	118	5,488	28,200	472	4,638	1,816	4,400	1,898	—	8,114
The Kansai Electric Power Co.	489	30,530	147,257	2,350	22,164	8,189	16,907	9,768	—	34,864
The Chugoku Electric Power Co.	186	11,919	61,259	982	10,445	2,905	8,016	1,280	—	12,201
Shikoku Electric Power Co.	146	5,809	28,161	522	6,045	1,141	3,696	2,022	1	6,859
Kyushu Electric Power Co.	237	17,541	84,399	1,310	12,660	2,378	11,778	5,258	3	19,417
Total - 9 companies	2,648	173,684	882,047	14,750	127,978	34,286	118,269	46,850	4	199,409
The Okinawa Electric Power Co.	8	1,524	7,376	147	1,570	—	1,924	—	—	1,924
Total - 10 companies	2,656	174,984	889,423	14,897	129,548	34,286	120,193	46,850	4	201,333

b.Comparison of Electric Power Generation with Other Countries

Due to its convenience, the consumption of electricity continues to increase steadily. Power sources are being continually developed and combined, resulting in a wide variety of combinations now in use in different countries. The figure on the right shows a comparison of the composition of electric power generation in major countries in 1980 and 2005 as based on information from OECD Energy Balances.

Steady Increase in Power Generation

A comparison of electric power production in 1980 and 2005 shows an average increase of approximately 72% in the total power produced in the seven major countries. This reconfirms that electric power consumption has been increasing due to the improvement and the maintenance of the production level and the living standards in all countries. At the same time, due to factors such as energy security, limited resources and the increasing concern with environmental problems, dependence on fossil fuels in the major countries has declined over the past 25 years. This decline has been particularly evident in Italy, France and Japan. In contrast, the use of natural gas as a primary energy source is on the increase.

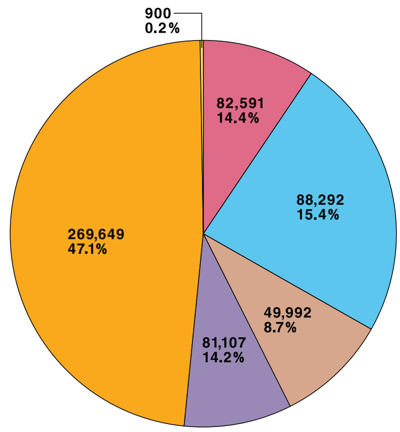


Electric Power Generation by Energy Source in Different Countries (Including Privately Generated Power)

Nuclear | Hydro | Coal | Gas | Oil | Others

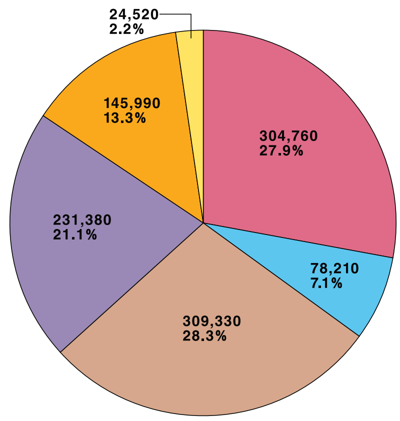
Source: OECD ENERGY BALANCES OF OECD COUNTRIES

Unit: Million kWh



1980 572,531

JAPAN



2005 1,094,190

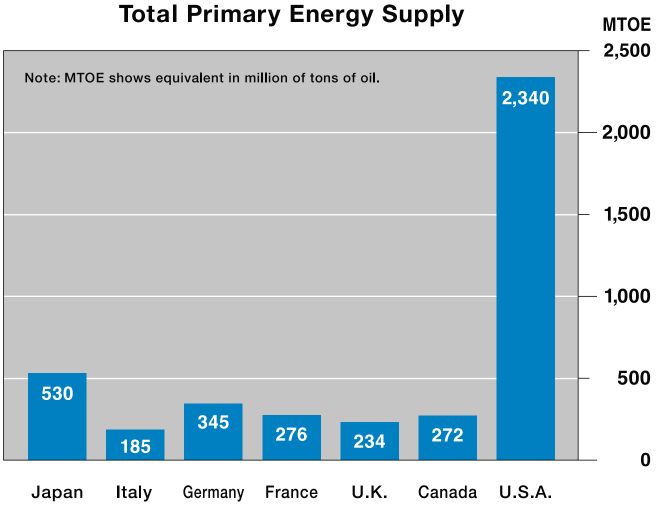
A Balanced Electric Power Composition

Japan relies on imports for 85% of its primary energy requirements. Given this situation, electric power development which depends on a particular energy source presents security and other problems. The best solution for Japan is to select an optimal combination of the three energy groups-hydro, nuclear and fossil fuel including oil, coal and LNG. The present composition of Japan's electric power source is approximately 7% hydro, 63% fossil fuel and 28% nuclear.

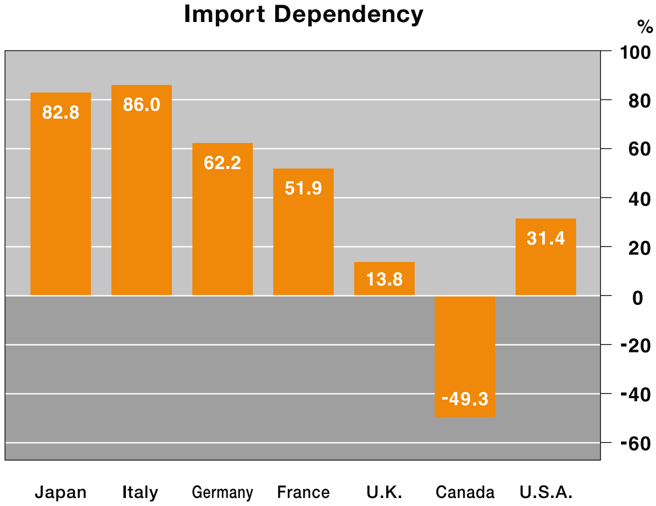
Primary Energy Supply and Import Dependency for Major Countries 2005

Source: OECD ENERGY BALANCES OF OECD COUNTRIES

Total Primary Energy Supply



Import Dependency



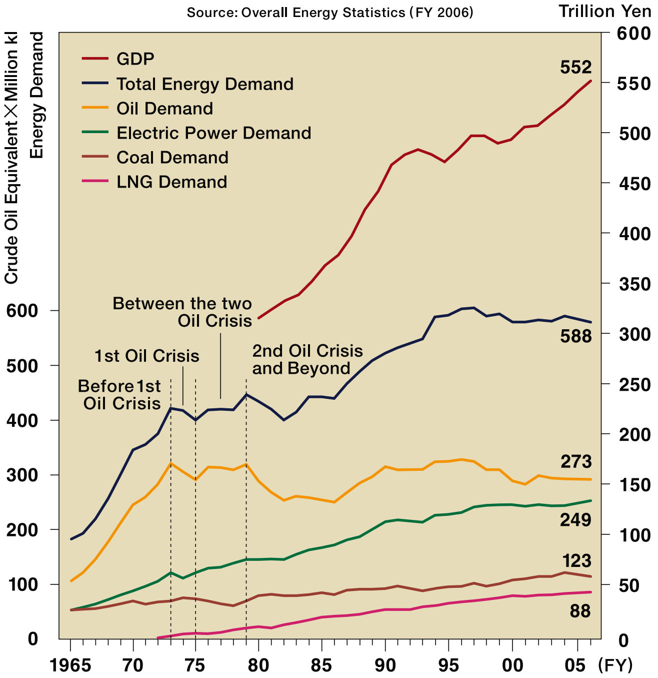
c.Energy Consumption in Japan

Changes in Demand

Japan's energy demand peaked at 443 million kl (crude oil equivalent) in 1979, but thereafter, with the oil crisis stimulating increased energy conservation, it declined annually until 1982. Demand has risen again in 1983, but the rate of growth was relatively low in comparison with past trends. This was mainly due to factors such as the shift from high energy consumption industries to low energy consumption industries in the manufacturing sector and the progress achieved in energy conservation programs. However, despite the marked decrease in dependency on oil, overall demand for electric power has continued to rise steadily along with the increased use of electrical appliances such as computers.

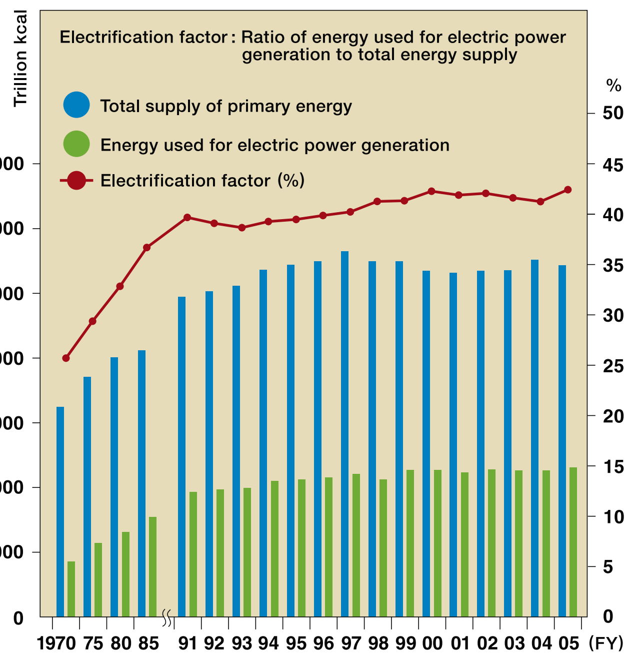
Changes in Energy Demand and GDP

Source: Overall Energy Statistics (FY 2006)



Trend of Japan's Electrification

Source: Overall Energy Statistics (FY 2006)



2

Dealing with Global Environmental Issues

There is currently considerable worldwide interest and concern in environmental issues such as global warming, acid rain, desertification, and the destruction of the ozone layer. It is essential that we seek a correct understanding of these problems and act in a concerted effort, both as individuals and as members of society. Environmental problems are closely linked to the way we utilize energy for economic activities and in our daily lives. Energy demand tends to increase yearly in proportion to economic and social development, and as contemporary information-oriented society develops toward a higher level of sophistication and our lifestyles become increasingly centered on amenities, the demand for electricity can be expected to rise further. The electric power industry is fully committed to global environmental issue in all its activities, including power supply, transmission and distribution. Recognizing our responsibility to pass on economic and social progress to future generations, we pursue a policy of socioeconomic development combined with active measures to protect the environment and conserve our irreplaceable natural resources. Efforts undertaken by the industry to deal with global warming, a problem closely related to the electric power industry as part of the energy sector, are presented below.

Finding a Solution to Global Warming

A principal cause of global warming, CO_2 emissions are a major problem for the electric power industry. Accordingly, the Federation of Electric Power Companies has set up the Investigative Committee on CO_2 Related Problems, with the purpose of studying and examining various possible measures for dealing with issues linked to CO_2 emissions. A comprehensive approach is required in order to control CO_2 emission levels. Steps to cut CO_2 emissions are based on a four-pronged control including supply and demand sides. The electric utility industry seeks to achieve a well-balanced combination of energy sources through the appropriate introduction of nuclear power and LNG power generation systems, based on a proper assessment of these power sources in terms of supply stability, economic efficiency and environmental protection. At the same time, efforts are being made to upgrade thermal efficiency in power plants and reduce energy loss in power transmission and distribution systems. The electric utility industry will continue to actively work on the CO_2 issue by focusing on the following activities.

a. Increased use of non-fossil energies
b. Improved efficiency of power facilities
c. Energy conservation
d. Load-leveling

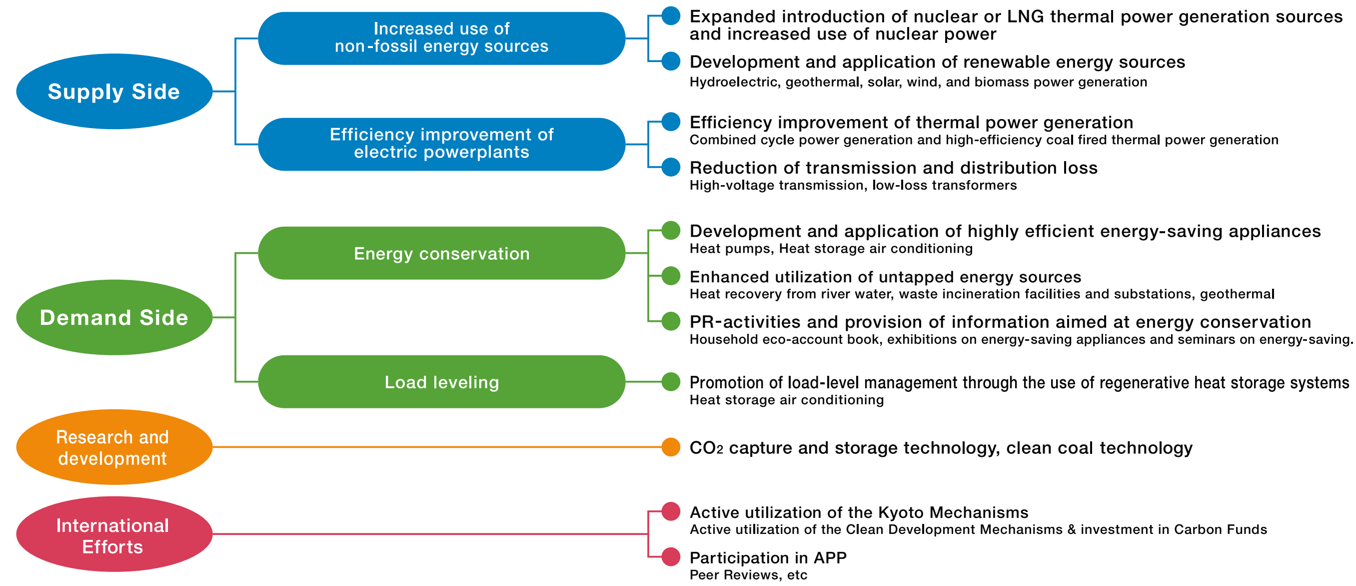
CO_2 emission levels in the electric power industry have raisen by 2.4 times compared to those during the Oil Crisis in the 1970s, where power demand has increased by 3.4 times during the same period. As a result, CO_2 emission levels (end use electricity) were 0.410 kg-CO_2/kWh in fiscal 2006. Resolving to continue lowering CO_2 emissions, the electric power industry has set a voluntary target to reduce CO_2 emissions intensity (end use electricity), although electricity demand will continue to increase. As part of its efforts, the industry formulated “Environmental Action Plan of the Electric Utility Industry” in November 1996, and made a tenth review in September 2007.

(Refer to P.35 and P.37 for details.)

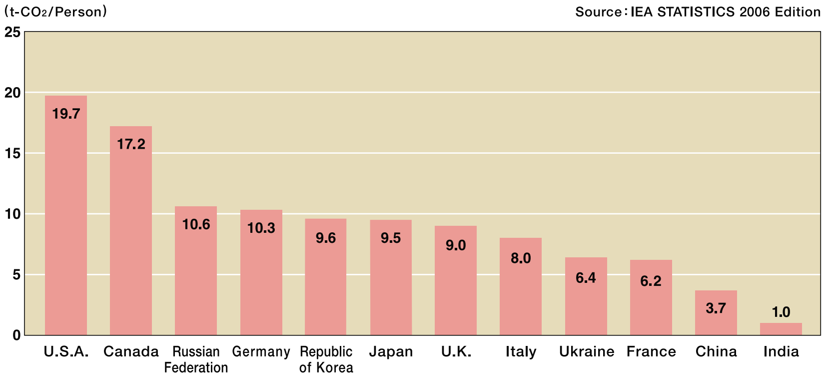
CO_2 emission control target of the electric power industry.

From fiscal 2008 to fiscal 2012, we aim to further reduce CO_2 emissions intensity (emissions per unit of user end electricity) by an average of approximately 20% from the fiscal 1990 level, to about 0.34 kg-CO_2/kWh.

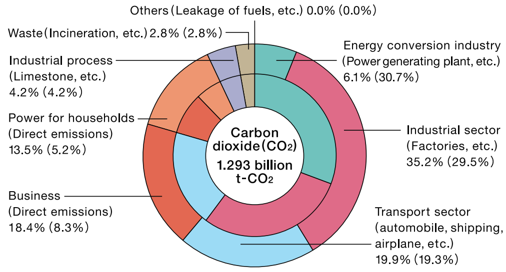
CO_2 Control measures



International Comparison of CO_2 Emissions per Capital 2004



CO_2 Emission Levels by Sector in Japan 2005

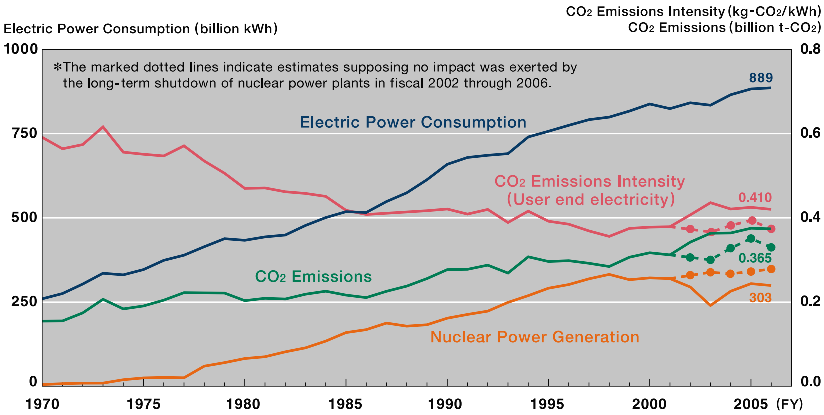


Source: Ministry of the Environment

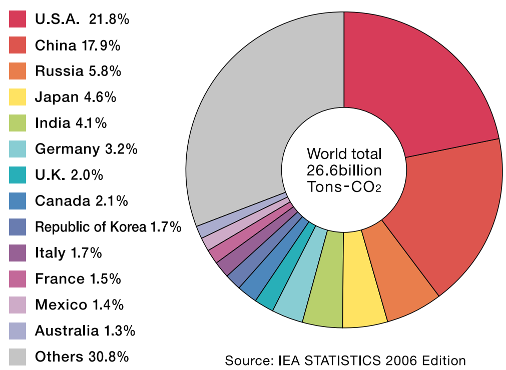
The outside circle shows CO_2 emission levels due to electric power generation assigned to respective final demand sectors in accordance with their electricity consumption. The figures in the inside circle are ratios of direct emissions (figures in parentheses).

Note: Respective shares might not necessarily total 100% due to rounding differences. Percentages above indicate the ratio to total CO_2 emissions, respectively. Other sectors includes statistical error and power consumption accompanied by the use of lubricating oils etc.

Trends in CO_2 Emissions by the Electric Utility Industry



International Comparison of CO_2 emissions 2004



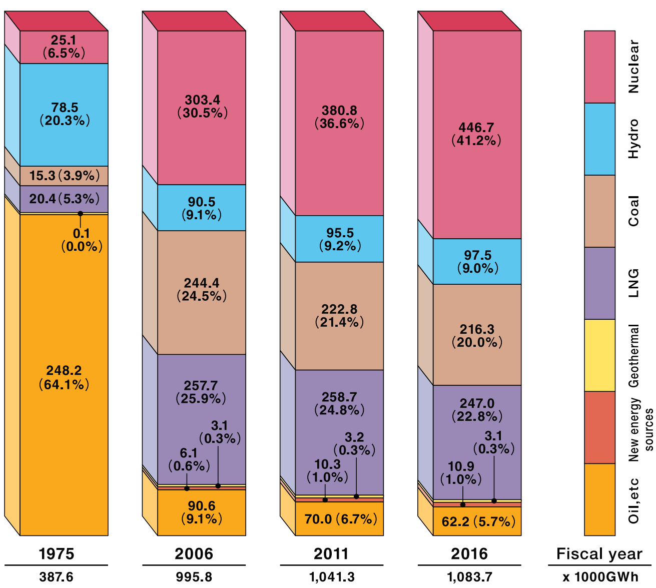
Source: IEA STATISTICS 2006 Edition

a.Promoting a Stable and Well-Balanced Combination of Power Sources

The three types of power generation systems-hydroelectric, thermal and nuclear-have different operational characteristics and economic efficiency. To counter the environmental threat of global warning and ensure stable and efficient power supply, a well-balanced combination of electric power sources is essential without excessive dependence on one particular form of energy. To that end, the industry stresses the combined use of different power sources including hydroelectric, thermal (oil, coal and LNG) and nuclear at optimally balanced percentages. Active efforts are also necessary to develop and use natural power sources such as geothermal, solar and wind power and fuel cells, with the aim of achieving greater diversification in power generation sources.

Composition of Electric Power Production

for the Ten EPCs, EPDC and Others Source: The Federation of Electric Power Companies



Genkai Nuclear Power Station, Kyushu Electric Power Co.

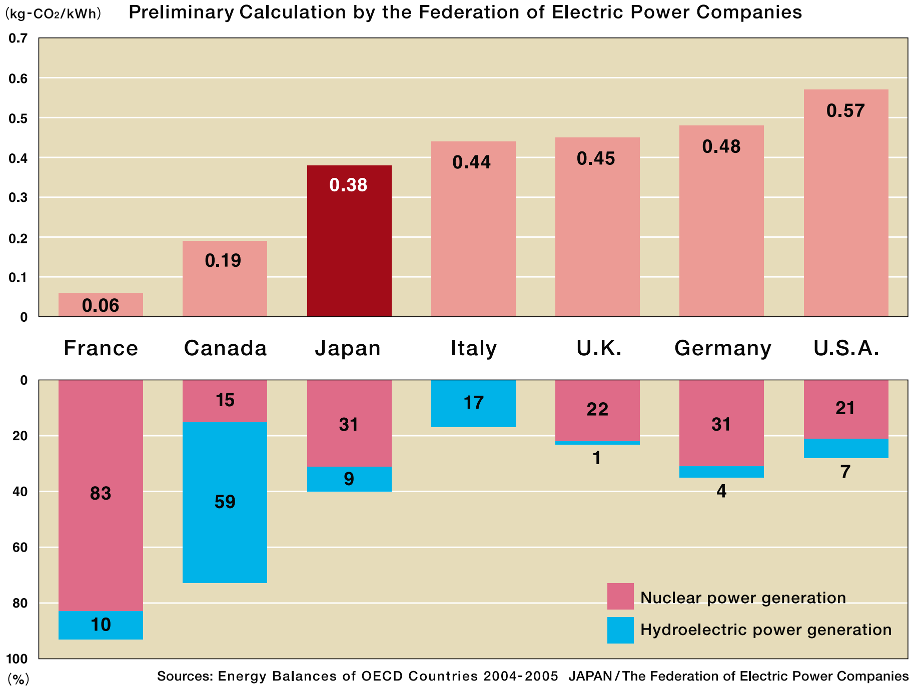
No.2 Numasawa Hydro electric Power Station, Tohoku Electric Power Co.

Tsuruga Thermal Power Station (coal), Hokuriku Electric Power Co.

Promotion of Developing Nuclear Power

Nuclear power is one of the most important power sources currently in use in Japan. Located in Ibaraki Prefecture, Japan's first commercial nuclear power plant started operation in 1966. As of August 2007, 55 plants with a total output capacity of 49,580MW are in operation throughout Japan. As a core energy resource, nuclear power has played an important role in recent years, accounting for roughly 30% of total power generated. Japan is a country with few domestic natural resources, and with the anticipated continued increase in the demand for electricity, nuclear power is expected to continue playing a vital role as a quasi-domestic energy source. The most important alternative to oil, nuclear power offers excellent supply stability and economic efficiency. Nuclear power does not produce CO_2, hence its use contributes to the prevention of global warming. For these reasons, nuclear power will continue to serve as the core energy source for power generation in Japan.

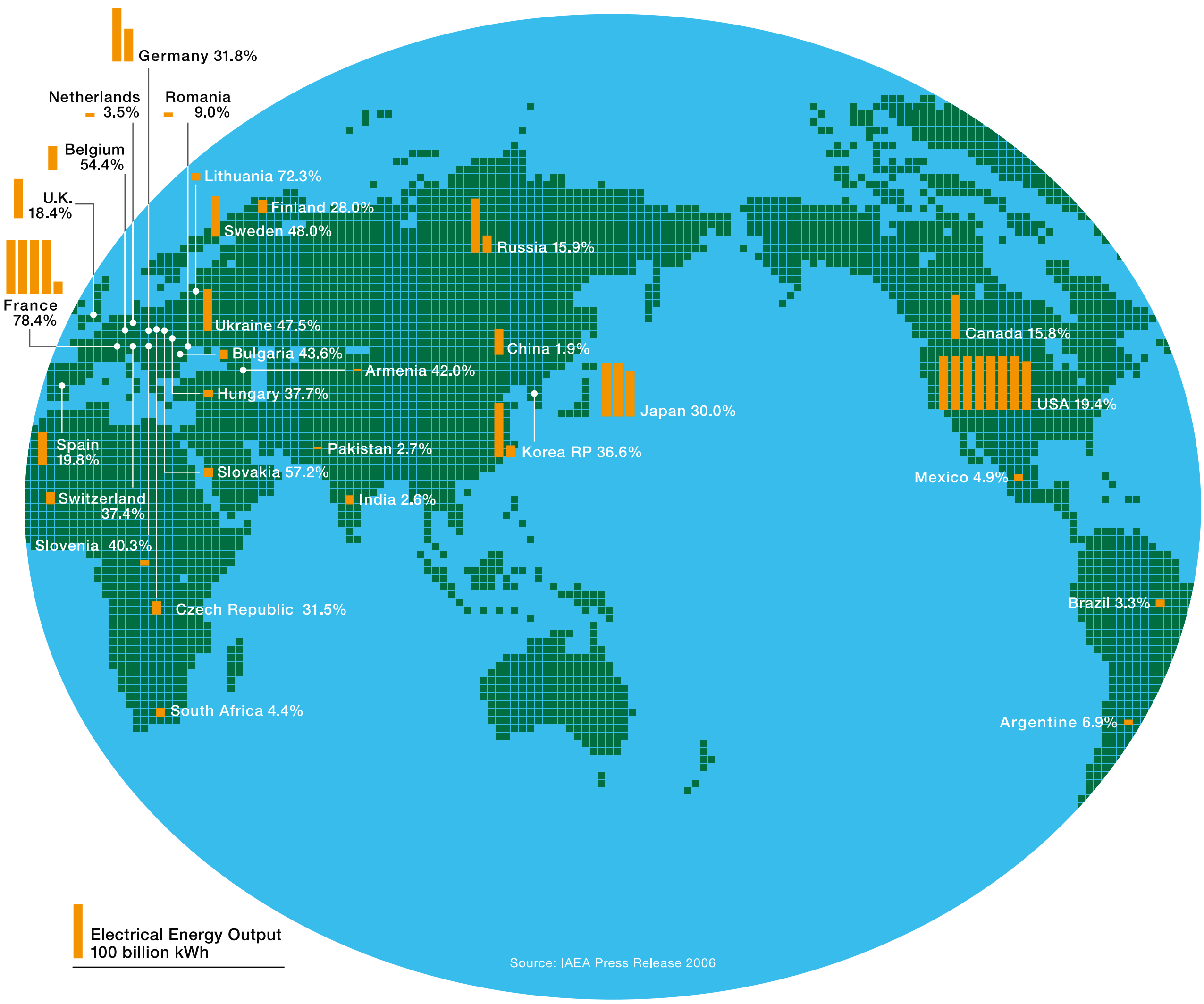
Comparison of CO_2 Emissions intensity (power generating side) in Major Countries 2005



Sources: Energy Balances of OECD Countries 2004-2005 JAPAN / The Federation of Electric Power Companies

*In France nuclear power generation accounts for a large share in total power output. As nuclear power does not emit CO_2, CO_2 emissions intensity levels are extremely low.

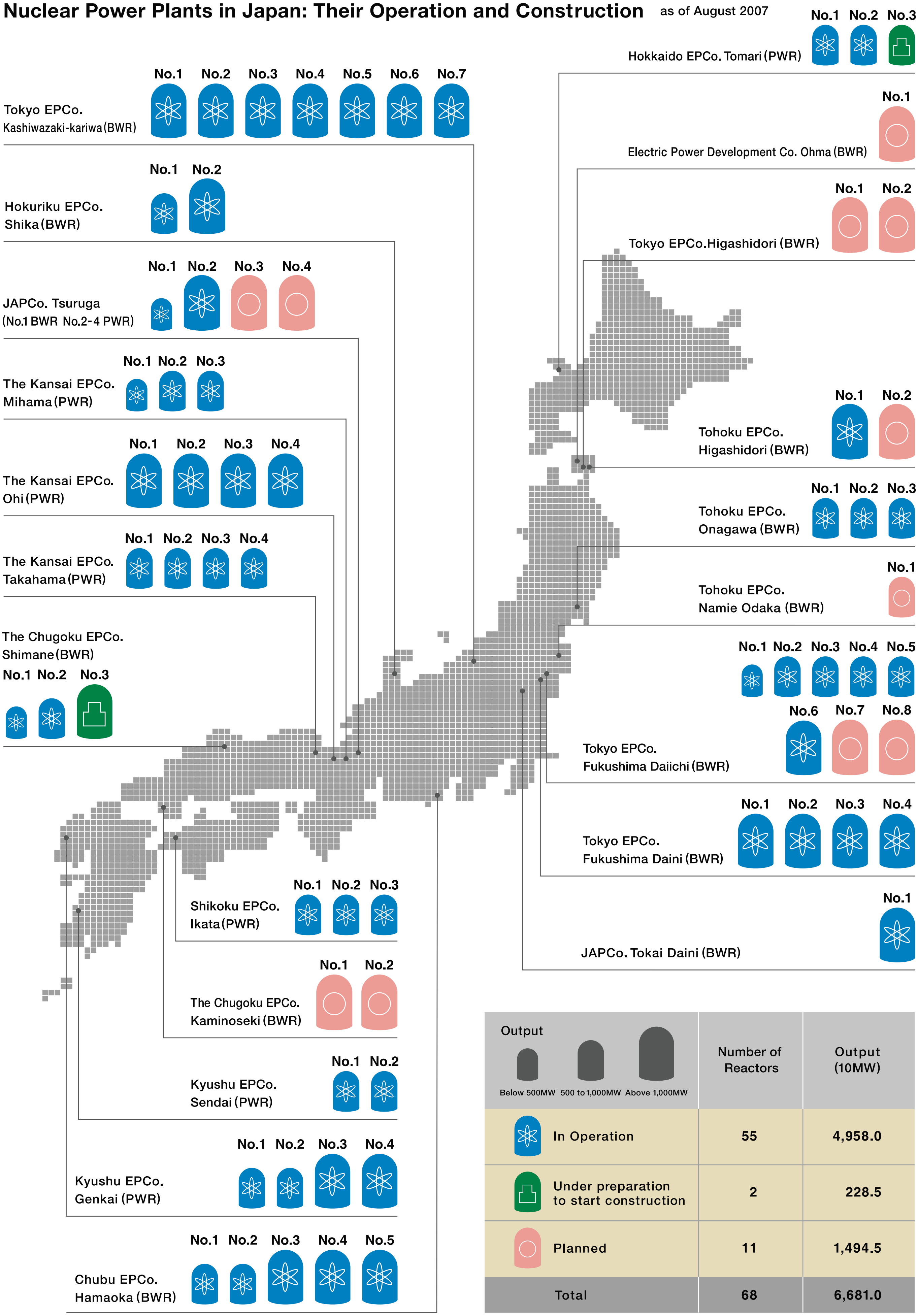
Electricity Supplied by Nuclear Power Reactors in 2006



Source: IAEA Press Release 2006

Nuclear Power Plants in Japan: Their Operation and Construction

as of August 2007



Output (Below 500MW / 500 to 1,000MW / Above 1,000MW)	Number of Reactors	Output (10MW)
In Operation	55	4,958.0
Under preparation to start construction	2	228.5
Planned	11	1,494.5
Total	68	6,681.0

b.Improved Efficiency of Power Facilities

Improved thermal efficiency in thermal power stations and reduced power loss during transmission and distribution are closely related to energy conservation and CO_2 emissions control. Operating within limitations caused by the fact that Japan has no significant natural resources of its own, the electric power industry has constantly made efforts to ensure the efficient utilization of energy sources. These include the construction of large-scale power generation facilities with higher thermal efficiency from improved steam conditions (temperature and pressure). Thermal efficiency and transmission/distribution loss factor in Japan are currently among the best in the world.

Shin-Nagoya Thermal Power Station Series No.7, Chubu Electric Power Co., Inc. (LNG)

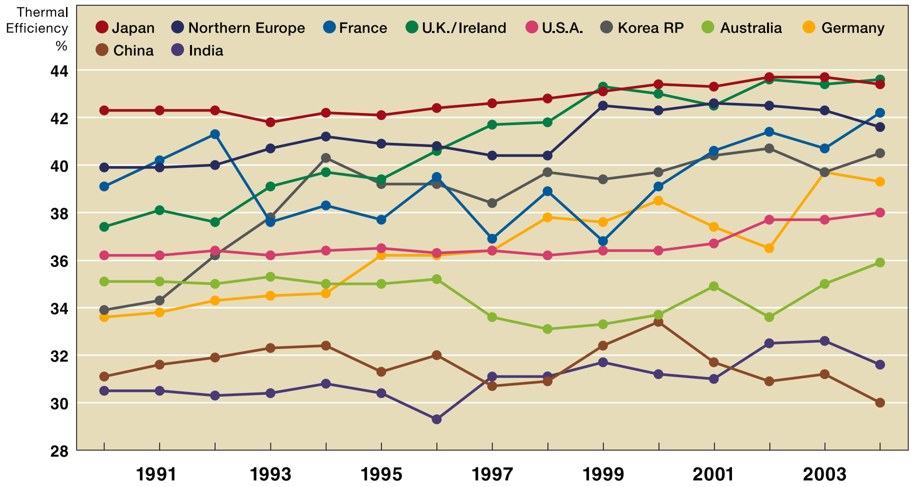
Comparison of thermal power plant efficiency in Japan with other countries

Sources: Updated Comparison of Power Efficiency on Grid Level, 2007 (Ecofys)

*Thermal efficiency is the gross generating efficiency based on the weighted averages of efficiencies for coal, petroleum and gas (low heat value standard).

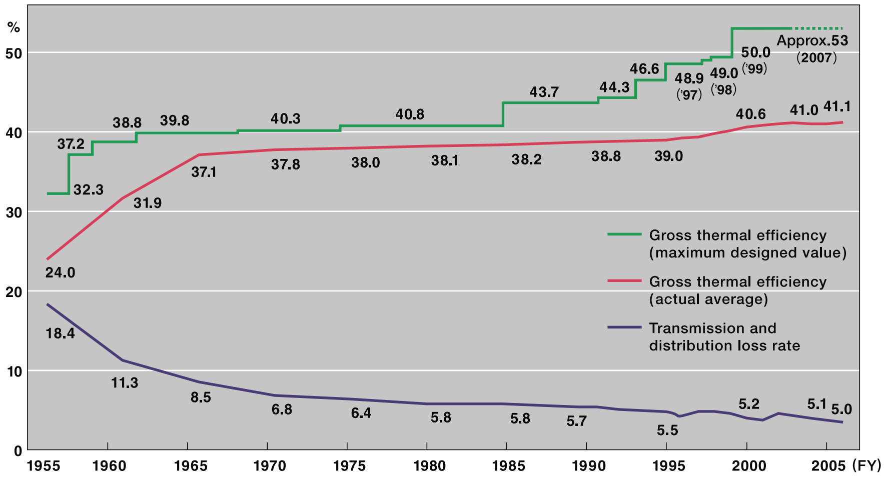
*Comparisons are made after converting Japanese data (high heating value standard) to low heat value standard, which is generally used overseas. Low heat value figures are around 5-10% higher than high heat value figures.

*Private power generation facilities, etc. not covered.

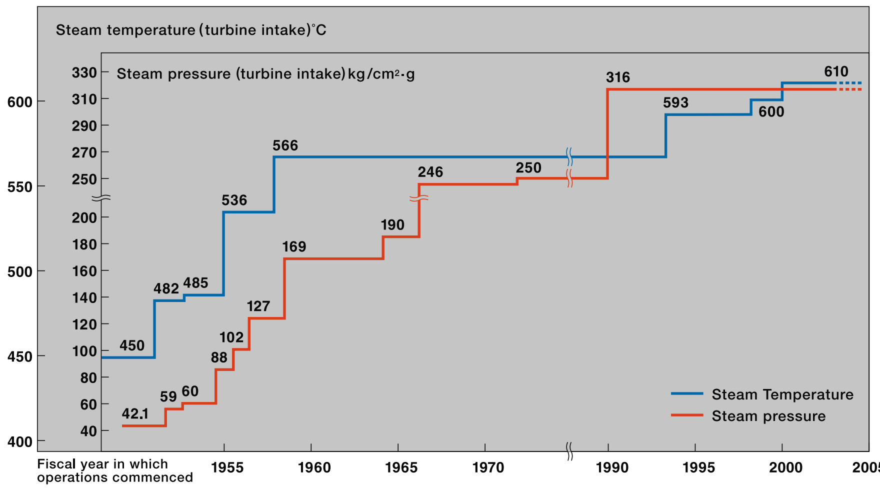


Improvements in Thermal Efficiency (High Heat Value) and Transmission/ Distribution Loss factor in Thermal Power Generation Facilities

Source: Japan Electric Utilities Handbook etc. (2007)



Improvements in Steam Temperature and Pressure in thermal Power Generation Facilities



c.Promoting Load-leveling in Power Demand

Electricity usage is subject to considerable variations according to the season and the time of day. Reducing these demand fluctuations, or load-leveling, helps raise the efficiency of existing power-generating facilities and reduce the necessity of constructing new power stations, thus contributing to energy conservation and environmental protection. In particular, load leveling is strongly recommended as a governmental policy in the Kyoto Protocol Target Attainment Plan because load leveling has a significant effect on CO_2 emission reduction. In practice, the industry's specific load-leveling measures are as follows:

① Extended use of regenerative systems

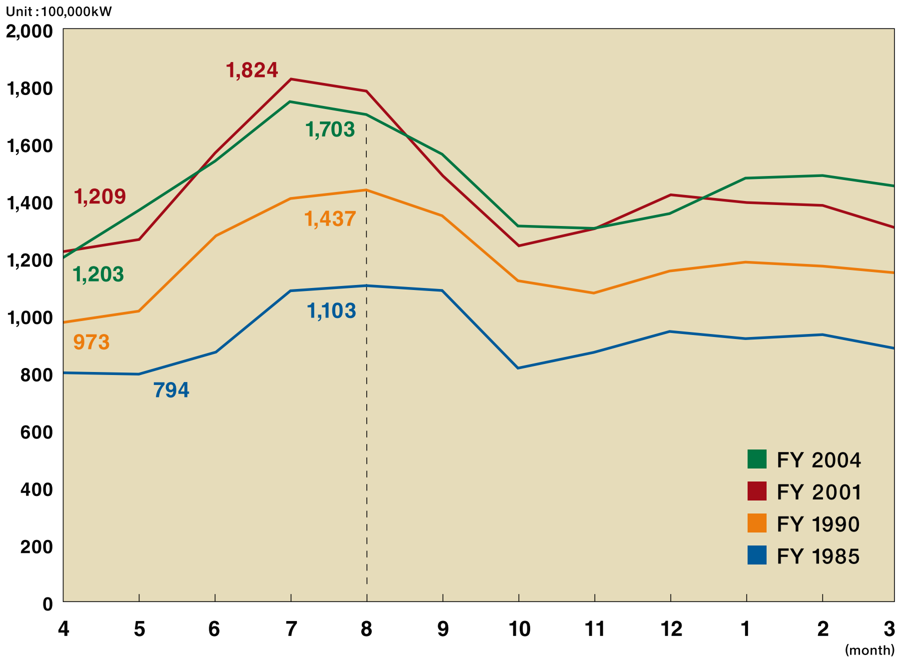
Regenerative systems contribute to load-leveling by storing heat at night when the electricity load is lower and using cold/warm thermal heat stored in a thermal storage tank during the day. A highly efficient heat pump adopted as a heat source unit ensures considerable energy conservation effects due to the release of higher heat quantity than input energy, the rated operation that makes the most of thermal heat stored at night during the day and the improved efficiency while regenerating heat using the cool outdoor air at night.

② Load leveling with electricity rate systems

Electricity rates are structured to offer consumers options based on the season or a time band, nighttime usage and the regeneration adjustments contract. The electric power industry uses these electricity rate menus as an indirect means to level power demand.

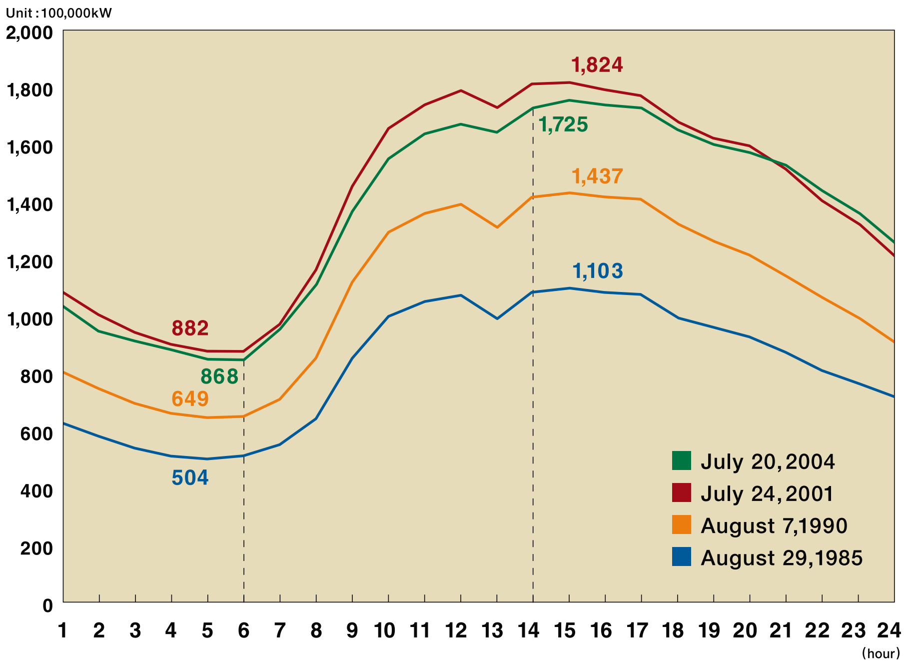
Monthly Electric Power Consumption

(Annual Load Curve) Ten companies combined



Variations in Daily Electric Power Consumption

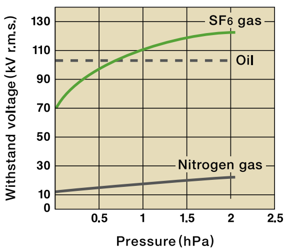
(Daily Load Curve) Ten companies combined



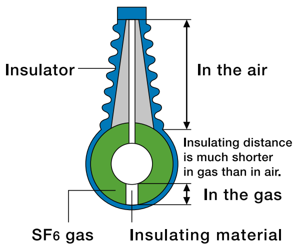
d. For the Use of Sulfur Hexafluoride (SF_6)

SF_6 gas, a compound of fluorine and sulfur, features excellent insulation, arc-extinguishing capabilities and stability, as well as being safe for human beings. In the electric power industry, SF_6 is often used for gas circuit breakers (GCB) and gas-insulated switch gear (GIS). Equipment can be configured in a compact package and because of its high level of safety and compatibility with the environment, its application has become vital in Japan to ensure stable power supplies. On the other hand, SF_6 has been said to have a high global warming potential. At the Third Conference of Parties to the UN framework Convention on Climate Change held in Kyoto in 1997, it was listed as a gas to be restricted under the Kyoto Protocol. Because an effective insulating gas that substitutes for SF_6 has not been found and the electric power industry will have to continue to use SF_6 in the future, the industry has set voluntary targets for emissions from these devices at the time of inspection (about 3%) and at their retirement (about 1%) from the viewpoint of promoting the recycling and the restricting of emissions of SF_6 as much as possible. These commitments were formulated in the "Voluntary Action Plan on SF_6 Emission Restrictions in the Electric Power Industry" in April 1998, and corresponding measures were taken later.

Excellent insulation

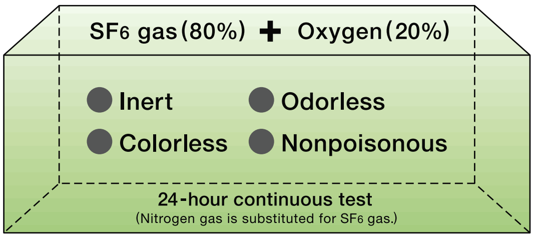


Comparison of dielectric strength

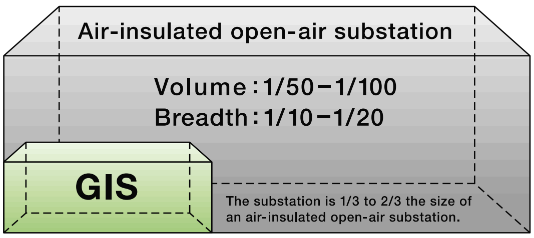


Insulating distance

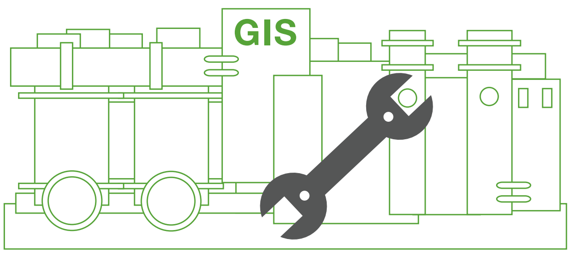
Safe and stable gas



Environmentally harmonious without requiring a large space



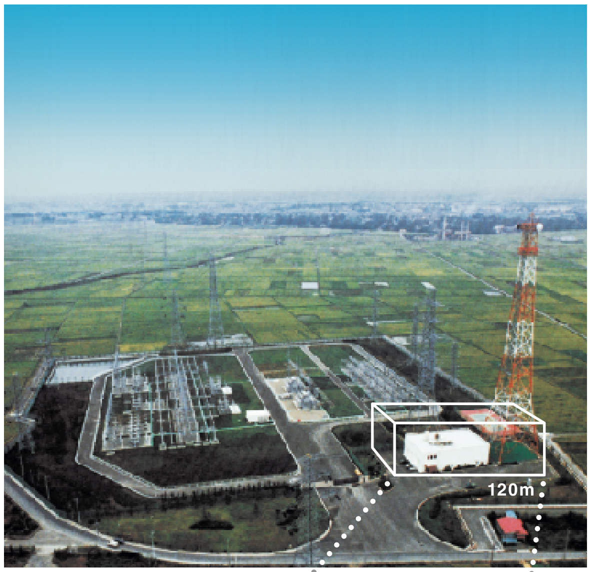
Maintenance operations can be rationalized



Comparison of both substation types

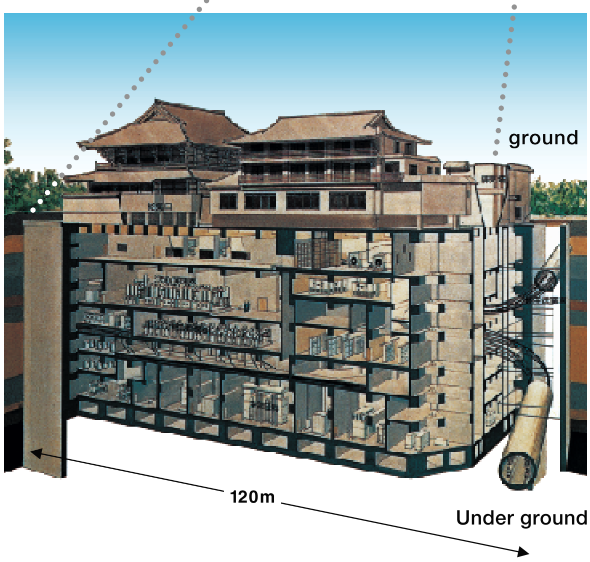
An air-insulated-type open-air substation

Kitakumagaya-Substation, Tokyo Electric Power Co. (275kV, 900MVA)



A gas-insulated-type underground substation

Takanawa-Substation, Tokyo Electric Power Co. (275kV, 1080MVA)



Efforts to Environmental Protection and

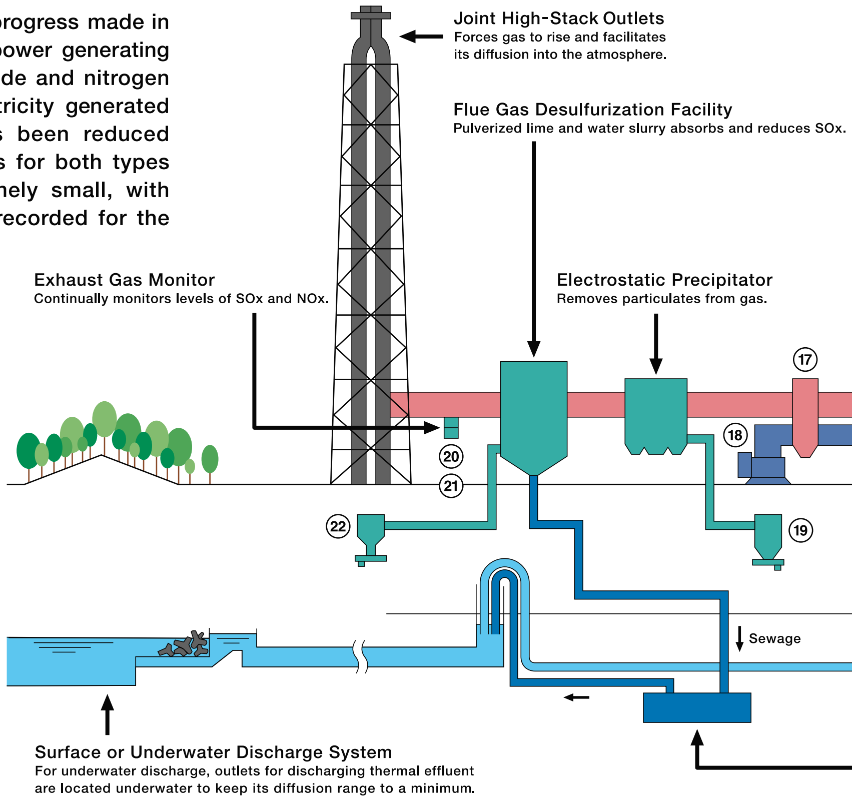
When establishing thermal, nuclear and other power-generating facilities, comprehensive environmental impact studies are carried out to assess air and water quality, noise, vibration, organisms and the possible effects on the surrounding environment. Information obtained is submitted to national and municipal authorities for approval, and conveyed to the residents of the area for their understanding. Since they rely almost completely on imports for fuel and utilize seawater as a coolant in their condensers, thermal and nuclear power stations in Japan are located along the coast. The seawater is used to cool steam generated in the station, and is consequently warmer when released back into the ocean. In light of this fact, when designing condensers and cooling water pumping stations, measures to minimize the effect of the thermal effluent on the surrounding marine environment, such as the reduction of difference in temperature between inflowing and outflowing water and the control of flow speeds, are implemented in accordance with the local conditions. Even after a power station has commenced operations, continuing efforts are made to ensure that the assessments made in the environmental impact

(1) Protection of the Atmosphere

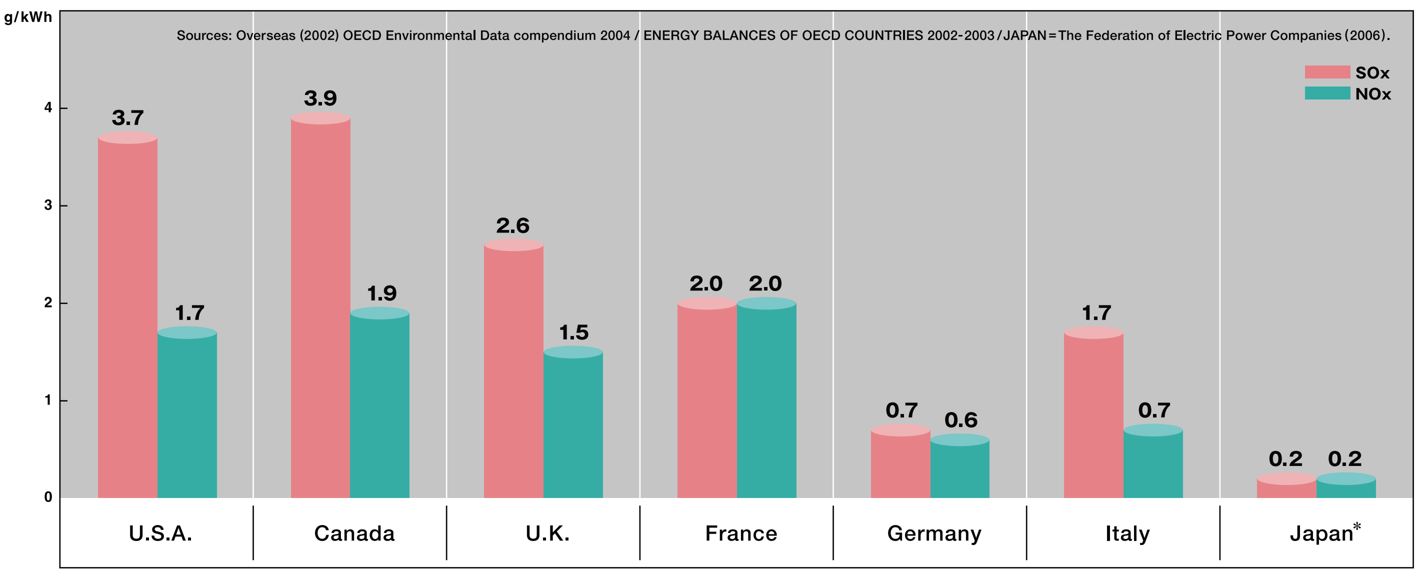
a. Reduction of SOx

From the mid-1970's, through progress made in improving fossil-fuel quality and power generating facilities, the volume of sulfur oxide and nitrogen oxide emissions per unit of electricity generated by thermal power in Japan has been reduced drastically. At present, the values for both types of noxious emissions are extremely small, with figures one digit lower than the recorded for the six leading OECD countries.

1 Net to Keep Out Jellyfish	12 Safety Valve Muffler
2 Curtain Wall	13 Feed Water Pump
3 Intake	14 Boiler
4 Screen	15 Gas Mixing Fan
5 Cooling Water Pump	16 Ammonia Injector
6 Switch	17 Air Heater
7 Soundproofing Wall	18 Forced Draft Fan
8 Main Transformer	19 Ash Treatment Equipment
9 Generator	20 NOx Continuous Measurement Facility
10 Steam Turbine	21 SOx Continuous Measurement Facility
11 Condenser	22 Gypsum



SOx and NOx Emissions per Unit of Electricity Generated by Thermal Power in Each Country



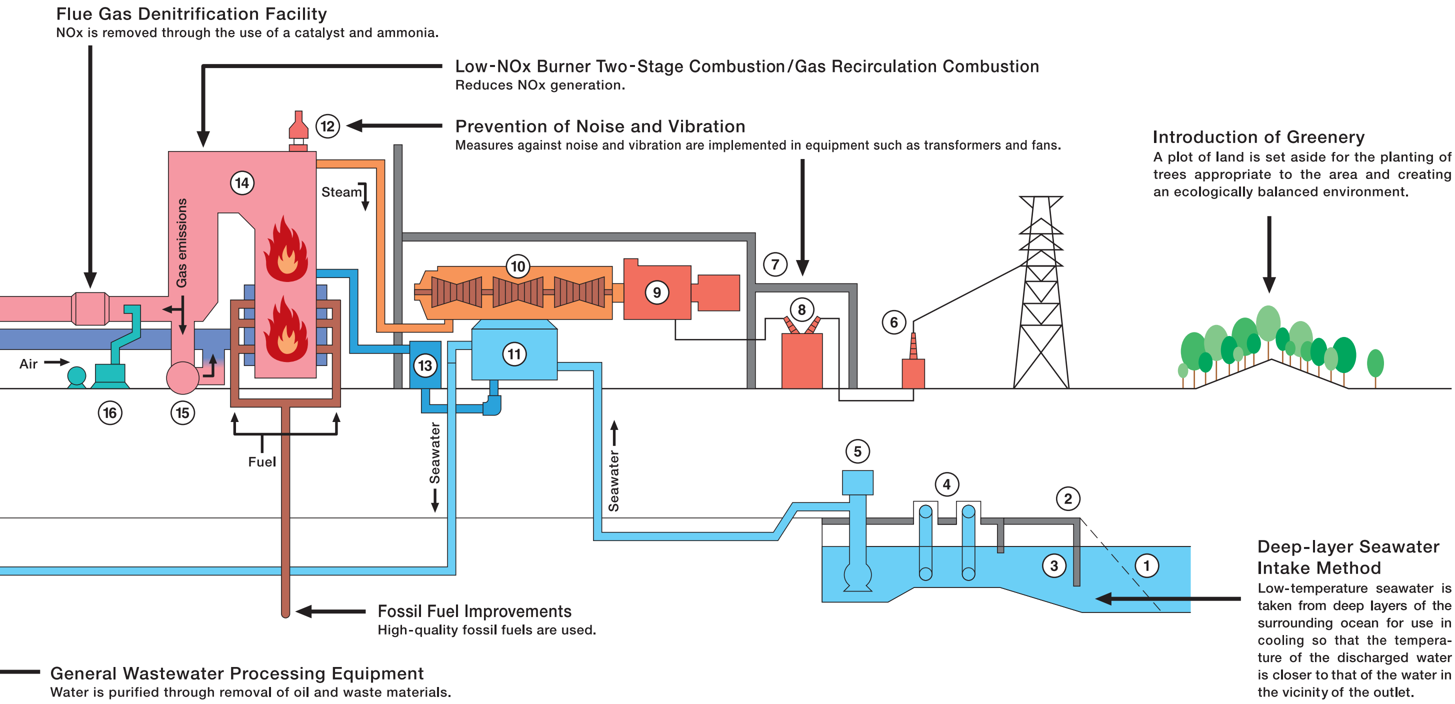
*(10 electric power companies and Electric Power Development CO.,LTD)

studies are fully observed. In comparison with other countries, Japan follows extremely stringent environmental quality and emission level standards. In addition, through agreements with municipal authorities, regional emission levels are often much lower than nationally prescribed standards. To highlight the industry's commitment to environmental protection, the following examples focus on atmospheric and water quality conservation measures, efforts to control wastes, anti-noise and anti-vibration measures, greening programs and environmental assessment procedures.

Yanai Thermal Power Station (LNG), The Chugoku Electric Power Co. Coastal Power Station

and NOx Emissions

Environmental Protection System in Thermal Power Station



Operation of SOx Treatment Facilities

1960s	1970s	1980s	1990s
1963 Research and Development of Wet-Type Desulfurization	1972 Research at Test Plant; 1973 Establishment of Full-Scale Facilities →	→	→
1963 Research into Dry-Type Desulfurization; 1966 Research at Test Plant	1972 Establishment of Full-Scale Facilities →	→	→
Activated Carbon Method Active Manganese Oxide Method	1967 Research at Test Plant		

Operation of NOx Treatment Facilities

1970s	1980s	1990s
1972 Use of Two-Stage Combustion and Exhaust-Gas Recirculation →	→	→
1973 Development of Low-NOx Burner Facilities →	→	→
1973 Research and Development of Flue Gas Denitrification; 1977 Beginning of Research Operation for Practical Application		
1977 Introduction of Flue Gas Denitrification Facilities →	→	→

b. Keep the Air Clean

The industry actively promotes a “Keep the Air Clean” policy with regard to fuel, equipment and operating procedures. Emissions of air pollutants such as sulfur oxides, nitrogen oxides and particulates are reduced through an appropriate combination of these three elements.

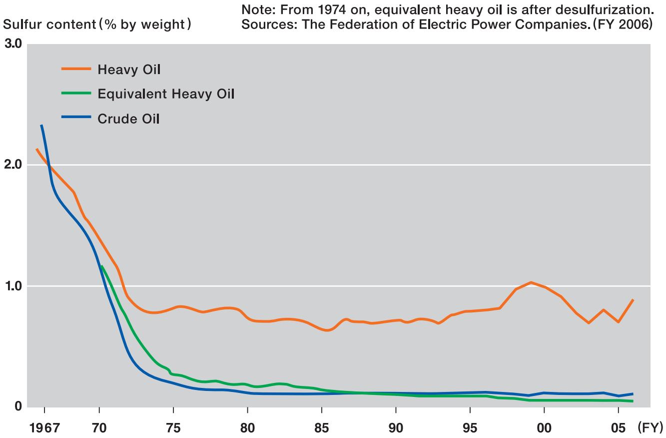
1. Fuel

Continuous reduction of SOx, NOx and particulate emissions is being achieved through the use of high-quality fuels such as heavy/crude oil and coal grates with low sulfur and nitrogen and LNG that contains no sulfur or particulates.

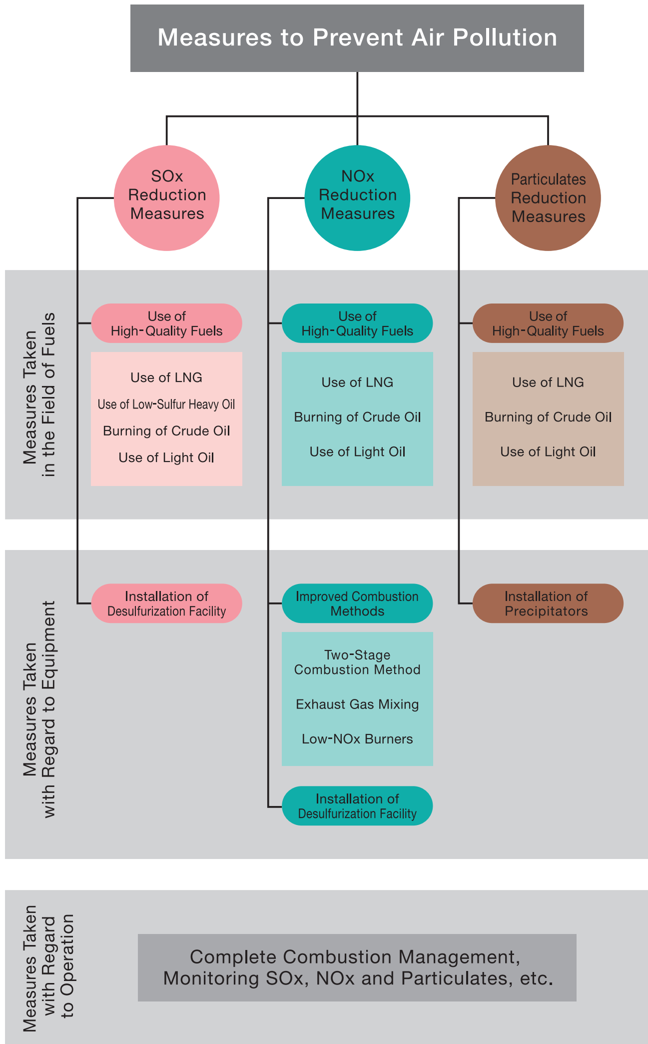
Shin ooita Thermal Power Station (LNG), Kyushu Electric Power Co.

Changes in Sulfur content of Fuels

Note: From 1974 on, equivalent heavy oil is after desulfurization.
Sources: The Federation of Electric Power Companies. (FY 2006)



Outline of Measures to Prevent Air Pollution



2. Equipment

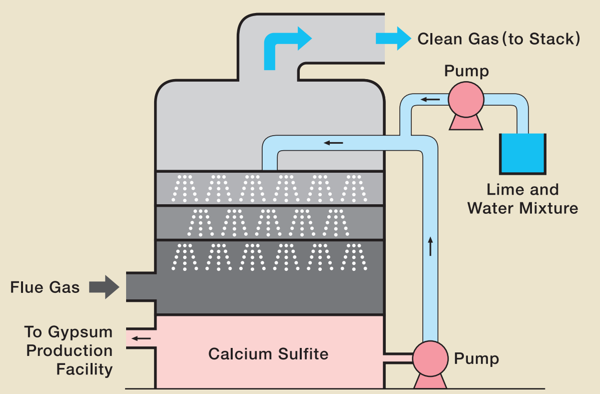
In addition to the above-mentioned measures, the following measures are taken with regard to equipment.

SOx

Sulfur oxides can be removed through the installation of desulfurization facilities using the wet-type lime-gypsum process. In recent years, high-efficiency flue gas desulfurization facilities capable of removing over 90% of SOx have been installed in Japan.

Flue Gas Desulfurization Facility
Reihoku Thermal Power Station (Coal), Kyushu Electric Power Co.

Configuration of Desulfurization Facility



The limestone is powdered and mixed with water. When this is blown as a mist into the flue gas, the sulfur oxides within the exhaust gas react with the lime to form calcium sulfite. This is combined with oxygen, reacting to form gypsum.

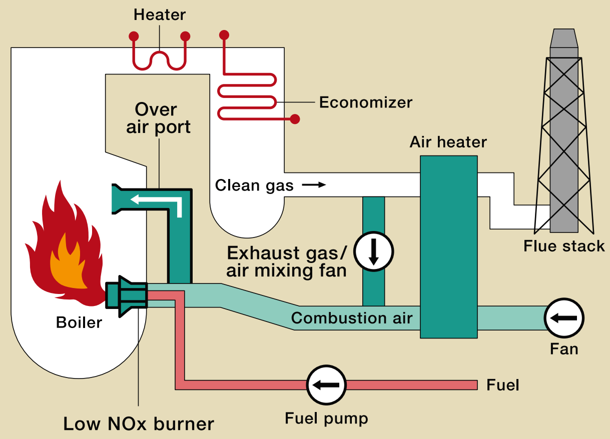
NOx

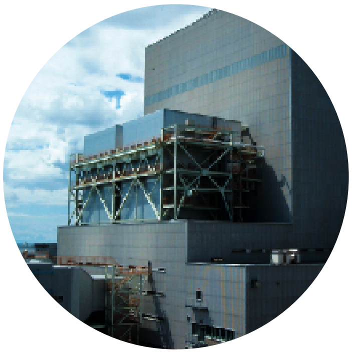
NOx can be controlled and reduced through improved combustion methods and the use of flue gas denitrification facilities. A combination of these methods and facilities is used in Japan. High-efficiency flue gas denitrification facilities capable of removing approximately 90% of NOx produced are operating in the latest combined-cycle LNG thermal power plants located near major urban centers.

- **Mixing of exhaust gases with air**
  In this method, part of the exhaust gases from the boiler are mixed with air for combustion.
- **Two-stage combustion**
  In this method, the air volume required for complete combustion of fuel is supplied in two stages: at the burner inlet and at the burner top (over air port).
- **Low-NOx burner**
  This method improves the way in which fuel is atomized and air is supplied.

All of the above techniques result in a reduced combustion temperature and are therefore capable of controlling the generation of nitrogen oxides (NOx).

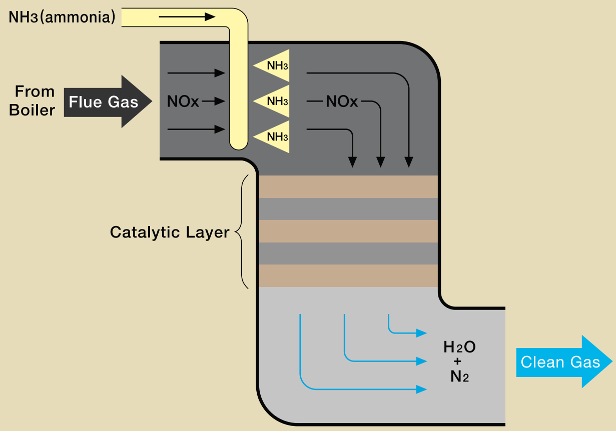
NOx Emission Control Measures Based on Improvements in Combustion Efficiency





Flue Gas Denitrification Facility
Tomatoatsuma Power Station No.4,
Hokkaido Electric Power Co., Inc. (coal)

Configuration of Flue Gas Denitrification Facility



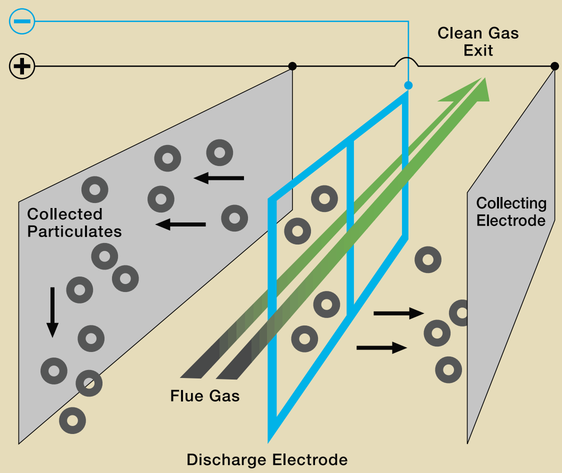
When ammonia is added to the flue gas, which includes NOx, and passed through the catalytic layer, the catalyst causes the NOx to separate into nitrogen and water.

Particulates

In order to reduce particulates, which include unburned carbon in heavy/crude oil combustion and fly ash in coal combustion, power producers in Japan have installed high-efficiency electrostatic precipitators which remove over 80% of particulates in almost all heavy/crude oil combustion and over 99% of particulates in coal combustion.

Electrostatic Precipitator
Saijo Thermal Power Station
(Coal, petroleum),
Shikoku Electric Power Co.

Configuration of Electrostatic Precipitator

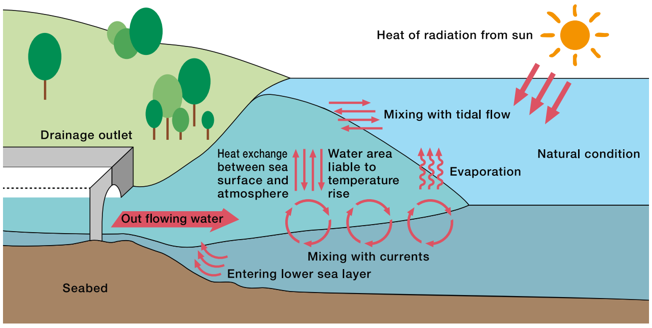


The electrostatic precipitator uses a voltage differential between two electrodes to extract and collect particulates.

(2) Conservation of Water Quality

a. Warm Discharged Water

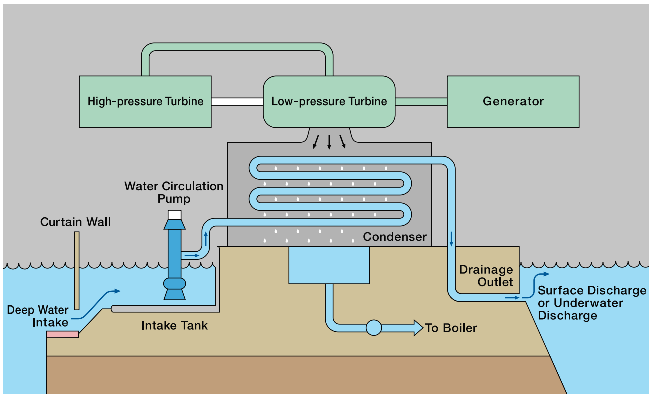
A thermal power station discharges approximately 40-45m^3/s per 1 million kW of warm waste water. Combined-cycle power generation, employing a combination of gas and steam turbine, offers higher efficiency and produces only about 60% of the aforementioned quantity of warm waste water. A nuclear power plant, with its different steam conditions, generates about 50% more waste water, which rapidly cools down and takes on the same temperature as the surrounding seawater when it mixes with the currents and the tidal flow, and also when heat is dissipated into the atmosphere.



Flow of Warm Waste Water

1. Warm Discharged Water Using Deep-Layer Seawater for Cooling

In the past condensers for cooling water in thermal and nuclear power stations were designed for a temperature rise of 8-10℃, but from the mid-1970's they have been designed for a temperature rise of 7℃ or lower. A system now in use pumps up water from the deep layers of the sea to be used as cooling water in the power plant, and discharged after cooling so that the temperature difference between the discharged water and the seawater around the discharge aperture is minimized. This means that the warm waste water from the power station is discharged into the surface layer of the sea to make use of the large surface area for more efficient heat dissipation into the atmosphere and seawater. In some cases, the waste water is discharged into the middle layer of the sea to achieve a more rapid cooling process. The warm effluent cools down quickly as it mixes with the currents and is swept away into the surrounding seawater.



Cooling Water System at Thermal Power Station

2. Effect of Warm Waste Water on Marine Environment

Long-term monitoring studies have been conducted at thermal and nuclear power stations for a predetermined period to assess the effect of warm waste water on the marine environment. The results have shown that while marine life is subject to certain natural variations, especially seasonal changes, there are no particularly noteworthy changes on a yearly basis. Scientific field studies and experiments at power stations in various parts of Japan have been conducted independently by the Marine Bio-Environment Research Institute, an organization under the joint jurisdiction of the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Environment, and the Ministry of Economy, Trade and Industry. The results of the institute's studies have likewise confirmed that warm waste water has little effect on the marine environment.

Marine life study in the vicinity of the project site.

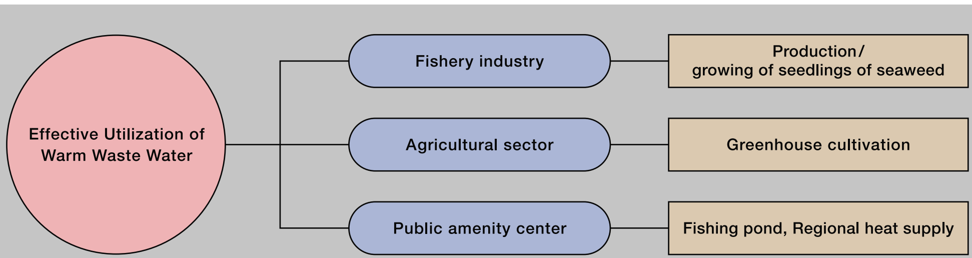
Ornamental plants grown in greenhouse
Takahama Power Station, The Kansai Electric Power Co.

3. System for Effective Utilization of Warm Waste Water

Heat contained in warm waste water from power stations can be effectively used in a variety of fields to suit specific conditions in the surrounding area. For example, a fish-breeding center or a research institute for seeds and saplings can be set up in the vicinity of a power station. These can make beneficial use of warm waste water from the power station. A public amenity center, an agricultural crop cultivation station, or an angling/fishing pond could also benefit from the warm waste water supply offered by a power station.

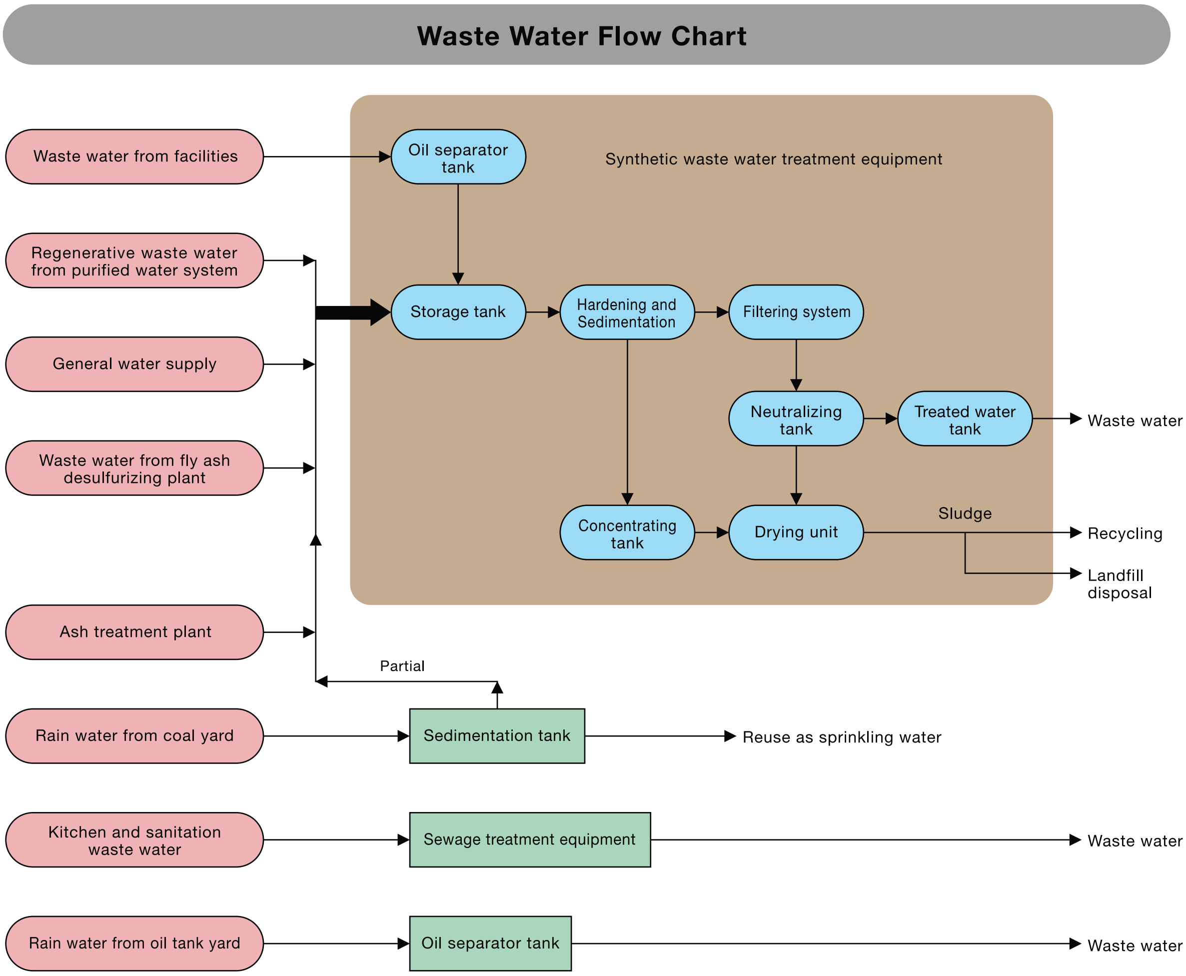
Fish breeding center in Fukushima Prefecture, Using warm waste water from the No.1 Fukushima Power Station, Tokyo Electric Power Co.

System for Warm Waste Water Utilization



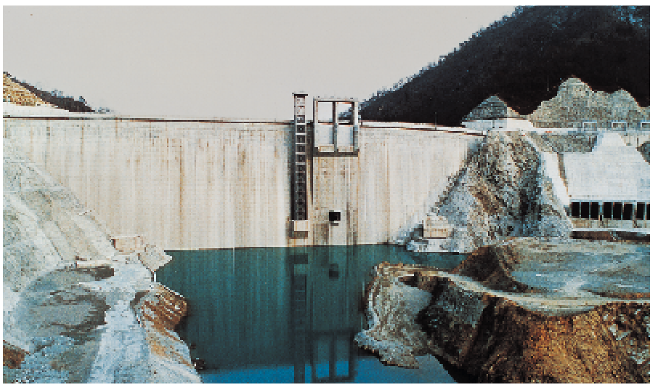
b. Dealing with Waste Water in Thermal Power Station Complexes

Rain water, waste water related to sanitation and other types of waste water resulting from the operation of thermal power plants are treated in a neutralizing, coagulation and sedimentation system, an oil separator and other systems. Waste water is discharged into the sea only after it has been fully treated.

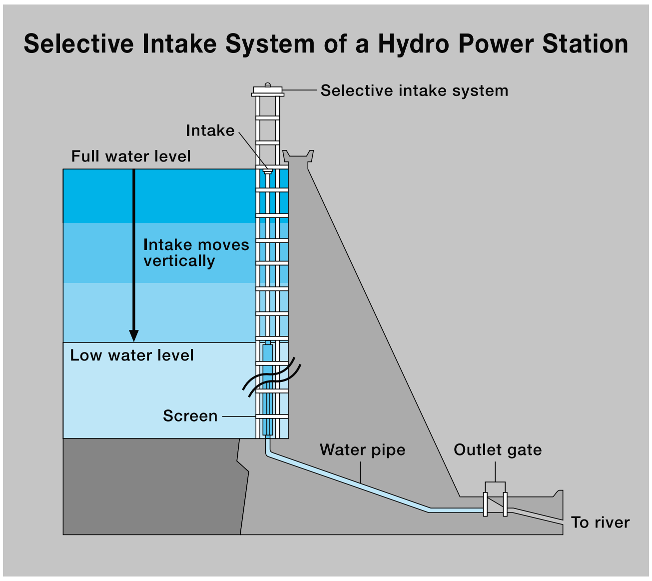


c. Water quality control at hydro power station

The selective intake system has been commonly installed at recently constructed hydro power station. The system, which enables to adjust the depth of withdrawing water from a reservoir, aims at preventing low-temperature or turbid water of the reservoir from discharging to the downstream.



Sabigawa Dam using selective intake system Tokyo Electric Power Co.



(3) Management of Waste

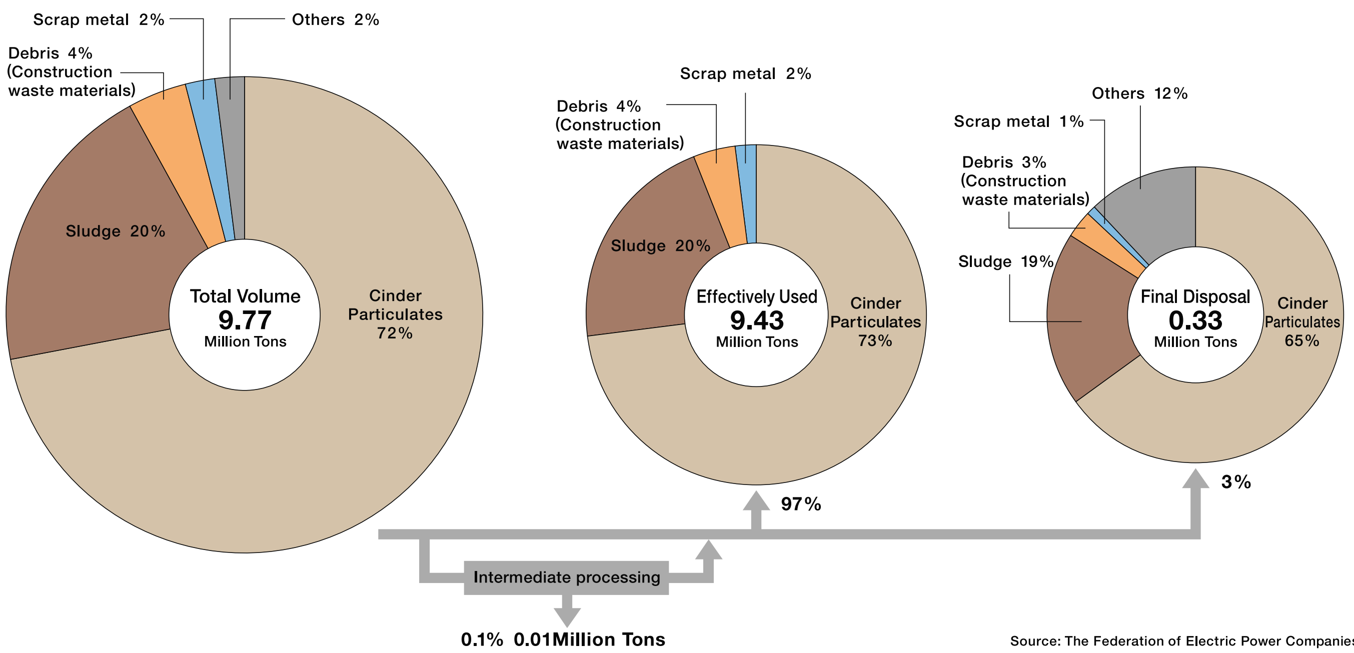
a. Recycling and Reuse of Wastes

Major waste materials include coal ash from thermal plants, debris (construction waste materials) related to power distribution works, such as scrapped concrete electricity poles; scrap metal, including electric wires; and desulfurizing gypsum, an important by-product produced in thermal power stations. Every possible effort is made by the industry to efficiently reuse waste products as resources in other industrial sectors. Approximately 97% of all coal ash, which is produced in large volume, is used for cement production, civil engineering works or as a landfill material, whereas all of the desulfurizing gypsum is used in the cement and construction industries. Through research and development, the industry will work to expand the areas in which coal ash in particular can be effectively used. The recycling of used office paper is also being vigorously promoted, especially in urban areas. A system has been established in which office buildings in a given area cooperate as a single unit sharing know-how on used-paper separation and collection and using fixed, common collection days. This system is beneficial in terms of both volume collected and collection/transport costs.

Recycling and Reuse of Wastes

Type of waste	Intermediate treatment	Application of recycled wastes
Scrapped concrete from electricity poles	Crushing-removal of steel reinforcement	Road bed material-raw material for iron production
Coal fly ash-desulfurizing gypsum		Cement-making material Construction materials
		Desulfurizing agent
Heavy petroleum ash	Bulk reduction by incineration	Vanadium recovery
		Cement-making material
Shells	Incineration	Soil enhancer-sludge hardener
	Crushing-washing	Cement-making material
	Drying-crushing	Fertilizer
Insulator scrap	Crushing-iron core extraction	Brick/tile-making material
Protective conduit pipes Wire-support guarding	Crushing-thermoforming	Plastic products
Wire sheathing waste	Crushing-thermoforming	PVC products
Waste oil		Fuel
Office waste paper	Recycling	Recycled paper-toilet paper

Waste Materials from Electric Power Industry Fiscal 2006



Source: The Federation of Electric Power Companies.

b. Recycling of Construction Wastes

Efforts are made by the electric power industry to recycle waste materials generated in construction work, including concrete blocks, asphalt/concrete slabs, wood, and excavated soil.

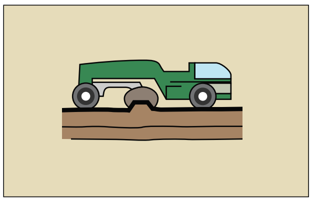
Concrete Blocks


Concrete blocks or lumps from structural demolition work


Concrete blocks are crushed to a size of 0-40mm dia.

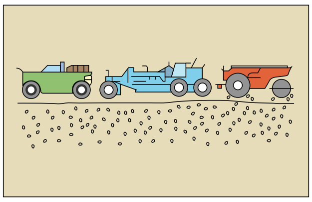

Used for laying temporary road bed to support heavy machinery

Asphalt / Concrete Slabs and Blocks


Removal of asphalt surface

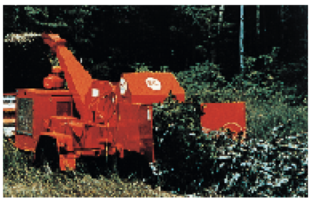
1. Crushing for reuse as road bed material
2. Crushing with subsequent heat treatment to obtain recycled asphalt mixture

Transportation torecycling facility


Road surfacing with recycled asphalt mixture

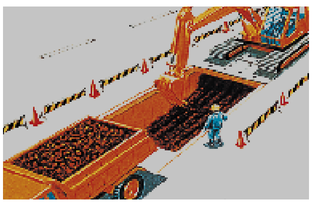
Wood

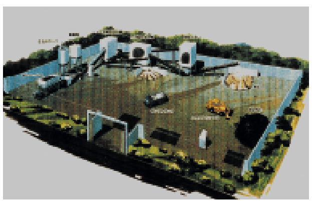

Cutting of tree branches

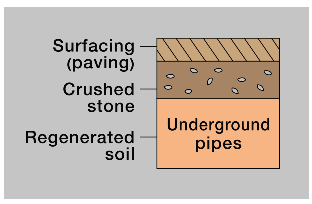

Converting wood to chips


Use as fertilizer or mulch

Recycling of Excavated Soil (Currently Under Study)


Trench excavation work


Recycling plant for excavated soil

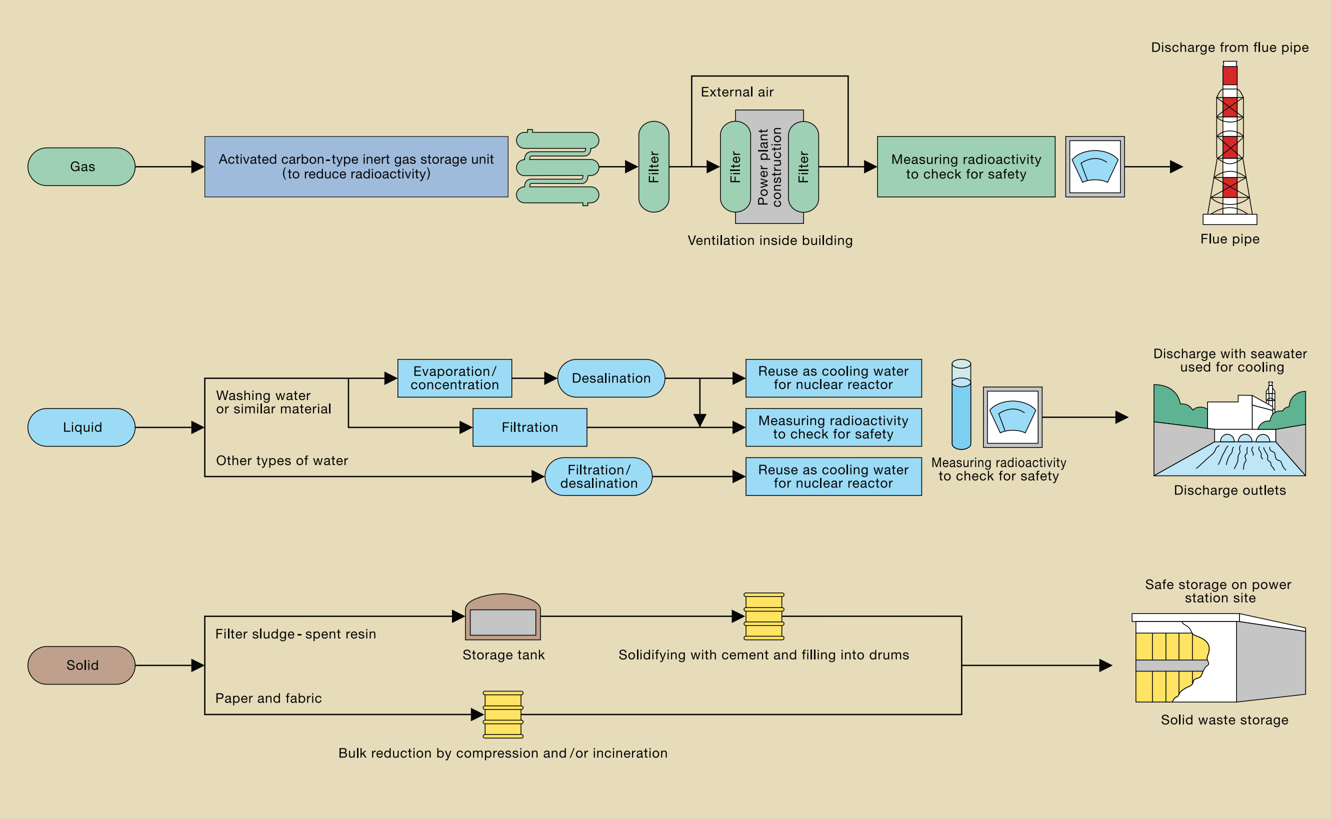


Refilling of excavated trench

c. Treatment of Radioactive Wastes

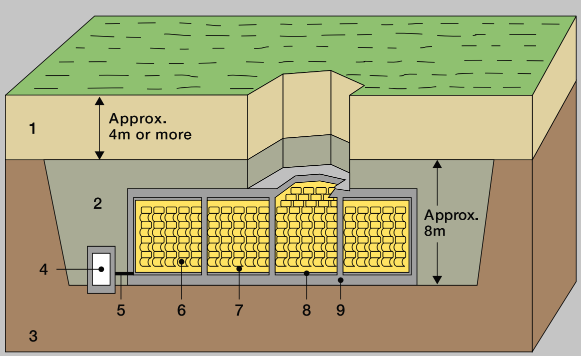
Because of radioactive content, wastes from nuclear power stations fall under a different category from ordinary industrial wastes, and are subject to very stringent control under current government regulations. Radioactive wastes are graded low-level or high-level, depending on radioactive concentration levels. Whether low-level or high-level, all radioactive wastes require disposal methods that do not affect the environment.

Disposal of Radioactive Wastes



Example of Buried Low-Level Radioactive Waste

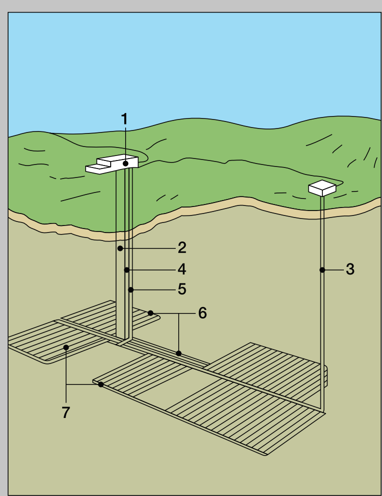
1. Top soil
2. Covering with bentonite-mixed soil
3. Rock bed
4. Inspection corridor
5. Waste water pipe
6. Drum
7. Cement-based filler
8. Porous concrete layer
9. Steel-reinforced concrete pit



Note: Bentonite is virtually impermeable to water.

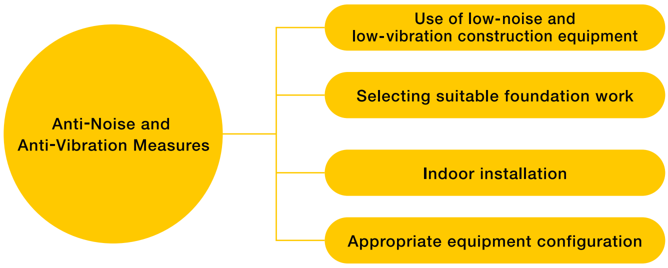
Concept of Underground Disposal of High-Level Radioactive Wastes

1. Ground reception facility
2. Vertical shaft for canister delivery
3. Vertical shaft for ventilation
4. Vertical shaft for human and material access
5. Vertical shaft for emergency access
6. Main tunnel
7. Disposal tunnel



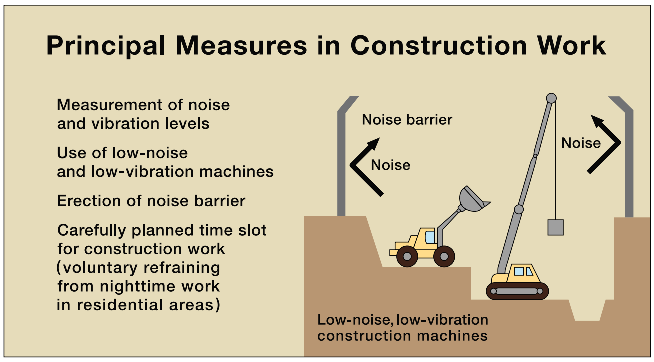
(4) Reducing Noise and Vibration

Noise and vibration in power stations and substations are reduced by installing generators and transformers indoors, or by selecting low-noise and low-vibration equipmentand installing sound absorbers and sound barriers. To cut down noise and vibration further, the equipment is installed on reinforced foundations, and at a maximum distance from neighboring residential areas. Starting from the design stage, measures against noise and vibration are also considered in the construction of buildings as well, and sheds, low-noise and low-vibration construction machines and methods are selected, and a noise barrier is erected during construction.




Safety valve silencer


Soundproofing wall

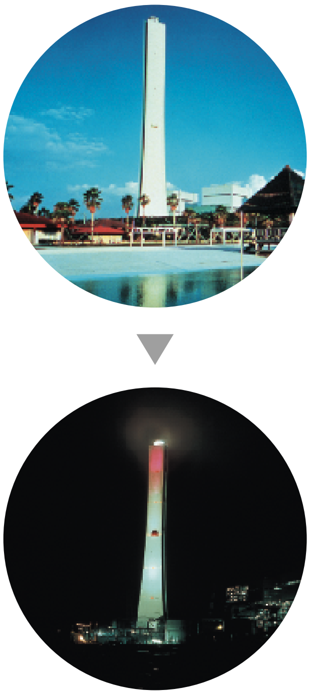


(5) Greening and Environmental Considerations

The scenic aspects of the surrounding natural environment are taken into consideration in power plant construction projects with provisions for the planting of trees and greenery. Specifically, as measures to preserve scenery, the industry gives consideration in its designs to the shape of on-site buildings, their layout and color schemes, and also keeps land alteration and tree clearing to an absolute minimum. Green belts are created around the facilities, on the outer perimeter of the site, and along the main roads, and greenery projects are otherwise actively conducted using trees and shrubs suited to the location. More than 20% of a new power plant site is set aside for green areas. When recreational facilities such as tennis courts and baseball grounds are added to this, the total area accounts for more than 25% of the plant site. Green belts around power plant facilities are home to a rich variety of wildlife such as wild birds, insects and small animals. Both the green areas and recreational facilities are open to local residents, thus helping build closer relations with the community.

Power Plants and Their Surrounding Environments


Yanai Power Station (LNG), The Chugoku Electric Power Co.


Nanko Thermal Power Station (LNG), The Kansai Electric Power Co.

A Power Plant Surrounded by Rich Foliage

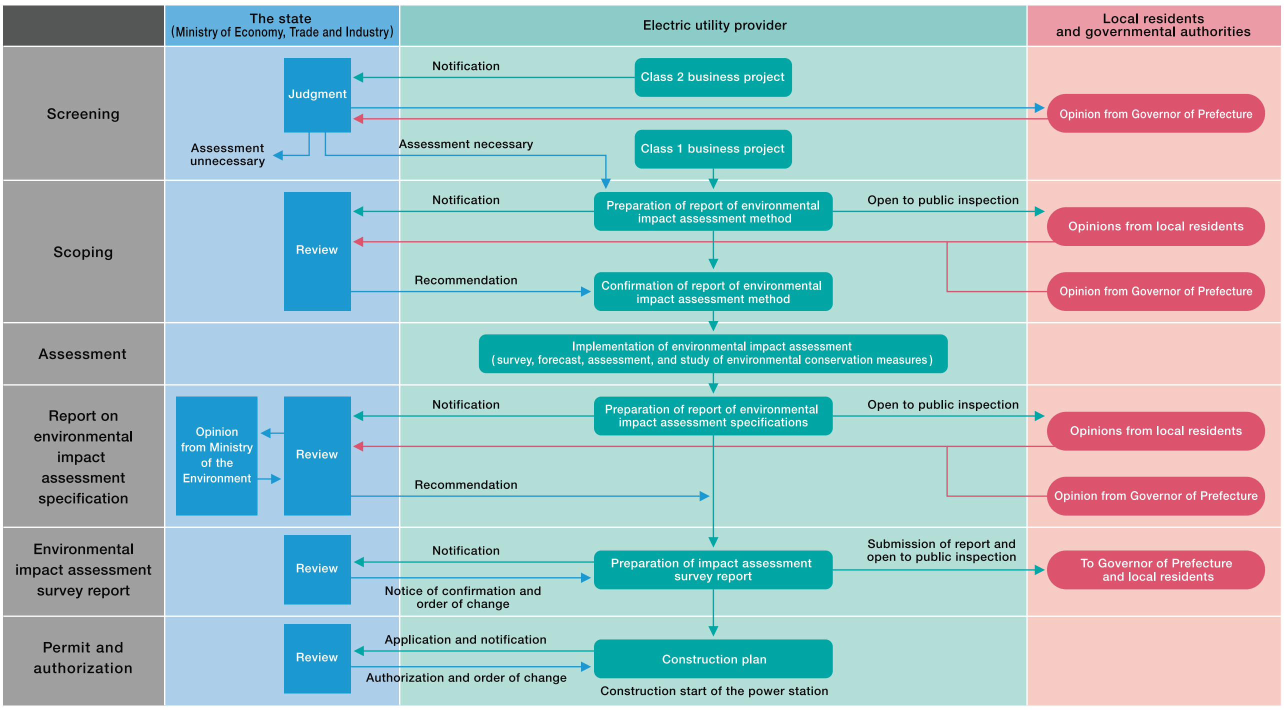

Niigata Thermal Power Station (Petroleum, LNG), Tohoku Electric Power Co.


Futtsu Thermal Power Station (LNG), Tokyo Electric Power Co.

(6) Environmental Impact Assessment

The Ministry of International Trade and Industry's July 1977 directive "Enforcement of Environmental Impact Assessment and Environmental Review for the Construction of Power Plants" provided a clearly defined framework of rules and regulations on environmental impact assessments, based on experience accumulated from about 130 cases. The Cabinet's August 1984 directive "Implementation of the Environmental Impact Assessment Law" similarly provided a guideline for the industry's activities besides power generation plant operation such as reclamation of land. Following the Basic Environment Law implemented in November 1993, legislation on environmental impact assessments were studied, and the Environmental Impact Assessment Law was legislated in June 1997 and then fully enforced in June 1999. At the same time as this Environmental Impact Assessment Law was introduced, the Electric Utility Law was modified to stipulate specific procedures for impact assessment related to power stations, such as a review by the Ministry of International Trade and Industry. The new assessment system under these two relevant laws-the Environmental Impact Assessment Law and the Electric Utility Law-requires that the opinions of local residents and governmental authorities be solicited earlier in the process (screening and scoping procedures) than was the case previously.

Flow Chart of Environmental Impact Assessment (For a thermal power station)



a Screening ▶ **b Scoping** ▶ **c Implementation of assessment** ▶ **d Report of environmental impact assessment specifications** ▶ **e Environmental impact assessment survey report** ▶ **f Authorization of the construction plan**

a The new assessment system requires environmental assessments of all businesses larger than a certain size (class 1 business project). Even for smaller businesses (class 2 business project), the State may decide whether the assessment should be implemented after listening to the opinion of the prefectural governor.

b The electric utility provider must prepare a report on the environmental impact assessment method that describes survey, forecast, and assessment methods, as well as items of environmental impact assessment, and openly submit it for public inspection. Implementation of assessment and proper survey items will be decided (scoping) after listening to the opinions of local residents and autonomous communities and receiving a review by the State.

c The electric utility provider must conduct surveys, forecast sand assessments based on the method stipulated according to the scoping procedure and study environmental conservation measures.

d The electric utility provider must prepare a report on environmental impact assessment specifications in which assessed results are contained and openly submit it for public inspection. As with the report on environmental impact assessment method, the report on environmental impact assessment specifications is subject to the opinions of local residents and autonomous communities, as well as a State review.

e The electric utility provider must carefully study the outcome of the State's review and the opinions of local residents and review the report of environmental impact assessment specifications to prepare an environmental impact assessment survey report. This report shall be submitted to the relevant local governmental authorities, receive a final confirmation by the State and local residents shall be informed through a process that is open to public inspection.

f The State ascertains that the construction plan complies with the environmental impact assessment survey report.

Business Projects Subject to Environmental Impact Assessment
(for a power station)

	Hydroelectric power stations	Thermal power stations	Geothermal power stations	Nuclear power stations
Class 1 business project	30 thousand kW or above	150 thousand kW or above	10 thousand kW or above	For all scales
Class 2 business project	22.5 to 30 thousand kW	112.5 to 150 thousand kW	7.5 to 10 thousand kW	——


Air quality survey


Public meeting to explain environmental assessment to local residents

Environmental Elements for Environmental Impact Assessment
(Example of a power station)

Maintenance of good conditions of the environment's natural constituents	Aerial environment (air quality, noise, vibration)
	Water environment (water quality, surface soil quality, water flow orientation, flow velocity)
	Topography, geological survey
Preservation of bio-diversity and systematic preservation of natural environment	Animals
	Plants
	Ecology
Securing good places for contact between people and nature	Natural scenery
	Places for contacts with the nature
Load on environment	Waste etc.
	Gases with global warming effect

(7) Control of Chemical Substances

Since 1997, the electric power industry has worked to determine the actual status of emissions and transfers of chemical substances released from power stations even before the enforcement of the Law Concerning Reporting etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management (PRTR Law) through its autonomous surveys on the target chemical substances, which have been increased in number step by step. In April 2002, the notification system began operation in accordance with the PRTR Law. Each power company now precisely records and reports released and transferred quantities of the targeted chemical substances under the Law for every business establishment. The emissions and transfers of chemical substances for fiscal 2006 are shown in the table on the right. The industry will continue to endeavor for its appropriate control and maximum reduction of emissions of these chemical substances.

Total Release and Transfer of Chemical Substance (Results for fiscal 2006)

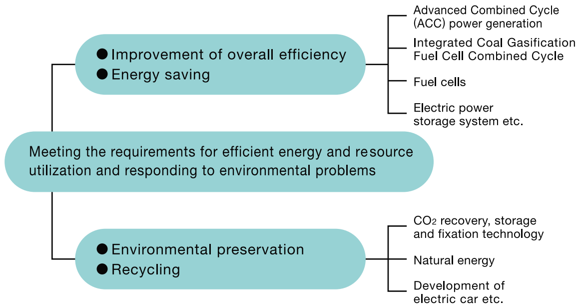
Chemical codes	Chemical	Volume released to the environment (kg/year)				Volume transferred (kg/year)		Application, etc.
		Air	Water	Soil	Landfill	Sewage	Others	
16	2-Amino ethanol	0	0	0	0	0	4,700	Feed water-processing agent
26	asbestos	0	0	0	0	0	150,000	insulating material, sealing material etc.
30	Bisphenol A type epoxy resin	140	0	0	0	0	0	Used in painting
40	Ethylbenzene	48,000	0	0	0	0	100	Used in painting
43	Ethylene glycol	3,900	0	0	0	0	0	Heat-source water for heat supply equipment
63	Xylene	140,000	0	0	0	0	680	Used in painting, power-generation fuel
121	Dichlorodifluoromethane (CFC-12)	500	0	0	0	0	0	Air conditioning refrigerant
124	2,2-dichloro-1,1,1-Trifluoromethane (HCFC-123)	1,300	0	0	0	0	0	Air conditioning refrigerant
144	Dichloropentafluoro-propane (HCFC-225)	10,000	0	0	0	0	0	To launder clothing
162	Dibromotetrafluoro-ethane (Halon 2402)	2,000	0	0	0	0	1,800	Fire extinguishing material
177	Styrene	15,000	0	0	0	0	4,400	Used in painting, Plastic fixation agent
179	Dioxins	12	0.057	0	0	0	26	Waste incinerators
227	Toluene	16,000	0	0	0	0	4.6	Used in painting, power-generation fuel
253	Hydrazine	11	2,500	0	0	0.8	890	Feed water-processing agent
286	Bromo-trifluoromethane (Halon-1301)	0	0	0	0	0	1,200	Fire extinguishing material
299	Benzene	150	0	0	0	0	0	Power-generation fuel, Painting
307	Poly-alkyl ether	0	0	0	0	0	9,200	Anti-scattering agent for coal storage
311	Manganese and its compounds	0	310	0	0	0	1,700	Wastewater treatment agent
353	Tris-phosphate (dimethyl phenyl)	0	0	0	0	0	19,000	Turbine control oil

* Chemical codes represent the number assigned to each chemical under the PRTR Law. * Volume transferred is the amount transferred from the plant for processing as waste, etc. Units in this table for release and transfer volumes for dioxin substances are measured as [kg/year→mg-TEQ/year].
* Figures for dioxin substances represent sum totals that include release and transfer volumes from those establishments designated in the Law Concerning Special Measures against Dioxins. Figures for all other substances represent sum totals that include release and transfer volumes from each establishment that handles at least one ton of the Type I chemical substances specified in the PRTR Law or at least half a ton of the special Type I chemical substances specified by this law.
* It has been confirmed that the volume of dioxin released or transferred is within the emission limits stipulated in the Law Concerning Special Measures against Dioxins.

4 Efforts to Technical Development

Japan's electric power industry has a long-standing commitment to technical development in a wide range of fields with a view to achieving greater efficiency in the use of energy and natural resources and the protection of the environment. This commitment is directed at the areas shown in the diagram.

Outline of Research and Development

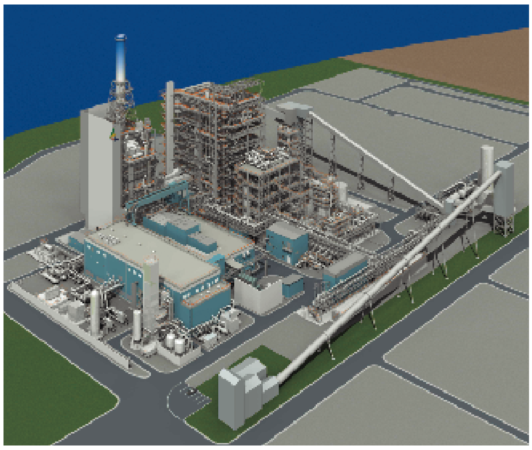


(1) Improvement of Overall Efficiency and Energy Saving

a. Integrated Coal Gasification Combined Cycle (IGCC) Power Generation

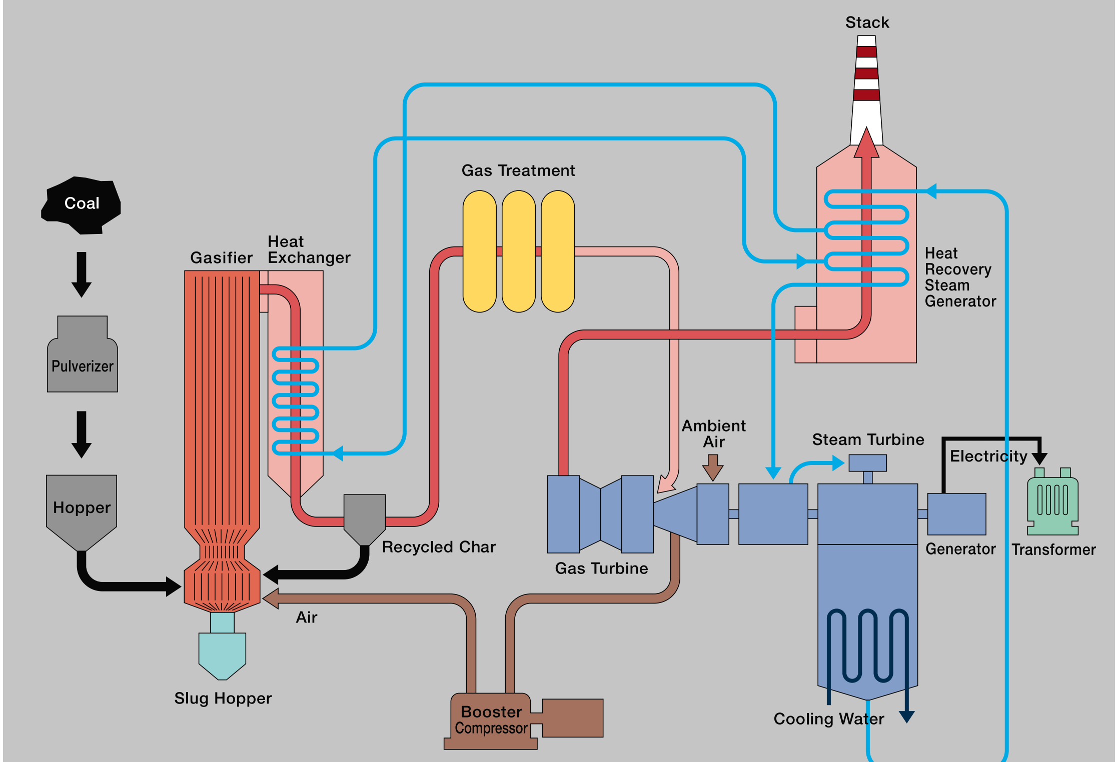
The IGCC process leads to efficient power generation using coal-gasified fuel, in which a gas turbine and a steam turbine are combined. This process extends fuel sources, with an estimated power generating efficiency of 48%-50%, which is higher than that of conventional powdered-coal-fired systems, and is expected to be a next generation coal-fueled technology. Therefore, trial IGCC power generation and related research were conducted from 1986 to 1996 with the participation of the major power companies at a pilot plant to demonstrate the economic and technological viability of basic IGCC system technology. Clean Coal Power R&D CO., LTD., was established in 2001 by nine power companies, Electric Power Development Co., Ltd. and the Central Research Institute of Electric Power Industry, and it is committed to an R&D project with a demonstration IGCC plant (250,000-kW class).

Birds-eye view of the IGCC demonstration plant



Source: Clean Coal Power R&D CO., LTD.

Structure of Integrated Coal Gasification Combined Cycle Generation system

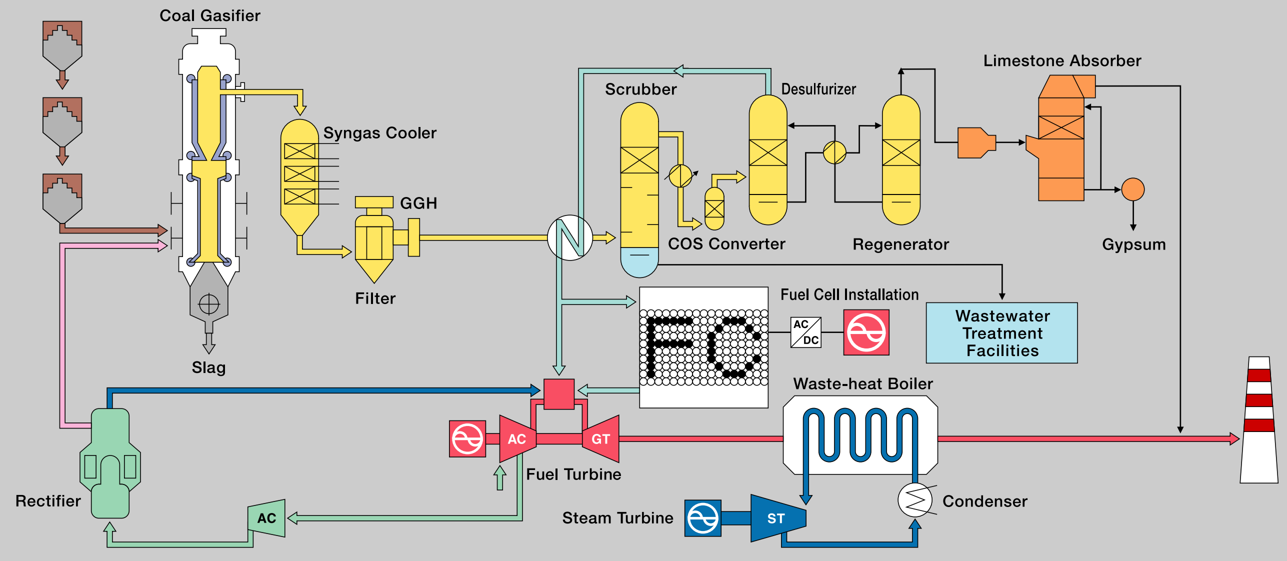


Source: Clean Coal Power R&D CO., LTD.

b. Integrated Coal Gasification Fuel Cell Combined Cycle

The plant for integrated coal gasification fuel cell combined-cycle consists of a gasifier, gas turbine, stream turbine, etc. The efficiency of power generation using an integrated coal gasification fuel cell combined-cycle exceeds 53%. R&D efforts for this system are under way.

Structure of Integrated Coal Gasification Fuel Cell Combined Cycle Generation system

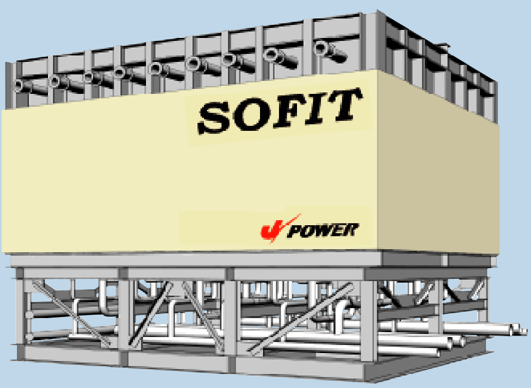


c. Fuel Cell Power Generation

The fuel cell directly uses an electrochemical reaction, which is the reverse reaction of electrolysis of water. In contrast to conventional thermal generation systems, the fuel cell does not burn fuel, and therefore, it is highly efficient, and is gaining at tention as an environmentally friendly way to generate electricity. R&D is going on especially for high-temperature fuel cells — molten carbonate fuel cells (MCFC) and sold oxide fuel cells (SOFC) — with an eye to their application in thermal power substitutive plants owning to their high generating efficiency and potential for various ways of fuel usage.

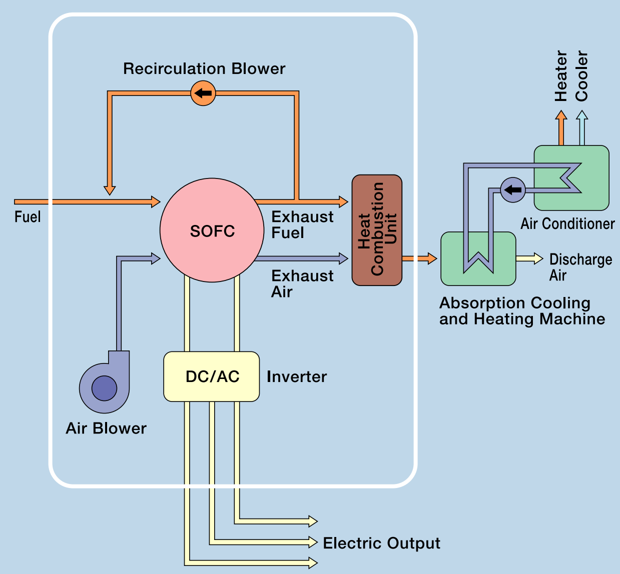
Current State of Development

For MCFC, success was achieved in fiscal 2004 for the world's first high-pressure (1.2 MP) operation with those fuel cells by long-term operation of the pressurized small-scale power generation system and high efficiency modules, showing the potential for larger units. The electric utility industry is developing a normal-pressure 150-kW class SOFC, among the largest in the world, to be used in the electric utility industry etc., and has started tests since January 2007 to be carried out for 1 year.



150-kW class cylindrical stack solid oxide fuel cell (SOFC) module

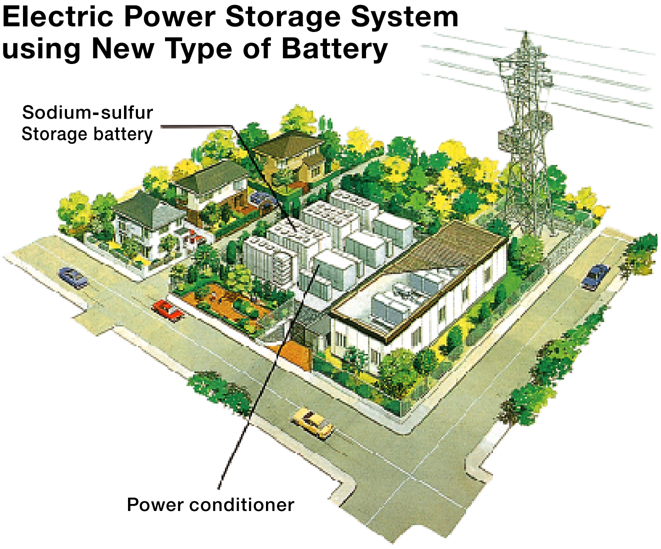
SOFIT System Flow

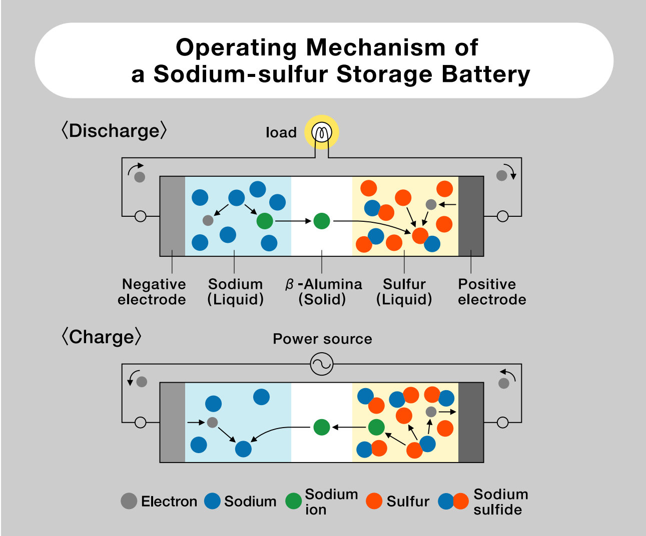


d.Power Storage System

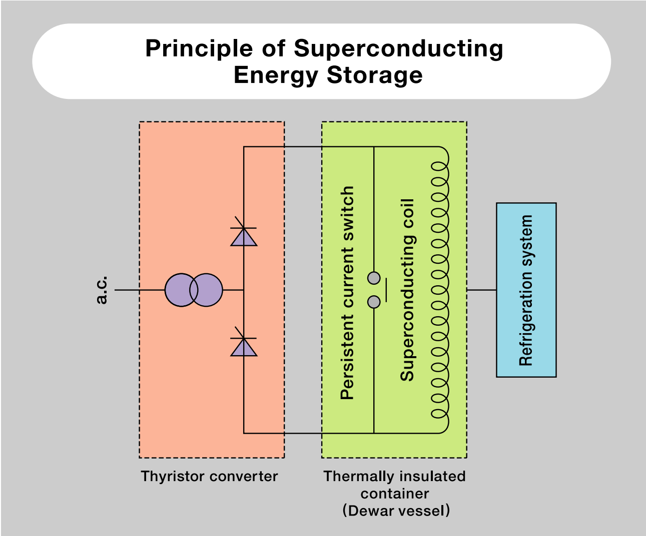
As the electric power demand pattern in Japan has more pronounced peaks, the electric power industry is asked to control and shift peak demand and equalize the daily load curve. In an effort to achieve this, the electric power industry has developed power storage systems to improve the annual load distribution and upgrade efficiency in power plant utilization.

Electric Power Storage System using New Type of Battery





Superconducting Magnetic Energy Storage (SMES)



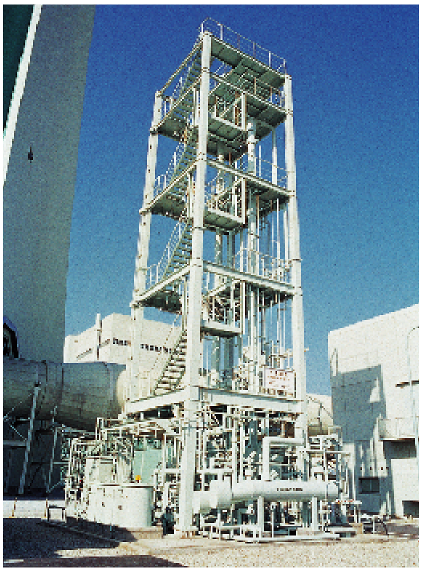
	Features	Present situation	Commercialization
Electric power storage using new types of batteries	Electric energy is converted to chemical energy for storage in a power storage system. When required, electric power is supplied through reverse reaction which converts chemical energy back to electric energy. Compared with conventional lead accumulator batteries, new types of batteries have features such as higher standards of energy storage density, efficiency and compactness. (1) Sodium-sulfur cell: The theoretical energy density of these compact sealed cells at high-temperature operation (350℃) is about four times that of conventional batteries. (2) Redox flow cell: Designed for use at normal temperatures, this type of cell features a simple construction and can be mass-produced without problem.	Dozens of MW class systems have been commercialized.	Already used for practical applications.
Superconducting Magnet Energy Storage (SMES)	Energy storage in the form of electromagnetic energy is performed by passing a persistent current through a superconducting magnet coil in an electric power storage system which provides access to the energy when required.	Superconducting electric power networks control technology is being developed for the period of FY 2004 through FY 2007.	After the year 2020

(2) Environmental Conservation and Recycling

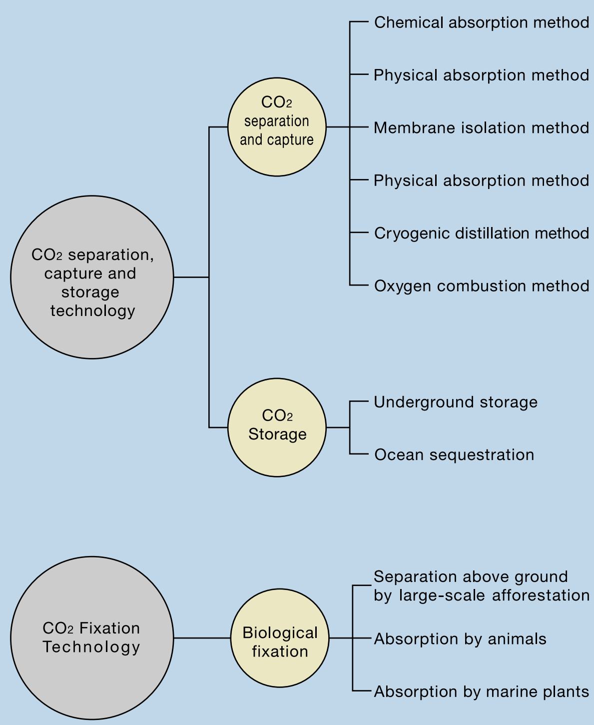
a. Development of CO_2 Recovery, Storage and Fixation Technologies

Japan's electric power industry is pressing forward with research and development work on the removal, separation, sequestration and fixation of carbon dioxide contained in flue gases from fossil-fuel power plants. Different methods for CO_2 control are currently under consideration. Upon completion of appropriate environmental impact studies, increased research and development work will be carried out with international cooperation.

Flue Gas CO_2 Recovery Pilot Plant
Nanko Thermal Power Station, The Kansai Electric Power Co.

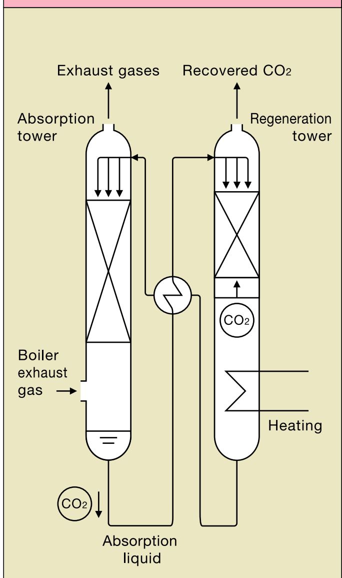


Technologies of CO_2 Recovery, Storage and Fixation



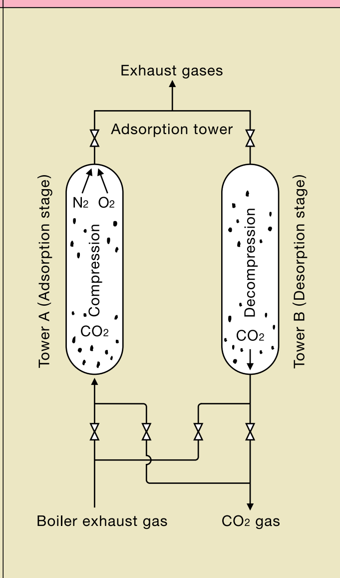
Principle of CO_2 Separation and Recovery Technologies

Chemical absorption



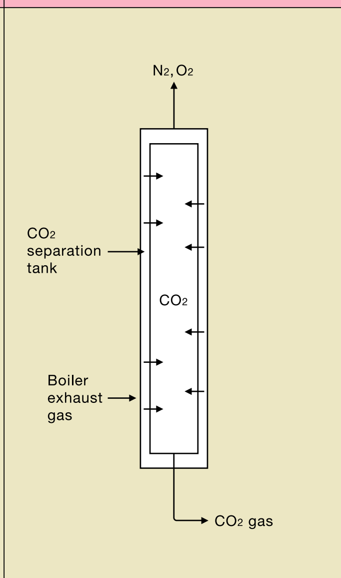
CO_2 is recovered and separated by using chemical reaction between CO_2 and absorption liquid; CO_2 is released from absorption liquid by heat application process.

Physical adsorption



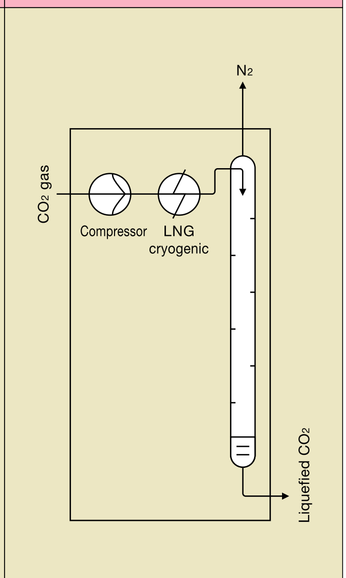
CO_2 is adsorbed on a solid adsorbent capable of readily adsorbing CO_2 by compression. The adsorbed CO_2 is then released and separated for recovery by decompression.

Membrane separation



CO_2 is separated on a macromolecular membrane by making use of the differences in the permeability coefficient of the various gases passed through the membrane.

Cryiogenic separation



The CO_2-containing fuel gas is compressed and liquefied and the CO_2 is separated for recovery by distillation.

Research & Development of CO_2 fixation by organisms

Japan's Electric Power Industry is carrying out R&D of afforestation etc. as an effective means of reducing atmospheric CO_2 concentration.

R&D of Technologies for Mangrove Afforestation

Joint research by The Kansai Electric Power Co., Inc., Kansai Environmental Engineering Center Co., Ltd., and Marine and Coastal Resources in Thailand.

A research project for regenerating mangrove forests at damaged former sites of shrimp-raising ponds or tidelands is ongoing. The effective utilization of mangrove forests silvo-fishery, combining afforestation with fisheries, is actively pursued in view of regional development.

Field Afforestation Test (Former site of a shrimp-raising pond in Khanom,Thailand) The tree height of planted mangroves was originally 60 cm, and they have grown to approximately 2.0m after 3 years.

Research on Estimation of Carbon Sink of Forest Ecosystems

Research project of Tokyo Electric Power Co. (TEPCO)

Research plots were constructed in beech, fir, and larch forests, which were typical types of forest in TEPCO owned land in Oze area, to evaluate the carbon sink of each type of the forest ecosystems including the vegetation and the soil. A direct measurement of CO_2 flux between the atmosphere and the forest ecosystem has been carried out above the crown of the trees. Measurements for growth of the vegetation, litter fall, and soil respiration have been also carried out and the results will be integrated to evaluate the carbon sink of the forest ecosystem.

b.New Forms of Natural and Other Energy Sources

With a firm commitment to confront global environmental issues, Japan's electric utility industry is working on research and development toward expanded implementation of new power generation systems such as solar, geothermal and wind energy.

Miyako Island Nanamata Wind and Photovoltaic Power Generation System, The Okinawa Electric Power Co.

Kakkonda Geothermal Power Station, Tohoku Electric Power Co.

Noma Wind Power Station, Kyushu Electric Power Co.

	Features	Present Development
Photovoltaic Power Generation	Photovoltaic power generation provides a clean, universally available source of energy. Power generation is carried out using solar cells which produce electricity when exposed to sunlight. It has many problems, such as cost, decline in electrical output at night or during bad weather, and a low energy density which necessitates the use of a large surface area to generate power on a large scale.	Corroborative research and trial operations are being carried out with outputs ranging from several kilowatts to 750kW. Installation of approx. 4,271kW capacity achieved by the end of fiscal 2006.
Geothermal Power Generation	Japan, one of the world's most volcanically active regions, is blessed with plentiful geothermal resources. Great expectations are being placed on the development of geothermal energy as a valuable domestic energy source that provides clean energy without the SOx and NOx emissions which accompany the use of fossil fuels.	There are twelve locations in operation as part of the electrical power industry, producing 497,100MW of power. (End of fiscal 2006)
Wind Power Generation	Wind power is harnessed by using the energy of the wind to turn a windmill, which in turn powers a generator. Its drawbacks include low energy density and the influence of variable wind conditions, but it has the benefit of being an inexhaustible, non-polluting natural source of energy.	Corroborative testing and operation with an output in the order of several hundred kilowatts is being carried out on isolated islands and in windy areas. Installation of 12,869MW capacity achieved by the end of fiscal 2006.

c.Electric Vehicles

Electric vehicles offer the benefit of reduced air pollution and more effective use of primary energy resources. Additionally, recharging these vehicles during late-night hours when electricity demand is low would contribute to leveling an electric usage and a more efficient use of power facilities. We thus promote research and development activities on these topics. At this time, there are still issues with driving distance, recharging time and price. These vehicles are put to use only where the daily travel distance is short, and they use lithium ion batteries which take up less space in the vehicle, charge quickly and have long life. Research and development is going forward aimed at promoting the use of electric vehicles by making them more convenient and less expensive.

● The R1e electric vehicle for commercial use by Tokyo Electric Power and Fuji Heavy Industries

● The iMiEV electric vehicle for commercial use by Tokyo Electric Power, The Kansai Electric Power, The Chugoku Electric Power, Kyushu Electric Power and Mitsubishi Motors Corp.

5 Efforts to Energy Saving

a. Energy Conservation Publicity and Information

Electric power companies use web sites, pamphlets and other media to give consumers information about saving energy by changing the way they use home appliances. Each month's usage statement, delivered after reading the meter, also shows consumers how much electricity they consumed during the same month in the previous year. Through these and other means,the electricity industry offers information to help customers use energy efficiently.

b. R&D and Promotion of High-Efficiency and Load-Leveling Equipment and Appliances

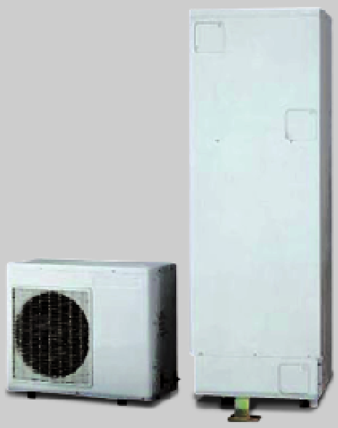
Japan's power companies have aggressively worked to develop and encourage the use of energy-efficient electric appliances and systems to achieve further energy conservation and load leveling in power demand. One result of such efforts is the development of a heat pump water heater using a CO_2 refrigerant through joint research with manufacturers and others. This hot water supply system uses a naturally occurring form of energy, the heat of the air, to heat water. CO_2 refrigerant / heat pump water heaters advance energy conservation in the water heating area, and as such their use is expected to grow at a quickening rate. Power companies will continue to develop and promote high efficiency and load-leveling equipment and appliances.

Hot-Water Supply System (ECO CUTE) with CO_2 Refrigerant Heat Pump

ECO CUTE runs on naturally occurring heat energy in the air instead of burning fossil fuels, as with conventional hot-water supply systems. Instead of a combustion system, ECO CUTE uses a high efficiency heat pump such as those found on appliances like air conditioners. With its high energy efficiency (it has a COP*1 of more than 4), ECO CUTE consumes only one-fourth the heat energy required to heat water. This means it can reduce CO_2 emissions by about 60% compared to a combustion-based supply system. In addition, its use of naturally occurring CO_2 as the refrigerant (the substance that conducts the heat energy), means less damage to the ozone layer as compared to CFC refrigerants and very little contribution to global warming, as well as excellent heating properties. Throughout Japan, more than 1 million ECO CUTE units have been installed (as of September 25, 2007), accounting for an estimated 600,000 t-CO_2 saved.

*1 $\text{COP (Coefficient of Performance)} = \dfrac{\text{Heating Capacity (kW)}}{\text{Electric Power Consumption (kW)}}$

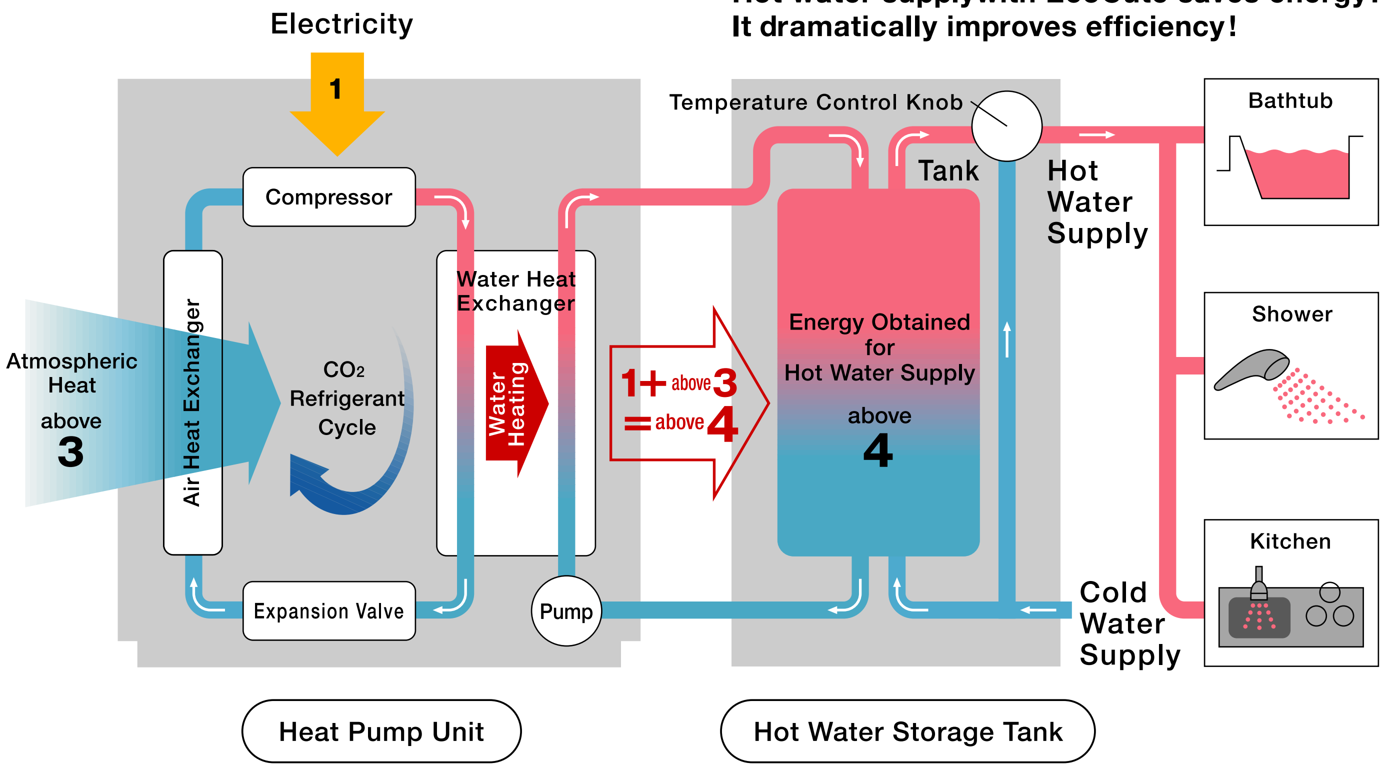
1 million ECO CUTE units have been shipped by domestic manufacturers.



EcoCute Hot Water Supply System Diagram

1 Electricity Enegy + above 3 Atmospheric Heat = above 4 Energy Obtained for Hot Water Supply

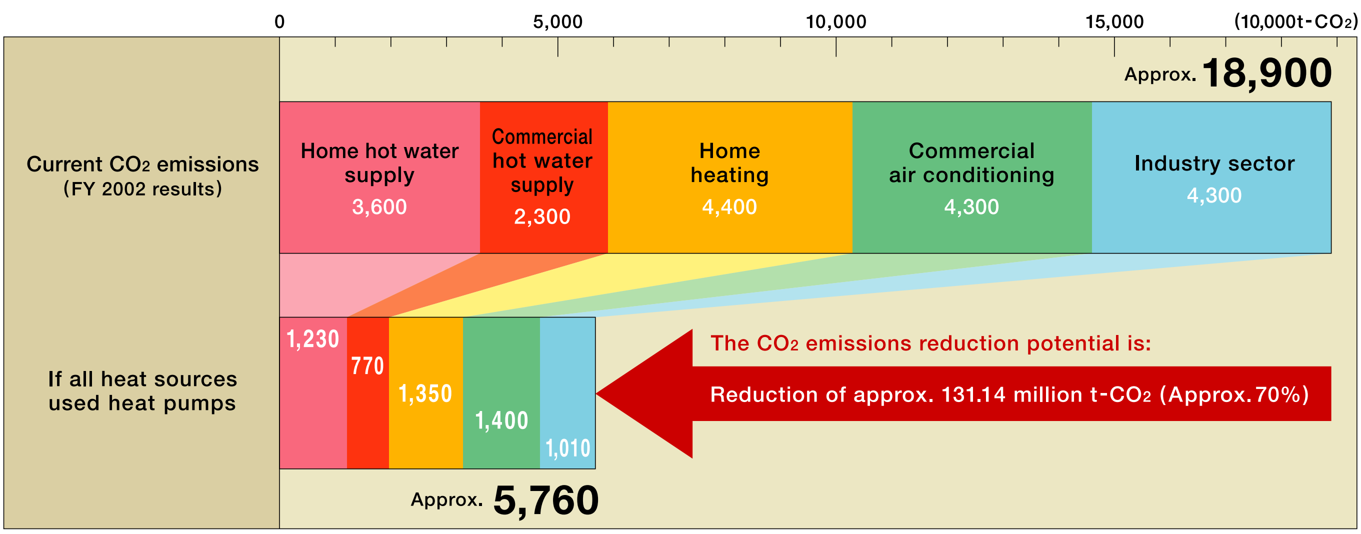
Hot water supplywith EcoCute saves energy!
It dramatically improves efficiency!



Possibility for CO_2 reduction through heat pump use

If conventional combustion systems for air conditioning and hot water supply which amounts to 50% of the civilian sector (homes and businesses) along with warming, drying and ventilation of the industrial sector are all replaced with highly efficient heat pump systems, approximately 130 million t-CO_2/year of CO_2 can be reduced. (Calculations by The Heat Pump & Thermal Storage Technology Center of Japan)

CO_2 reduction effect of heat pumps

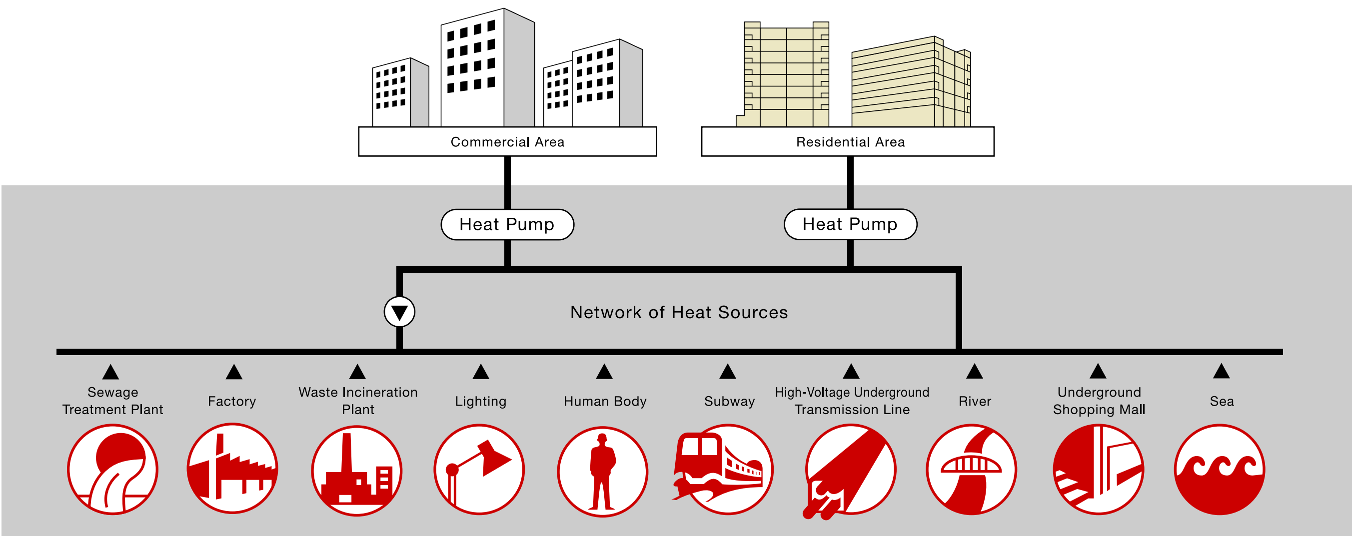


- A reduction of 130 million t-CO_2 means that approximately 10% of Japan's CO_2 emissions which is currently approximately 1.3 billion t-CO_2 can be reduced.

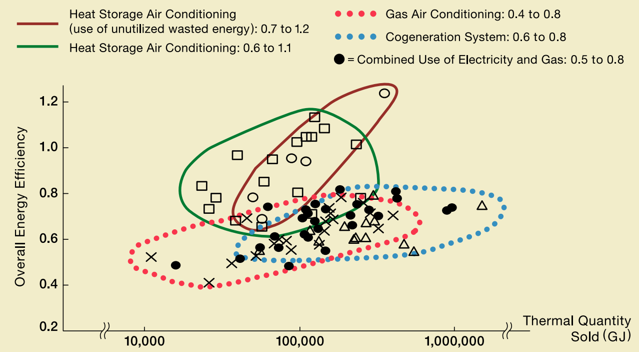
c.Promoting the Operation of Regional Heat Supply Services Using Untapped Energy

Various forms of unutilized energy, such as exhaust heat emitted from buildings, factories, substations or sanitation plants and energy from temperature differences discharged by sea, river or sewage are recovered as the effective thermal energy through heat pumps, and can be utilized for regional heat supply. Such regional heat supply services operations can make a significant contribution to reducing the use of fossil fuels and the emission of sulfur oxides (SOx), nitrogen oxides (NOx) and the greenhouse effect-causing gas, CO_2. Electric power companies in Japan are strongly advocating and promoting the introduction of this type of waste heat recovery as it can help achieve more efficient energy use and better power demand load-leveling in combination with heat storage systems.

Conceptual Illustration of Local Air Conditioning Service Using Urban Waste Heat



Overall Energy Efficiency of Local Air Conditioning Service



Points Investigated: Areas where both heating media - cold water and hot water (including steam and hot water supply) - are supplied mainly to commercial and business facilities.
Converted into electricity at 2,450 kcal/kWh and intotown gas at 11,000 kcal/m³.
Overall Energy Efficiency = Thermal Quantity Sold / Primary Energy Input

Source: Fiscal 2004 Heat Supply Business Handbook

Utility Service Center Plant

Regional heat supply service using river water
(Hakozaki area)

d.Power Generation Using Wind Power and Solar Energy

Electric power companies are purchasing surplus power so that environment-friendly power generation systems using no fossil fuels such as wind power, solar energy and other natural energies are used effectively. At the same time, they are introducing their own systems, working to promote popularization of those energies. Under the Green Electric Power System, started in October 2000, customers who approve of the further diffusion of renewable power-generation systems are asked to contribute a certain sum of money. The Japanese Renewable Portfolio Standard (RPS) Law was enacted in April 2003. The law obligates each electric utility company (including specific-scale electric utility companies, etc.) to use a certain level of electric power generated from natural energy sources according to the amount of electric energy it sells.

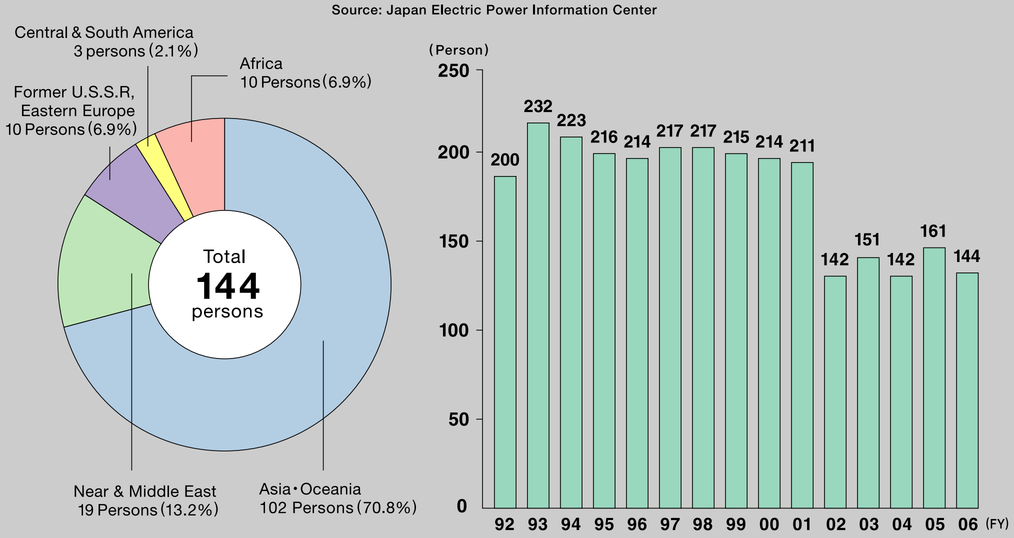
Photovoltaic Power Generation Matsuyama Photovoltaic Power Generation Station, Shikoku Electric Power Co.

6 International Cooperation

One of the policies of Japan's electric power industry is to continuously develop new measures and technologies to improve environmental protection and reduce energy consumption, both independently and in cooperation with manufacturers and related industries. As a matter of policy, the industry offers technical assistance and support to other electric power industries, specifically in the form of educational programs for foreign trainees, the dispatch of technological specialists overseas, and a regular exchange of information and technology with other electric power industries around the globe. To meet the worldwide need for stable energy supply and environmental conservation, in recent years there has been an increased global commitment toward technological cooperation on environmental measures for coal-operated thermal power stations as well as on nuclear power. Responding to this call for greater global cooperation, intensive exchange programs with engineers from overseas have been conducted by the electric power industry. With the exceptional, efficient energy conversion technologies and the environmental preservation technologies that the industry already has accumulated, and the expected results of ongoing research and development, the industry hopes to make major contributions toward energy conservation and environmental protection in both advanced and developing countries. The industry considers it especially necessary to tackle the issue of global warming through international cooperation. The industry actively looks for opportunities to cooperate with advanced countries in creating technologies that will further reduce fossil-fuel consumption. At the same time, through the Japan Electric Power Information Center and in cooperation with electric power corporations and related companies, the industry seeks to introduce technologies suited to specific economic and social conditions in developing countries.

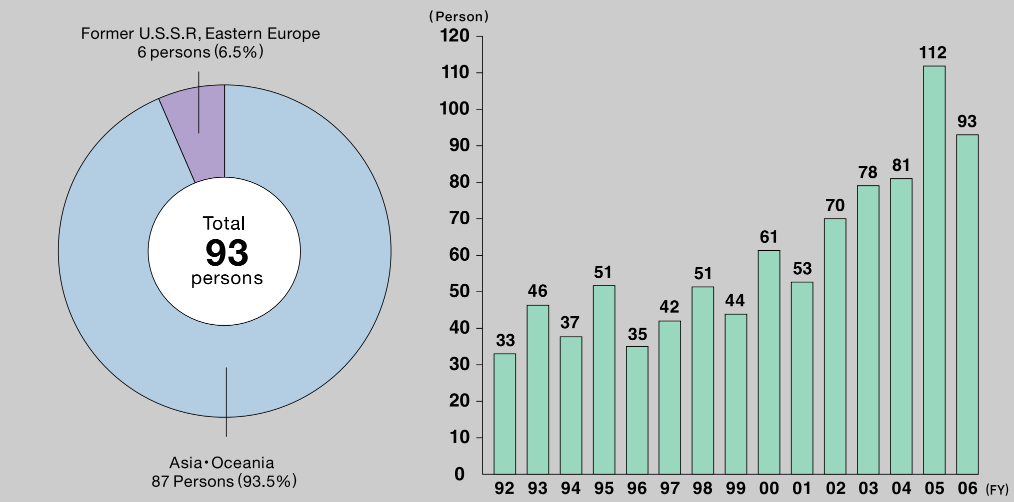
Statistics for Trainees from Developing Countries through the Japan Electric Power Information Center (FY 2006)

Source: Japan Electric Power Information Center



Statistics for Japanese Specialists Sent to Developing Countries through the Japan Electric Power Information Center (FY 2006)

Source: Japan Electric Power Information Center



Involvement in CO_2 Reduction Activities through International Cooperation

The Kyoto Mechanisms* are expected as measures that complement domestic policy because of their contribution to preventing global warming and their cost effectiveness in reducing CO_2 emissions. The industry is conducting projects that help reduce CO_2 emissions and feasibility studies for other projects overseas, including biomass power generation, thermal efficiency improvement projects and afforestation projects. Such projects are targets of the Joint Implementation and Clean Development Mechanisms stipulated in the Kyoto Protocol. The industry also provides investment to such entities as the World Bank's Carbon Fund and the Japan Greenhouse Gas Reduction Fund (JGRF) that Japan's industries participate in, and is otherwise actively involved in projects to prevent global warming. The industry is also actively involved in technology transfer to developing nations by instruction on energy-saving technologies and seminars on improving and managing thermal efficiency though projects to prevent global warming and afforestation. Global warming prevention activities will continue in the future on a global scale.

*Refers to emissions trading (ET), joint implementation (JI) and the clean development mechanism (CDM) stipulated in the Kyoto Protocol.

Examples of CO_2 Reduction and Absorption by Electric Utilities Overseas

Project	Outline	Start period
Bhutan micro hydro power CDM project	UN CDM Executive Board approved CDM project to provide electricity to a region without it by constructing a micro hydro power plant.	2003～
Fuel switch project in Chile	CDM project approved by the United Nations CDM Executive Board for switching fuel from coal and petroleum to natural gas at food production plants	2003～
Methane capture and combustion from swine manure treatment in Chile	CDM project to collect and combust methane released in the air from state-ofthe-art animal waste facilities approved by the CDM Executive Board	2004～
Landfill gas reduction project in Brazil	CDM project approved by the CDM Executive Board for recovering and incinerating biogas emitted by waste disposal facilities, reducing greenhouse gases	2002～
China micro hydropower CDM project	CDM Executive Board approved CDM project to construct a micro hydro power plant and sell the power to a local electric power company	2003～
China micro hydropower CDM project	CDM Executive Board approved project to effectively use rice husks that are disposed of through combustion as fuel for power generation	2003～
Biopower rice husk power project in Thailand	CDM Executive Board approved project using palm fronds produced in palm oil manufacturing process as fuel for power generation	2006～
Hydroelectric plant regeneration project in Vietnam	CDM Executive Board approved project to regenerate the Son Mak power plant which is not producing electricity	2006～
Electric generation operation in Honduras using sugar cane residue	Japanese government approved CDM project for biomass electric generation project using as fuel sugar cane residue (bagasse) generated in the sugar production process	2002～
Micro Hydro power project in Indonesia	Japanese government approved project to sell electric power to the Indonesian national power company, by generating hydro power from the unused pressure differential in irrigation canals.	2008～
Afforestation business projects in Australia	Afforestation projects designed to preserve the world's forest resources and fix atmospheric CO_2	Implemented multiple times

Measures to mitigate climate change

CO_2 Emissions Control Initiatives

[CO_2 Emissions Control Targets]

The electric power industry sets CO_2 emissions control targets using CO_2 emissions per kWh of electric power consumed by power industry customers (this is known as the user-end CO_2 emissions intensity). The industry has declared that "From fiscal 2008 to fiscal 2012 we aim to reduce CO_2 emissions intensity by an average of approximately 20% from the fiscal 1990 level, to about 0.34kg-CO_2/kWh."

[CO_2 Emissions Control Targets]

CO_2 emissions intensity (user end electricity) was 0.410 kg-CO_2/kWh in fiscal 2006, which was down by 0.013 kg-CO_2/kWh (3.1%) compared to fiscal 2005. This is because despite the slight decrease in usage of nuclear power facilitiescompared to fiscal 2005, the amount of hydroelectric power generation increased compared to fiscal 2005 due to high-water flows, which in turn slightly reduced the amount of thermal power generation.

[CO_2 Emissions Control Measures]

Measures by the electric utility industry to suppress CO_2 emissions can be classified into 4 groups including "supply side" and "demand side" measures. Following is a summary of these groups.

Supply-side measures

- Expanded introduction of nuclear power, which emits no CO_2, and of liquefied natural gas (LNG) thermal power, which emits comparatively little CO_2; increased rate of use of nuclear power generation
- Development and promotion of renewable energy sources such as hydroelectric, geothermal, solar, wind and biomass
- Enhancing the efficiency of thermal power generation by introducing combined-cycle systems and high-efficiency coal-fired thermal power generation, as well as improving the efficiency of power facilities by reducing transmission /distribution power losses

Demand-side measures

- Development and promotion of heat pumps and other highly efficient, energy-conserving appliances, PR activities and provision of information on energy conservation measures for customers.
- Promotion of load leveling by the use of thermal storage air conditioning systems, etc.

Research and development etc.

- CO_2 capture and storage technology, clean coal technology

International efforts

- Active utilization of the Kyoto Mechanisms
- Participation in the Asia-Pacific Partnership (APP)

○ Promotion of nuclear power on the precondition of ensuring safety and restoring trust

Nuclear power is of great importance because CO_2 is not emitted when generating electricity. It stands to play a central role in future initiatives in Japan to counter global warming. Along with working to restore the public's trust in nuclear power, the industry will continue to make the promotion of nuclear power a top management priority. In cooperation with the government, the industry will devote maximum effort to "locating sites for nuclear power plants", "raising the capacity factor", "establishing the nuclear fuel cycle", and "strengthening back-end measures", all while putting safety above all else and eliciting the understanding of local communities and the general public. With regard to raising the capacity factor at nuclear power facilities, the industry will work to expand implementation of constant rated thermal power operation, which is already in effect at 90% of nuclear power plants nationwide. It will also endeavor to make further improvements by managing operations scientifically and rationally while learning from achievements overseas.

○ Efforts for Helping to Spread the Use of Renewable Energy

The industry has already been promoting the long-term proliferation of renewable energy by participating in the Green Power Fund for individuals and the Green Power Certification System for corporations. Also, the Special Measures Law Concerning the Use of New Energy by Electric Utilities (RPS Law) mandates use of electricity such as that from new energy. The ten public electric utilities continued in fiscal 2006 to put great effort into securing use of the mandated volume of new energy. Last year, the mandated volume from fiscal 2006 to 2009 was raised, and this year it was set once again until fiscal 2014. We intend to continue to live up to our obligations.

○ Further increase in thermal power efficiency and review of thermal power plant operating methods

The industry is working to install and expand high-efficiency facilities including LNG combined-cycle systems, and it is also developing integrated coal gasification combined cycle (IGCC) power for the efficient use of coal. Additionally, the industry is studying eco-friendly thermal power plant operating methods, taking into account fuel procurement and equipment operating restrictions and the need for energy security.

○ Development and promotion of energy-conserving equipment

The industry actively develops and popularizes thermal storage air conditioning systems, which help customers save energy and enable them to make more use of nighttime energy, thereby evening out demand and helping reduce CO_2 emissions. The industry further develops and popularizes CO_2 heat pump water heaters and high efficiency commercial air conditioners that use heat pump technology.

○ PR-activities and provision of information aimed at energy conservation

The electric utility industry will actively roll out initiatives that contribute to the promotion of energy conservation by customers by providing information that helps customers in their energy saving activities and proposing measures through diagnosing their energy usage.In addition to the above, starting this fiscal year we have positioned the promotion of our "Household CO_2 Account book" as the approach for the whole industry, and decided to actively work to expand its use. Also in "Cool Earth 50" announced by Prime Minister Abe in May 2007, he proposed the development of a national movement with the motto "1kg of CO_2 reduction per person per day". The electric utility industry also agrees to that purpose and has decided to carry out such activities.

○ R&D Initiatives

In response to the problem of global warming, the industry recognizes the need for promoting supply-side, demand-side and environmental conservation technical research and development from a medium to long-term perspective. Specifically, the industry is researching and developing technologies etc. that help customers conserve energy, technologies for the capture and storage of CO_2 in the gas emitted by thermal power plants, nuclear technologies, and technologies related to utilizing forests as carbon sinks.

○ International Initiatives

The electric utility industry recognizes the importance of the Kyoto Mechanisms as measures that complement domestic policy because of their contribution to preventing global warming and their cost effectiveness in reducing CO_2 emissions. The industry will also continue to promote projects that utilize such efforts as the Kyoto Mechanism and afforestation, and utilize suppressed CO_2 emissions in achieving its targets.Since the CO_2 emissions of the 6 participating countries (United States, Australia, China, India, South Korea, and Japan) of Asia-Pacific Partnership on Clean Development and Climate (APP) exceed 50% of the total global amount and because striving to reduce the emissions of these 6 countries would have great significance, the electric utility industry is actively participating in these activities.

○ Other Efforts

Since 2000, the electric utility industry has been implementing measures to reduce consumption of electricity for its offices and fuel for its own transport. Each company has set targets, and in this way is making efforts to suppress CO_2 emissions.

[Future Efforts and Issues]

The targets found in the electric industry's environmental action plans were set based on supply and demand forecasts and nuclear power development plans from that time (1996) and assumed full-scale efforts. Even though the industry acknowledges that the target is an extremely challenging figure, it will actively evaluate and carry out all kinds of measures such as those from electricity supply and demand sides and also international efforts etc. The above measures include improvement of capacity factor for nuclear facilities through various ingenious efforts, development and popularization of energy-saving devices and use of Kyoto Mechanism by participation in CO_2 reduction projects. Going forward, the electric utility industry will continue to commit its full efforts to achieve its target by steadily implementing existing measures and by strengthening the following initiatives in order to further improve effectiveness.

- Promotion of nuclear power on the precondition of ensuring safety and restoring trust
- Further improvement of the efficiency of thermal power and review of methods for managing thermal power
- Active utilization of the Kyoto Mechanisms, etc.

Response to the problem of global warming from a long-term perspective

With next year being the first commitment period of the Kyoto Protocol, in Japan the plan for achievement of Kyoto Protocol targets is being reviewed. Internationally, specific "Post-Kyoto Protocol" discussions are being held, such as the United States' agreement to participate in discussions about the next framework, held in June at the G8 summit in Germany.The electric utility industry has a corporate social responsibility to make maximum efforts from 2013 onwards to prevent global warming and construct a sustainable society. We in the electric utility industry will continue to go forward with proactive measures to prevent global warming, centering on the following 4 activities that make use of our industry traits.

- Promotion and effective use of nuclear power
- Contribution toward the shift to a low-carbon society
- Active support for other countries
- Development of innovative technologies

Establishing a Recycling-based Society

Measures for waste reduction and recycling

[Waste Recycling Rate Target]

As power supply and demand grow, so does the amount of waste generated as a result. The industry forecasts its total volume of waste will expand to 9.6 million tons in fiscal 2010, about twice as much as that in fiscal 1990. Seeking to reduce the amount of waste finally disposed of and to realize a society based on a recycling economy, the industry has set a target of reaching a waste-recycling rate of 95% by fiscal 2010.

[Waste Recycling Achievements]

Waste generated by the industry amounted to 9.77 million tons in fiscal 2006, a decrease of 0.16 million tons from the fiscal 2005 level. This is because the generated amount of electricity from coal-fired power stations decreased. On the other hand, the recycled volume has decreased by 0.12 million tons from the previous year to 9.44 million tons. The result is that a recycling rate of 97 was achieved in fiscal 2006, a 1% increase over fiscal 2005. By category of waste, coal ash was the most voluminous at 7.05 million tons, of which 6.83 million tons was recycled, primarily as a raw material for cement, an admixture for concrete, or material for land reclamation. Almost all the metal scrap and debris produced were recycled, and the industry worked to recycle other waste material to the extent possible. The byproduct desulfurization gypsum was completely recycled as building materials like gypsum boards or as a raw material for cement.

[The Three R's and Future Efforts]

The electric utility industry continues to work on the following issues in order to form a recycling-based society.

- Coal Ash: Recycling of coal ash remains an important issue, thus we are working on the development of applications and a technology to handle large volumes of coal ash in a stable manner.
- Desulfurized gypsum: We will maintain 100% re-utilization.
- Other wastes: Actively implement 3R

Recycling by the Nuclear Industry

In Japan, for which more than 80% of its primary energy derives from offshore supplies, the nuclear fuel cycle, which recycles uranium and plutonium recovered from spent fuels, is an effective system. The cycle brings out the properties of nuclear power production by securing stable energy sources while complementing a recycling economy. A chemical reprocessing plant for spent fuels is under construction in Aomori Prefecture to establish the nuclear fuel cycle, and the plant is scheduled to start operation in 2007. The industry is continuing with various activities to help people better understand the "Plu-thermal" plan, in which plutonium recovered from spent fuels will be used in existing light water reactors as an MOx fuel (Mixed Oxide Fuel: a mixed fuel of uranium and plutonium). This policy is based on Japan's national principle of not storing surplus plutonium. In the future, the use in fast breeder reactors, on which R&D efforts are in progress, would be most effective, and its practical application should dramatically improve the utilization of uranium resources.

Management of Chemical Substances

Management of chemical substances The electric utility industry has carried out PRTR (Law Concerning the Reporting, etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management) studies since 1997, even before the relevant laws were enacted, in an effort to precisely monitor release and transfer volumes at power generators and other facilities as the amount of special chemical substances gradually increase. A system for reporting emission volumes and other factors was introduced in April 2002 and was based on the PRTR Law. Under this system, electric utility companies gather information on the release and transfer volumes for specific chemical substances at each of their facilities and report their findings to the national government. In the future, the industry will endeavor to appropriately control and maximally reduce emissions of these chemical substances.

Promotion of Environmental Management

The Japanese power companies have established in-house environmental management systems by establishing an environment department, and their involvement in efforts to protect the environment has been disclosed through CSR reports and websites. As for environmental management systems, each power company actively and voluntarily commits to various measures based ion its own policies, such as the reinforcement of an internal environmental management system in compliance with the requirements of the ISO 14000 series of international promotion of environment management and the acquisition of the ISO 14001 certification for its representative business establishment.

Environmental Considerations in Overseas Projects

The electric power industry has long trained personnel in environmental fields by accepting trainees from developing countries and providing technical assistance by dispatching specialists from Japan. With regard to participation in projects overseas and technology collaborations, the industry has conducted initiatives in consideration of local environmental issues and global-scale environmental preservation. These include biomass power generation, afforestation and measures to reduce the environmental impact of thermal power plants. The electric power industry plans to continue to aggressively promote these kind of initiatives that give adequate consideration to the environment.

Conclusion

As shown in this brochure, the energy conservation and environmental preservation efforts by Japan's electric power industry are contributing toward the solution of environmental problems such as global warming and acid rain. The industry is committed to continue working for the further reduction of energy and resource consumption and the protection of the environment, through increased technology transfers, to make further contributions to international efforts that address global environmental issues. The leading role of the government and international cooperation system are indispensable in scientific elucidation of its mechanisms, the search for new sources of energy, and the establishment of appropriate countermeasures to environmental problems, on the issue of global warming. The industry expects appropriate response of the government and international organizations, and will cooperate positively for the preservation of the environment at the private level.

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The paper used in this Energy and Environment is "thinnings paper", made from 10% domestic thinnings pulp and 90% market collected waste paper. The use of thinnings paper helps to stimulate the domestic forestry industry. It also contributes to "forest management" for CO_2 reduction as cited in the Kyoto Protocol, and promises effects in mitigating global warming.

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