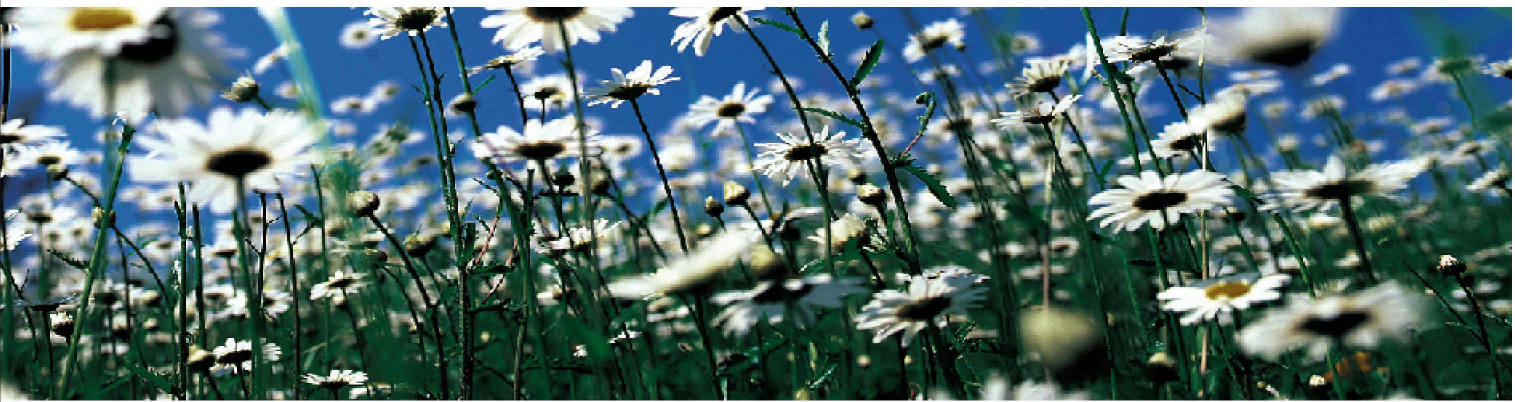
ENERGY AND ENVIRONMENT

JAPAN'S ELECTRIC POWER INDUSTRY IN THE WORLD



The Federation of Electric Power Companies
http://www.fepc.or.jp/

2006 2007

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.

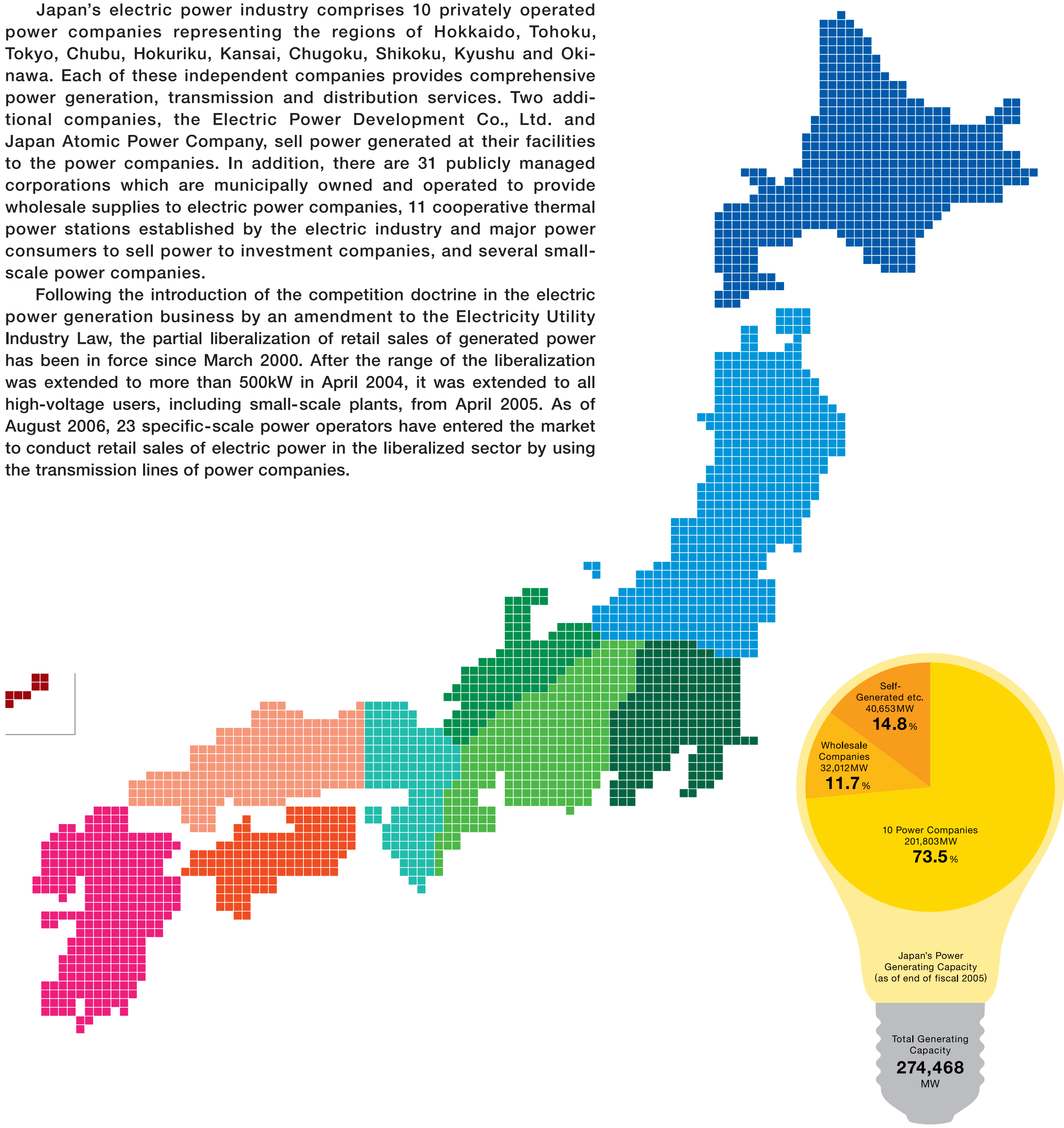
This brochure provides information on the activities of Japan's electric power companies which are directed at the reduction of energy and resource consumption, environmental preservation and the problem of global warming. We hope to contribute to the better public understanding of the electric power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

1. Overview of Japan's Electric Power Industry

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, 11 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 2006, 23 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.



Outline of 10 Major Japanese Power Companies Fiscal 2005

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	5,462	30,833	513	5,844	1,226	4,115	1,158	—	6,499
Tohoku Electric Power Co.	251	15,200	79,664	1,494	12,263	2,415	10,919	3,274	—	16,609
Tokyo Electric Power Co.	676	60,118	288,655	4,897	38,039	8,993	35,536	17,308	1	61,837
Chubu Electric Power Co.	431	26,680	130,561	2,045	16,180	5,220	22,369	4,997	—	32,586
Hokuriku Electric Power Co.	118	5,486	27,966	466	4,692	1,816	4,400	1,898	—	8,114
The Kansai Electric Power Co.	489	30,780	147,108	2,369	22,229	8,186	17,807	9,768	—	35,761
The Chugoku Electric Power Co.	186	11,500	59,501	969	10,690	2,894	8,026	1,280	—	12,200
Shikoku Electric Power Co.	146	5,542	27,968	516	6,043	1,143	3,696	2,022	1	6,862
Kyushu Electric Power Co.	237	16,489	82,956	1,314	13,066	2,378	11,770	5,258	3	19,409
Total - 9 companies	2,648	176,383	875,212	14,584	129,046	34,270	118,639	46,963	4	199,877
The Okinawa Electric Power Co.	8	1,493	7,346	143	1,552	—	1,926	—	—	1,926
Total - 10 companies	2,656	177,696	882,559	14,727	130,598	34,270	120,565	46,963	4	201,803

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 2004 as based on information from OECD Energy Balances.

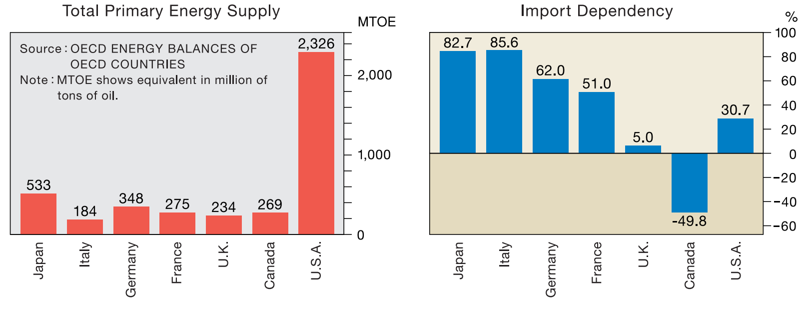
Steady Increase in Power Generation

A comparison of electric power production in 1980 and 2004 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 24 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.

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 9% hydro, 63% fossil fuel and 26% nuclear.

Primary Energy Supply and Import Dependency for Major Countries 2004



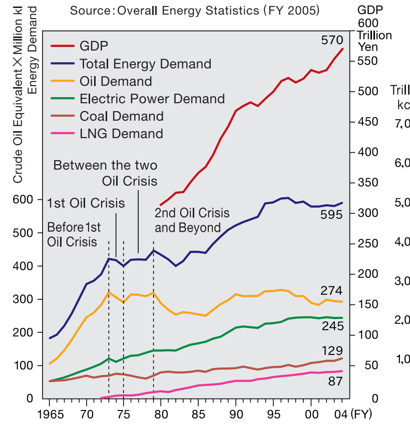
c. Energy Consumption in Japan

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.

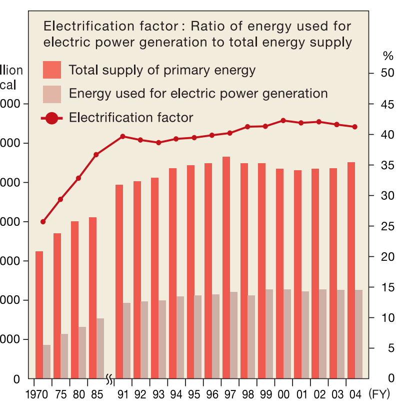
Changes in Energy Demand and GDP

Source : Overall Energy Statistics (FY 2005)

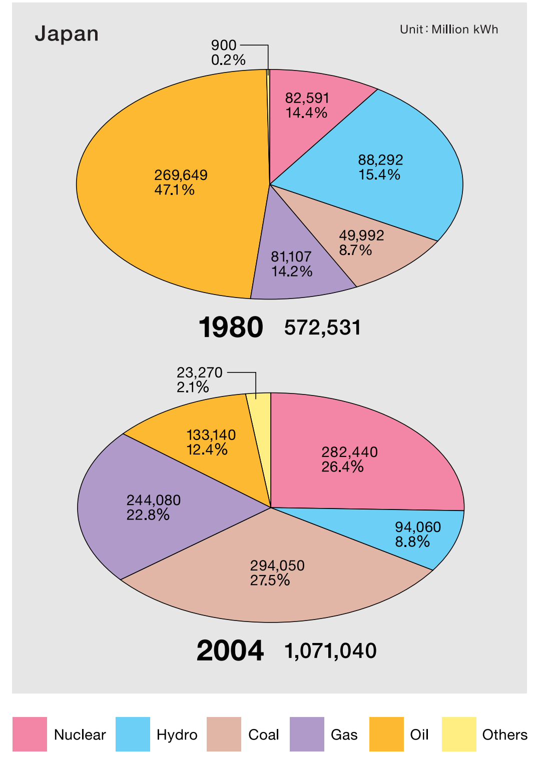


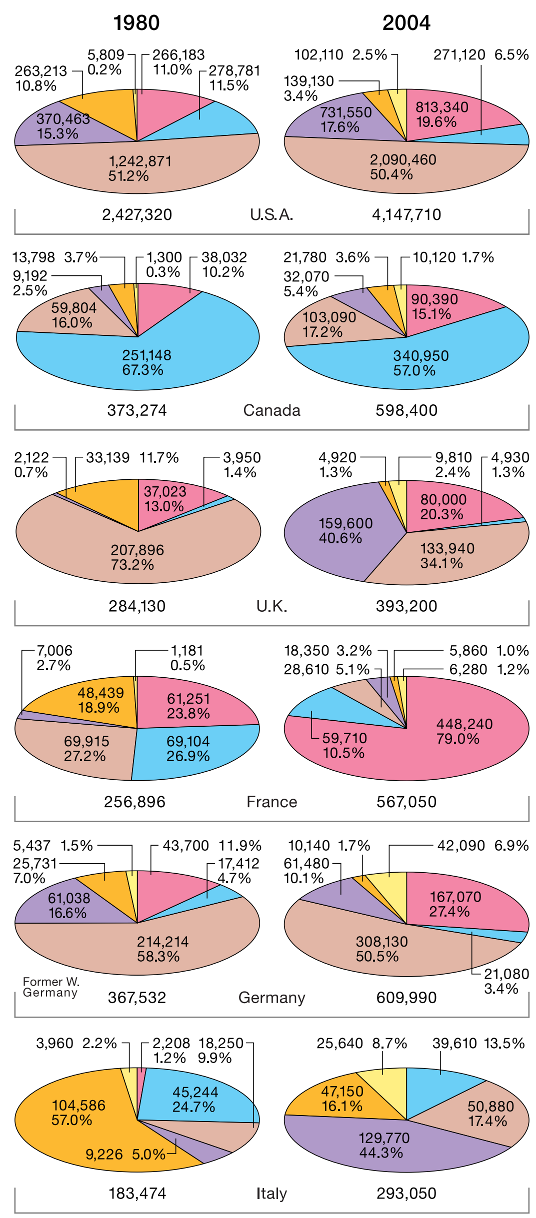
Trend of Japan's Electrification

Source : Overall Energy Statistics (FY 2005)



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





Source : OECD ENERGY BALANCES OF OECD COUNTRIES

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

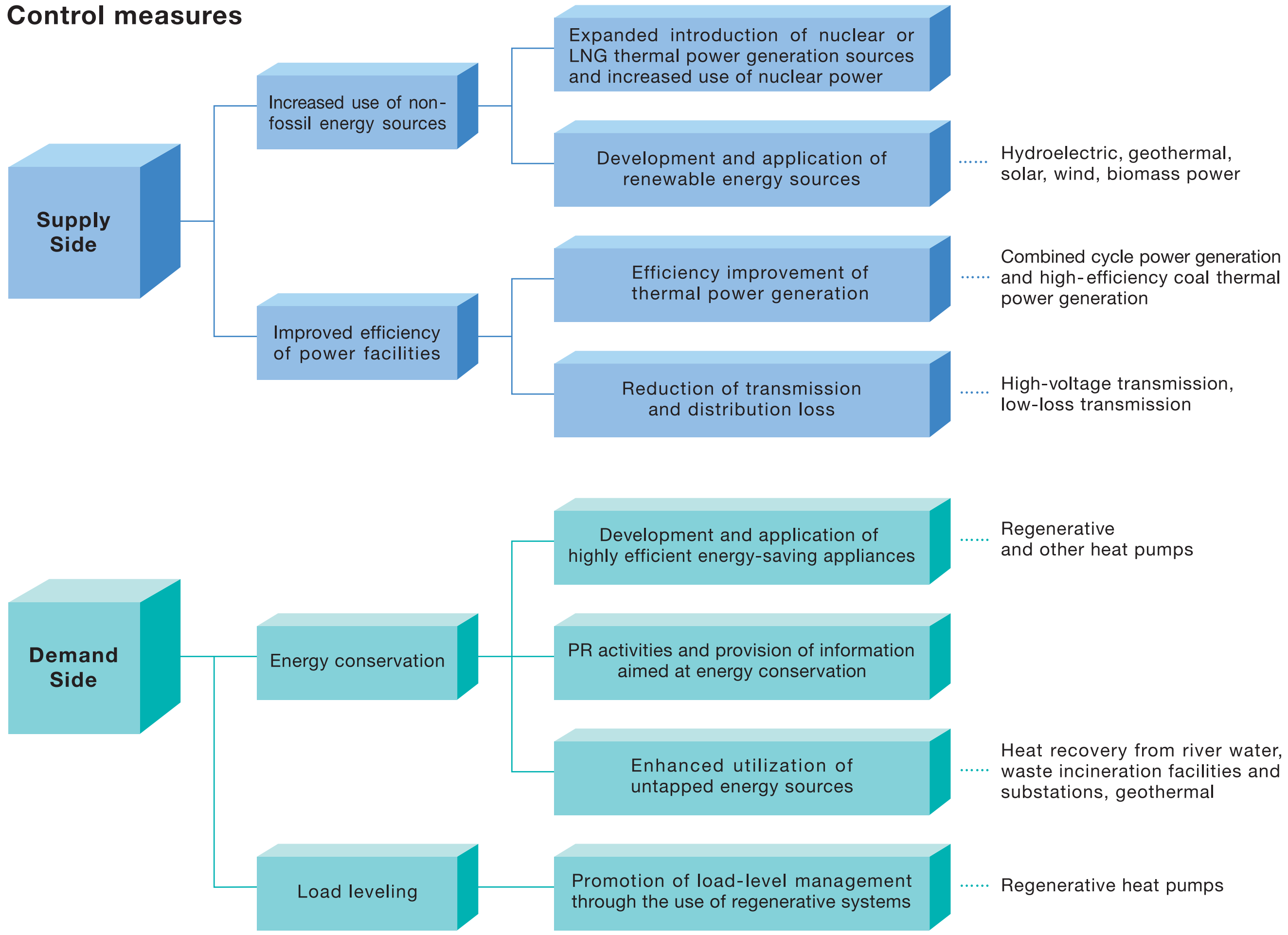
A principal cause of global warming, CO_2 emissions are a major problem for the electric power industry. Accordingly, the Federation of Electric Power Companies has set up the Investigative Committee on CO_2 Related Problems, with the purpose of studying and examining various possible measures for dealing 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 two-pronged control on the supply and demand sides. The electric power 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 power industry considers the CO_2 issue to be of paramount importance, and accordingly aims to achieve the following objectives in its future activities:

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

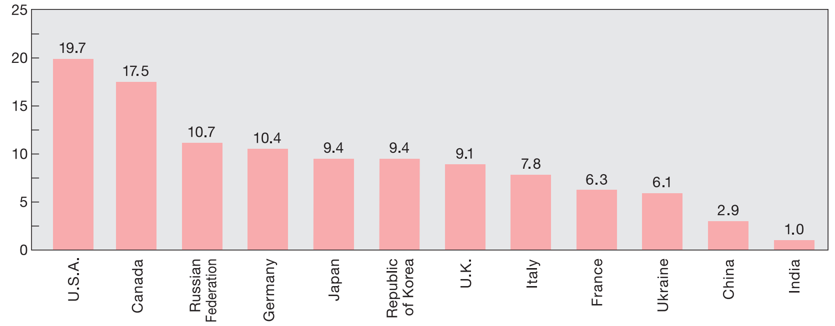
CO_2 emission levels in the electric power industry have raised by about two-fold compared to those during the Oil Crisis in the 1970s, whereas power demand has increased by about three times during the same period. As a result, CO_2 emission levels (end use electricity) were 0.425 kg-CO_2/kWh in fiscal 2005. 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 ninth review in September 2006. (Refer to P.28 and P.29 for details.)

CO_2 emission control target of the electric power industry.
By fiscal 2010, we aim to further reduce CO_2 emissions intensity (emissions per unit of end-use electricity) by approximately 20% from the fiscal 1990 level, to about 0.34kg-CO_2/kWh.

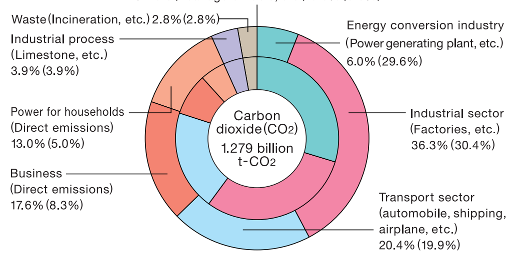
CO_2 Control measures



International Comparison of CO_2 Emissions per Capital 2003

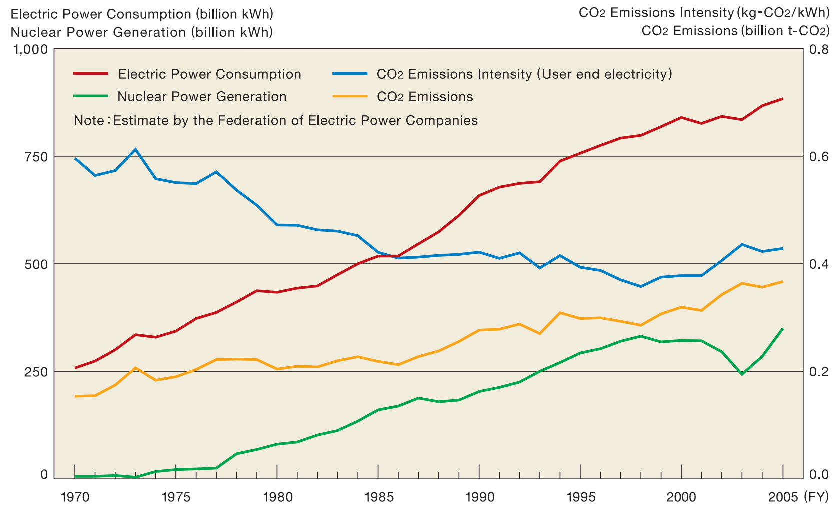


CO_2 Emission Levels by Sector in Japan 2004

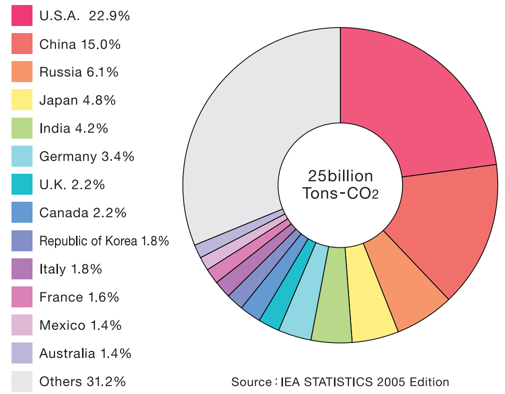


Source : Ministry of the Environment
The outside circle shows CO_2 emission levels due to electric power generation assigned to respective final demand sectors in accordance with their electricity consumption. The figures in the inside circle are ratios of direct emissions (figures in parentheses).
Note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

CO_2 Emissions by the Electric Utility Industry



International Comparison of CO_2 emissions 2003



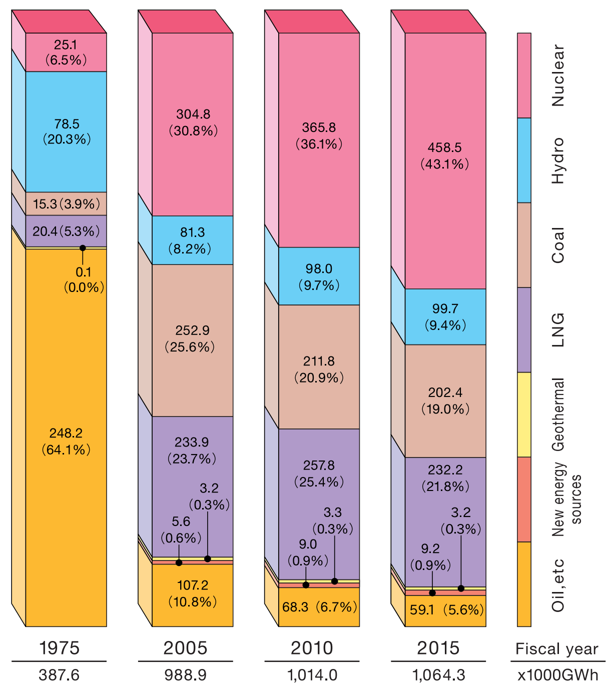
Source : IEA STATISTICS 2005 Edition

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.

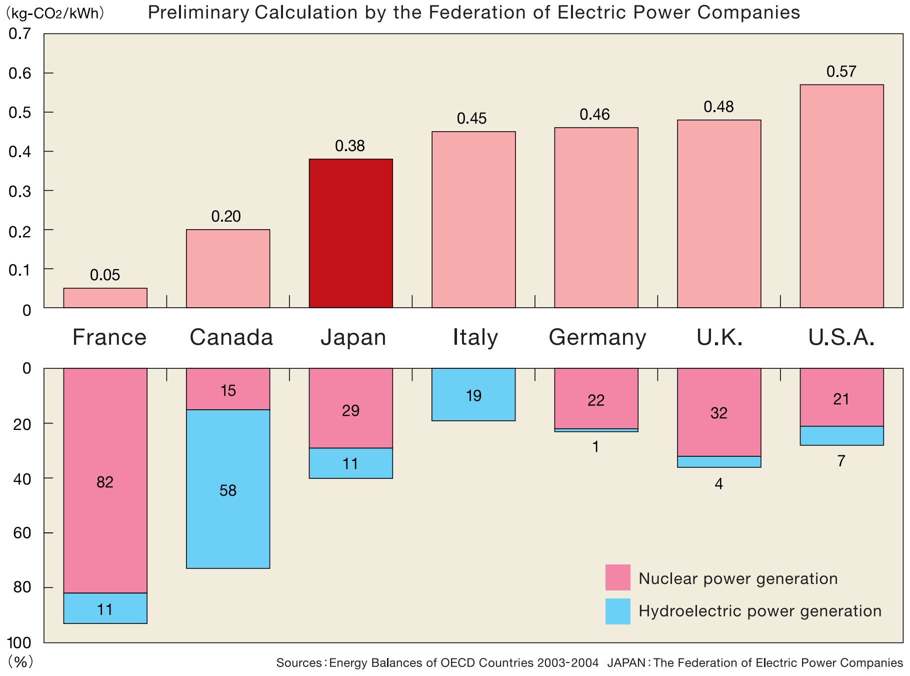

Tsuruga Thermal Power Station (coal), Hokuriku Electric Power Co.

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 2006, 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 2004

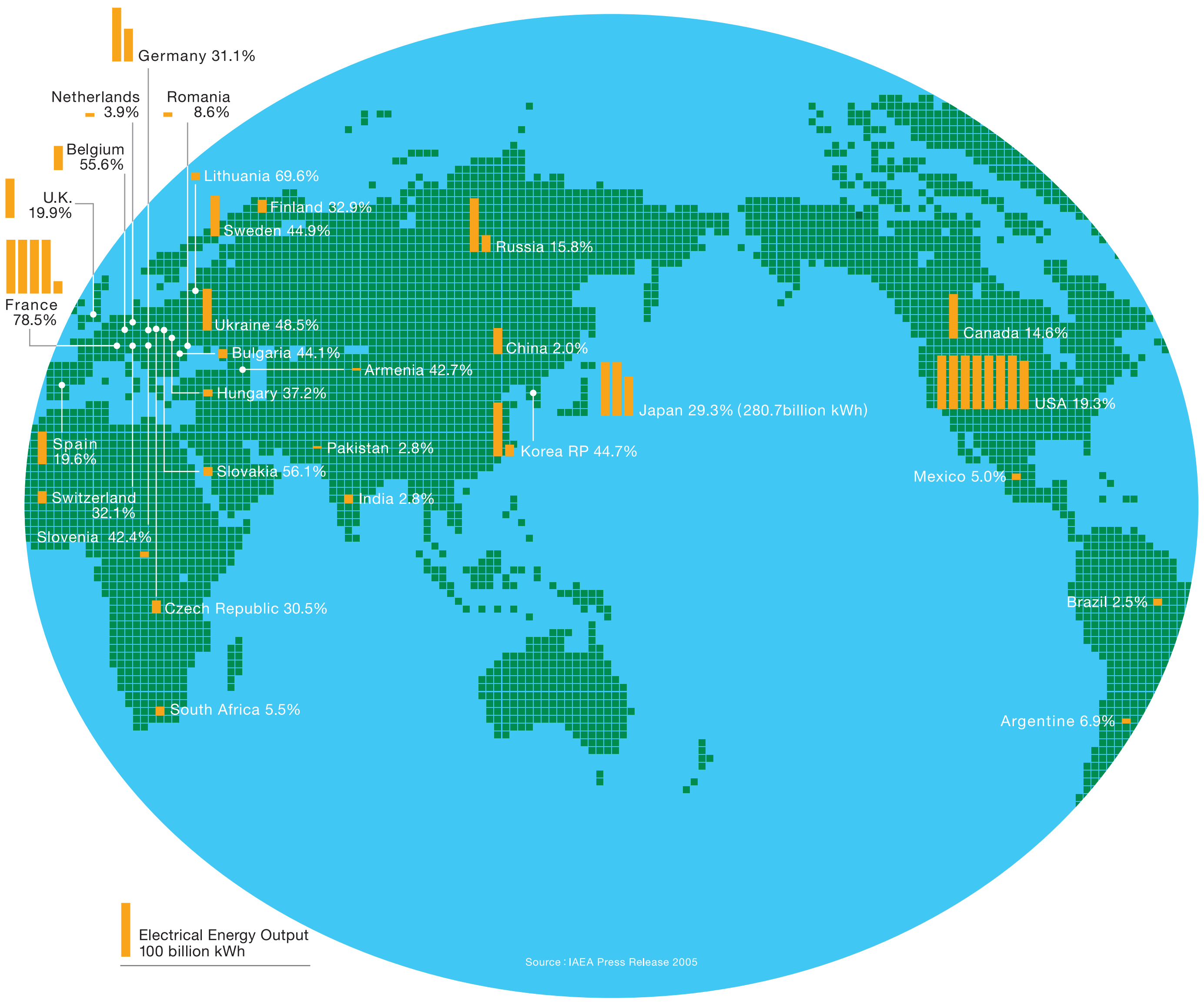
Preliminary Calculation by the Federation of Electric Power Companies



Sources: Energy Balances of OECD Countries 2003-2004 JAPAN: The Federation of Electric Power Companies

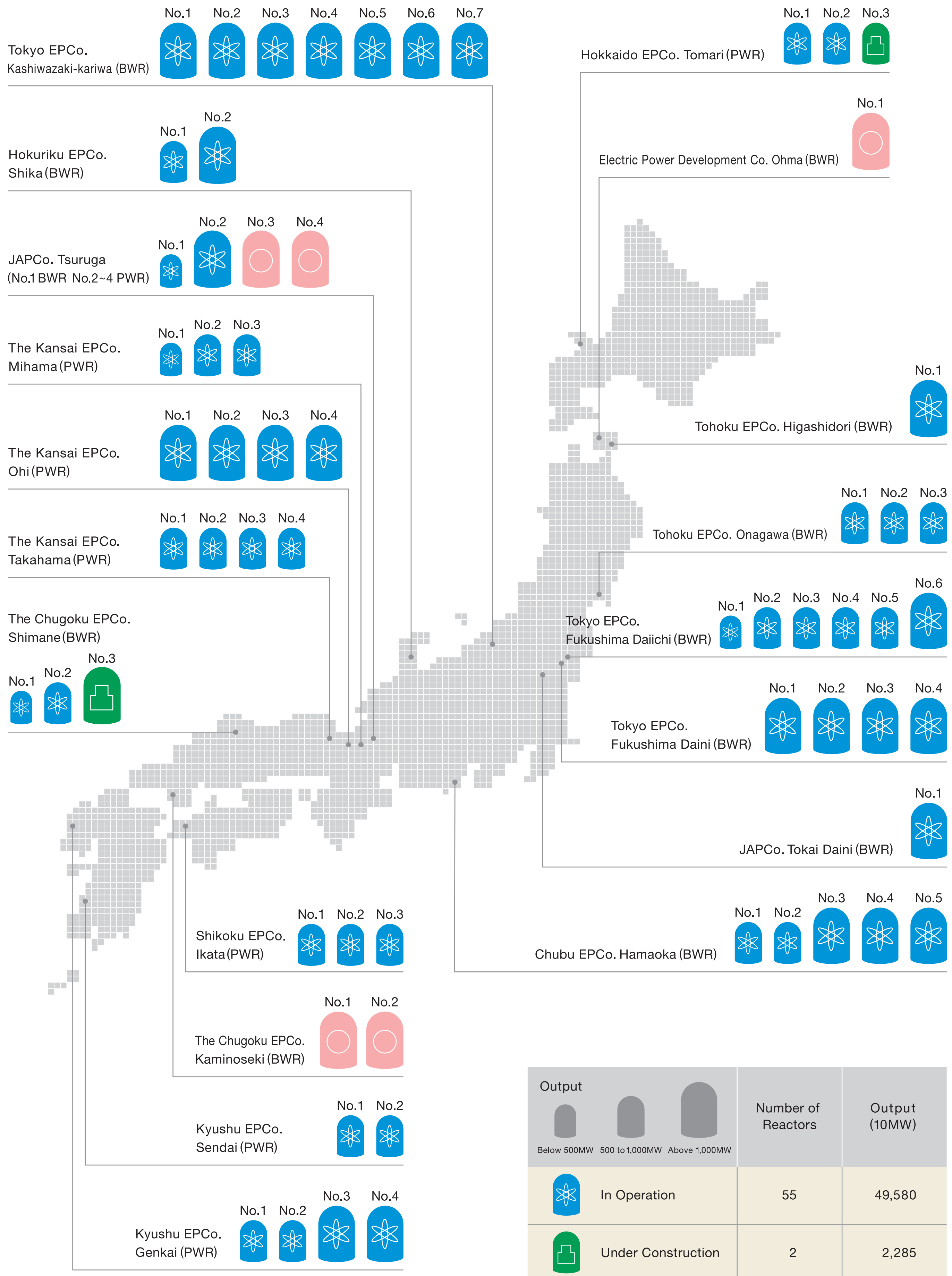
* In France nuclear power generation accounts for a large share in total power output. As nuclear power does not emit CO_2, CO_2 emissions intensity levels are extremely low.

Electricity Supplied by Nuclear Power Reactors in 2005



Nuclear Power Plants in Japan : Their Operation and Construction

as of August 2006

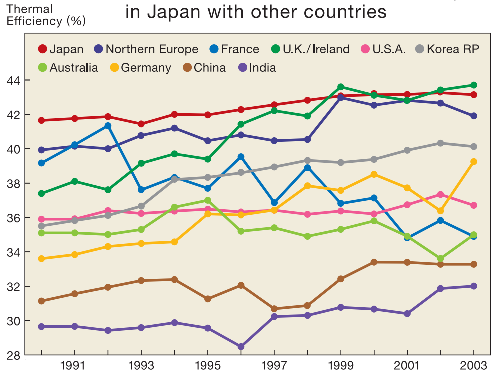


Output (Below 500MW / 500 to 1,000MW / Above 1,000MW)	Number of Reactors	Output (10MW)
In Operation	55	49,580
Under Construction	2	2,285
Planned	5	7,205
Total	62	59,070

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.

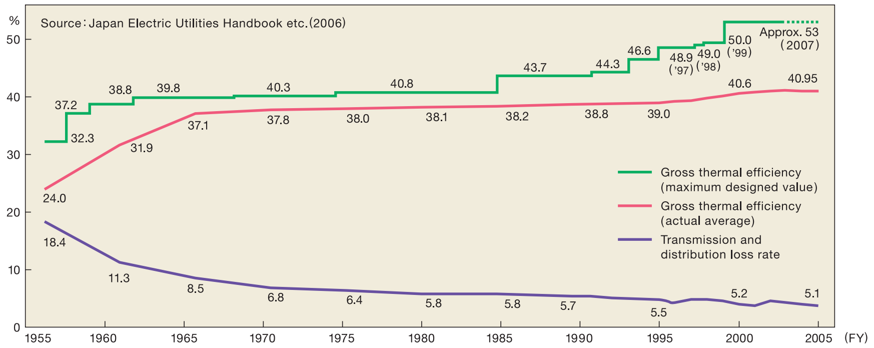
Comparison of thermal power plant efficiency in Japan with other countries



* 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.

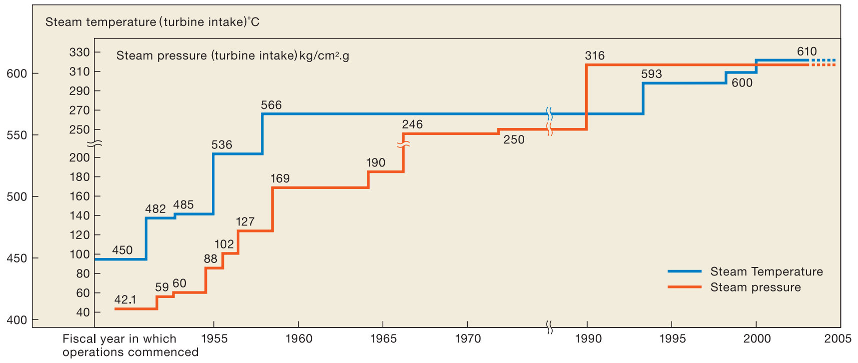
Sources: Updated Comparison of Power Efficiency on Grid Level, 2006 (Ecofys)

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



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

Improvements in Steam Temperature and Pressure in thermal Power Generation Facilities



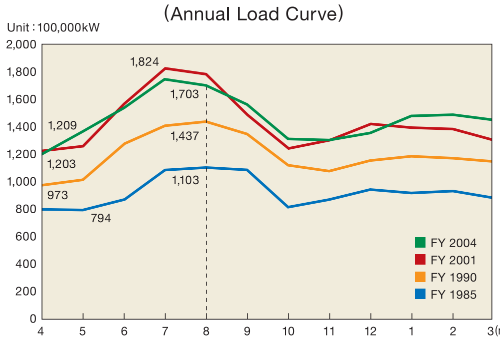
c. Promoting Load-leveling in Power Demand

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.

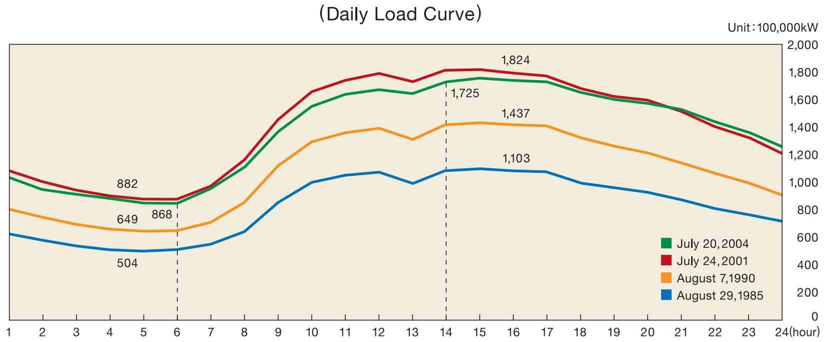
Monthly Electric Power Consumption

(Annual Load Curve)



Variations in Daily Electric Power Consumption

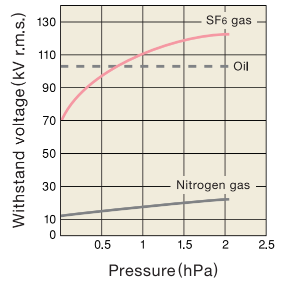
(Daily Load Curve)



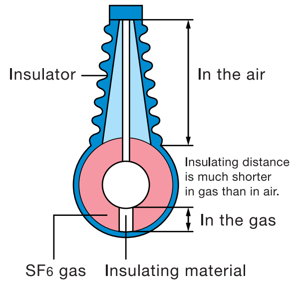
d. For the Use of Sulfur Hexafluoride (SF_6)

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

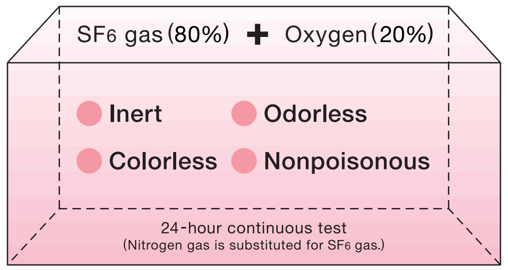


Comparison of dielectric strength

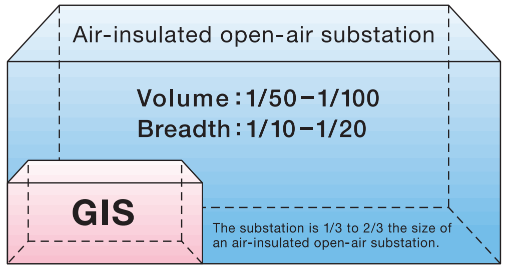


Insulating distance

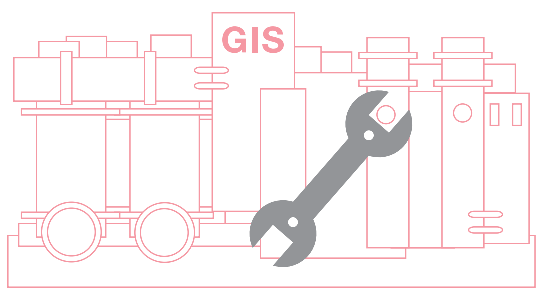
Safe and stable gas



Environmentally harmonious without requiring a large space



Maintenance operations can be rationalized



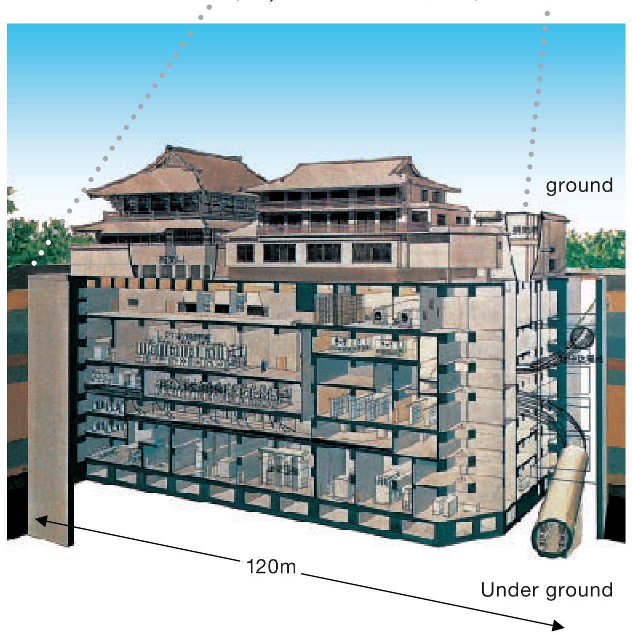
Comparison of Both Substation Types

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)



3.Efforts to Environmental Protection and Harmony

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 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.

Coastal Power Station

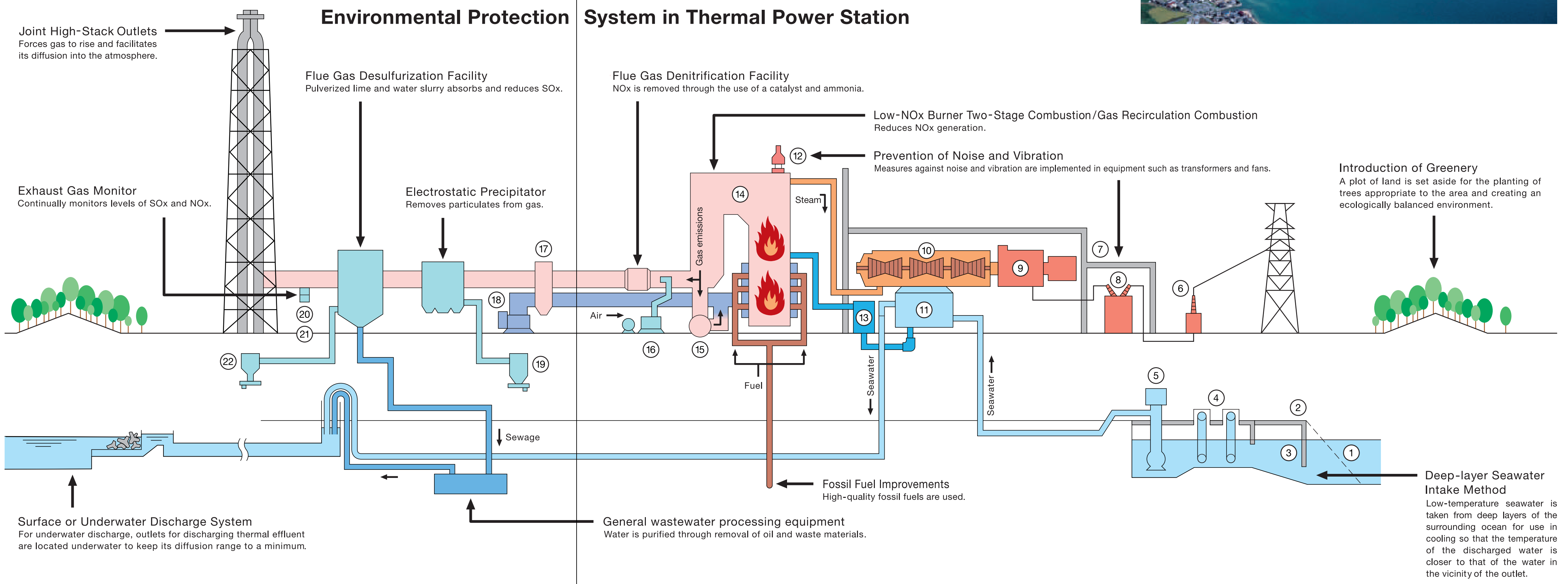
Yanai Thermal Power Station (LNG), The Chugoku Electric Power Co.

(1) Protection of the Atmosphere

a. Reduction of SOx and NOx Emissions

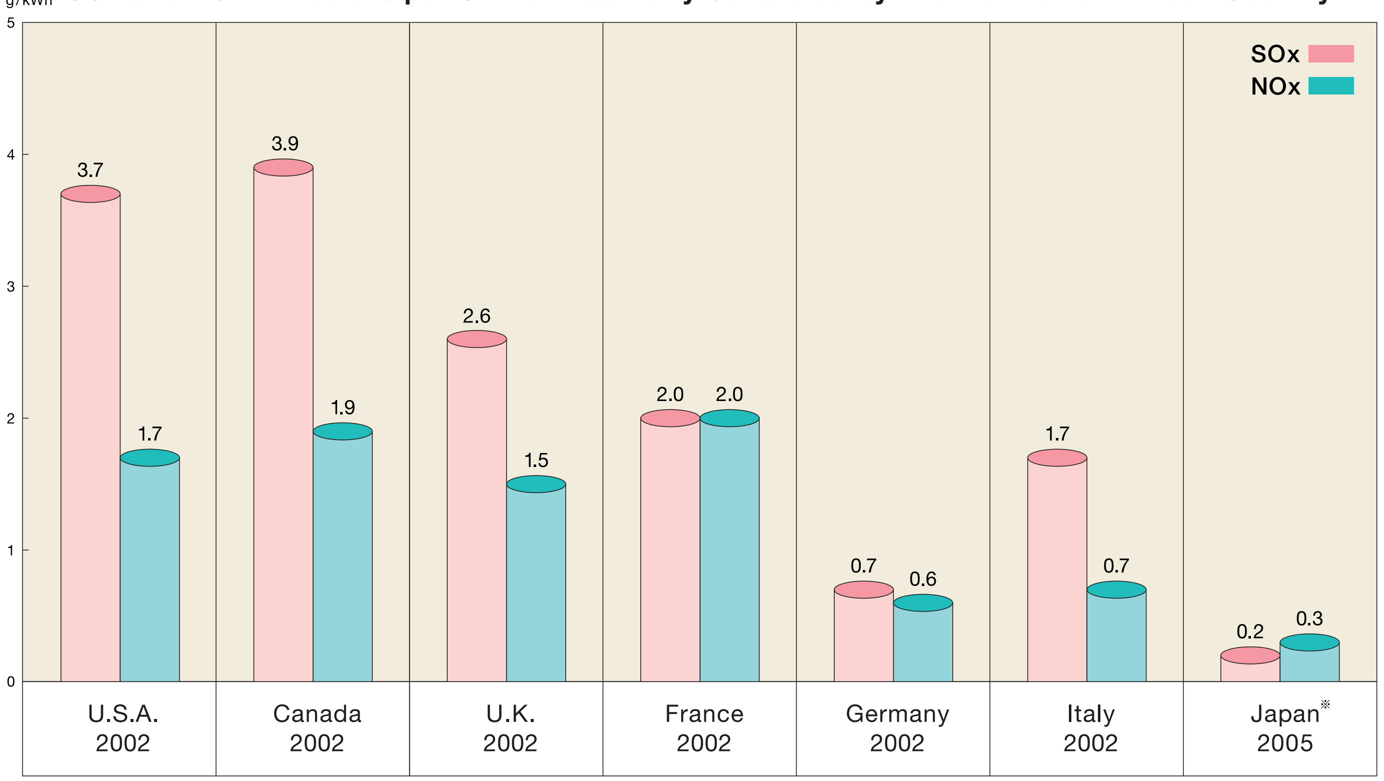
From the mid-1970's, through progress made in improving fossil-fuel quality and power generating facilities, the volume of sulfur oxide and nitrogen oxide emissions per unit of electricity generated by thermal power in Japan has been reduced drastically. At present, the values for both types of noxious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

Environmental Protection System in Thermal Power Station



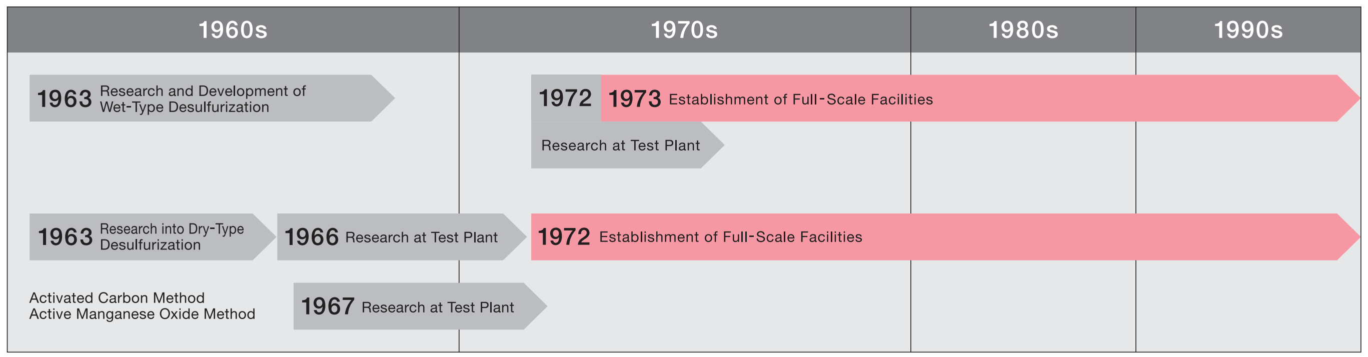
1 Net to Keep Out Jellyfish	9 Generator	17 Air Heater
2 Curtain Wall	10 Steam Turbine	18 Forced Draft Fan
3 Intake	11 Condenser	19 Ash Treatment Equipment
4 Screen	12 Safety Valve Muffler	20 NOx Continuous Measurement Facility
5 Cooling Water Pump	13 Feed Water Pump	21 SOx Continuous Measurement Facility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

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

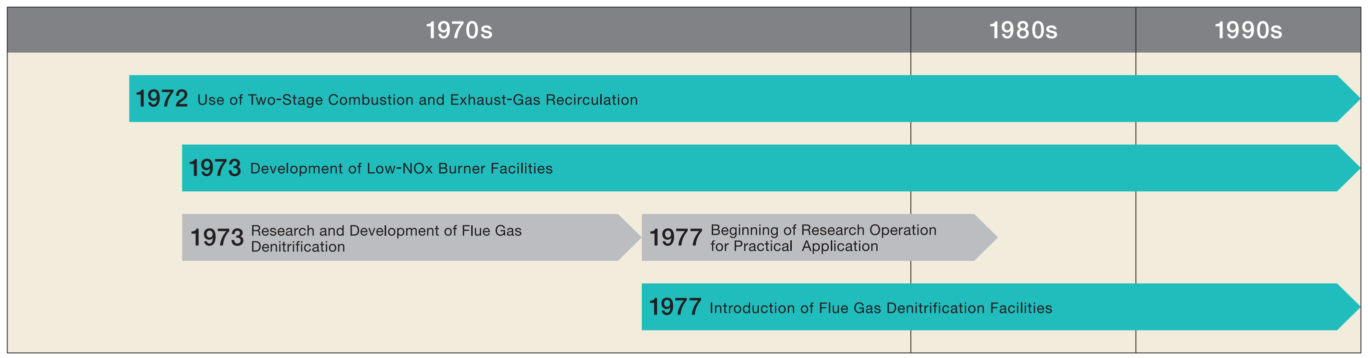


Sources: OECD Environmental Data compendium 2004 ENERGY BALANCES OF OECD COUNTRIES 2002-2003 / JAPAN = The Federation of Electric Power Companies. ※(10 electric power companies and Electric Power Development CO.,LTD)

Operation of SOx Treatment Facilities



Operation of NOx Treatment Facilities



b. Keep the Air Clean

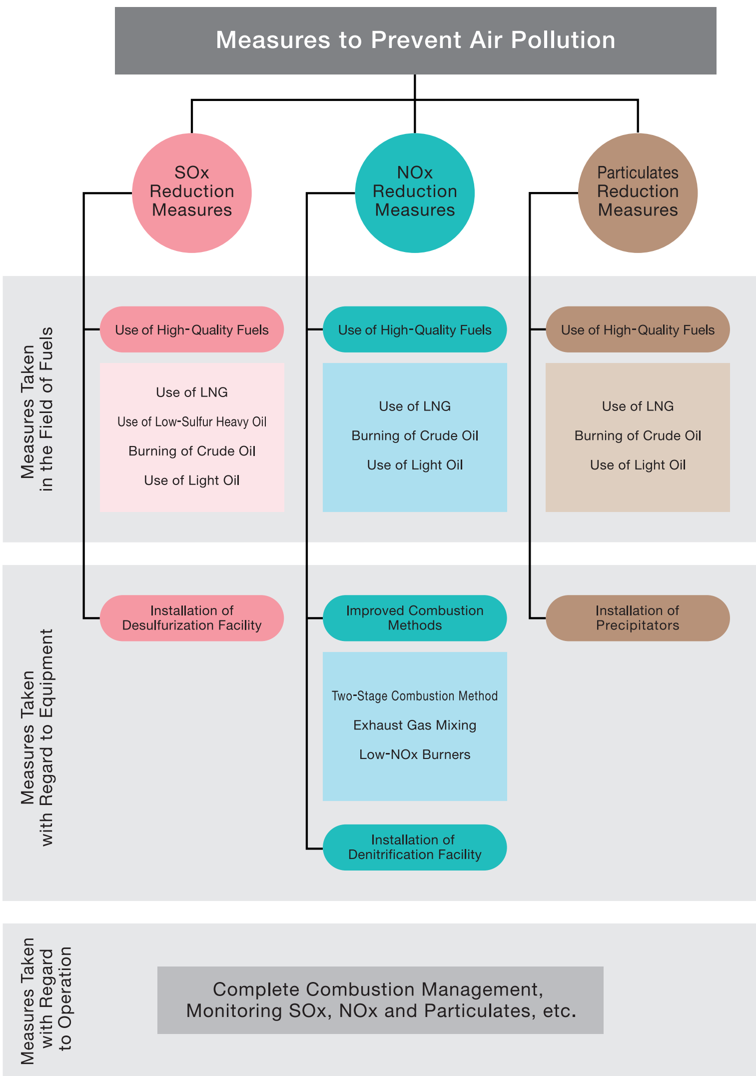
The industry actively promotes a "Keep the Air Clean" policy with regard to fuel, equipment and operating procedures. Emissions of air pollutants such as sulfur oxides, nitrogen oxides and particulates are reduced through an appropriate combination of these three elements.

1. Fuel

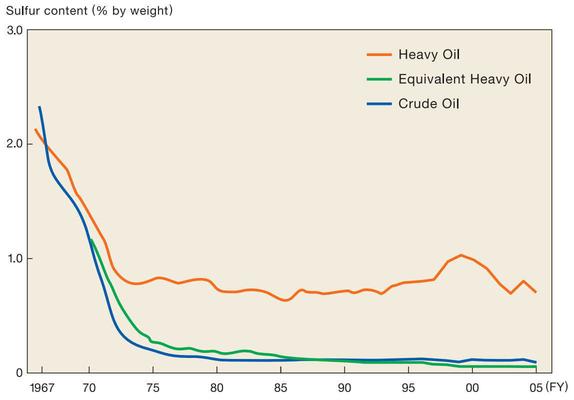
Continuous reduction of SOx, NOx and particulate emissions is being achieved through the use of high-quality fuels such as heavy/crude oil and coal grates with low sulfur and nitrogen and LNG that contains no sulfur or particulates.

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

Outline of Measures to Prevent Air Pollution



Changes in Sulfur content of Fuels



Note: From 1974 on, equivalent heavy oil is after desulfurization.
Sources: The Federation of Electric Power Companies.(FY 2005)

2. Equipment

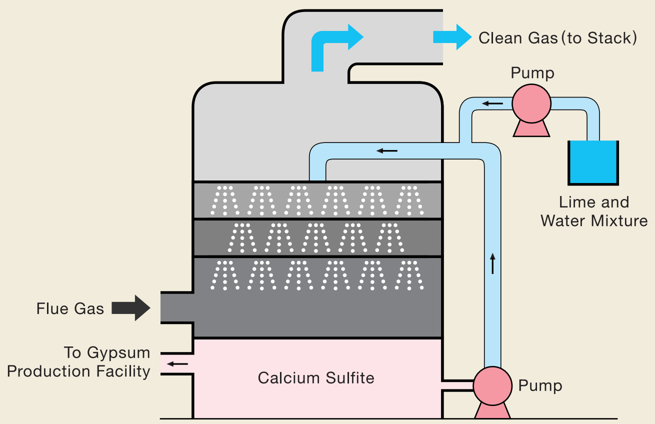
In addition to the above-mentioned measures, the following measures are taken with regard to equipment.

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.

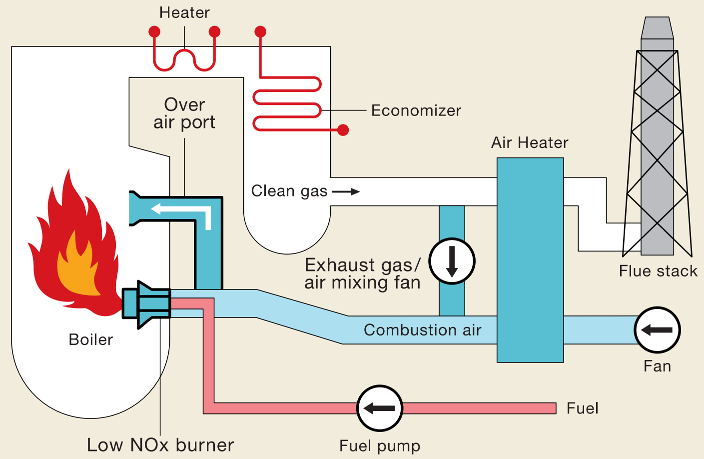
NOx

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.

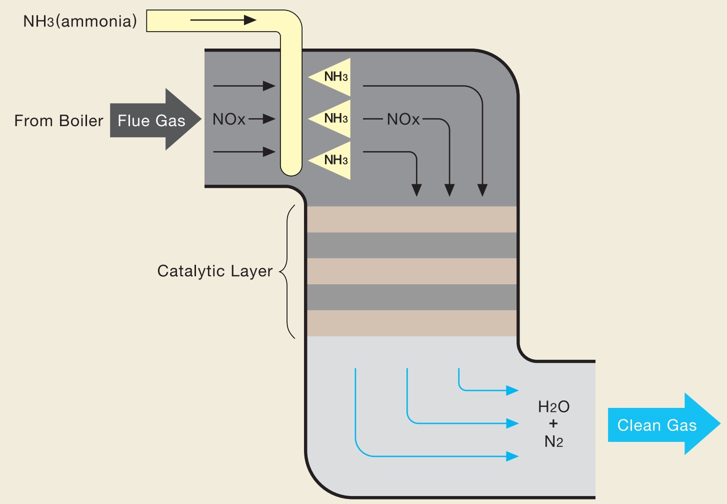
All of the above techniques result in a reduced combustion temperature and are therefore capable of controlling the generation of nitrogen oxides (NOx).

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



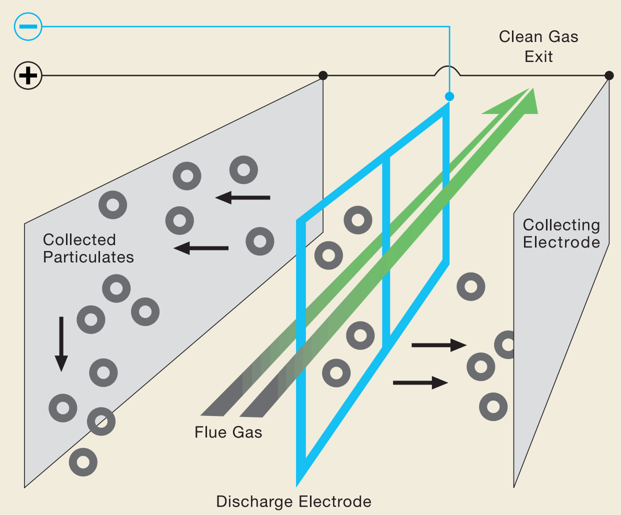
When ammonia is added to the flue gas, which includes NOx, and passed through the catalytic layer, the catalyst causes the NOx to separate into nitrogen and water.

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

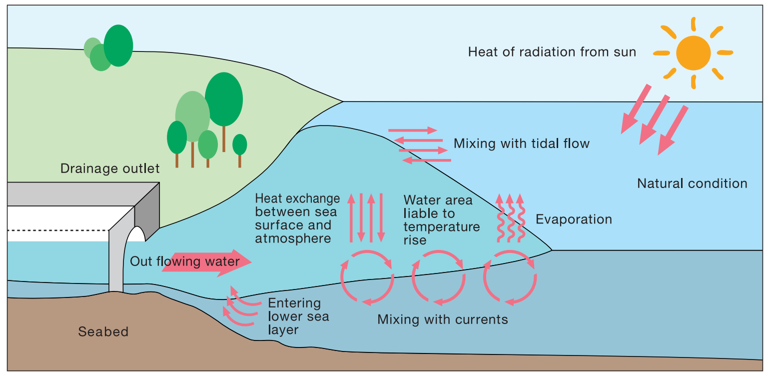


The electrostatic precipitator uses a voltage differential between two electrodes to extract and collect particulates.

(2) Conservation of Water Quality

a. Warm Discharged Water

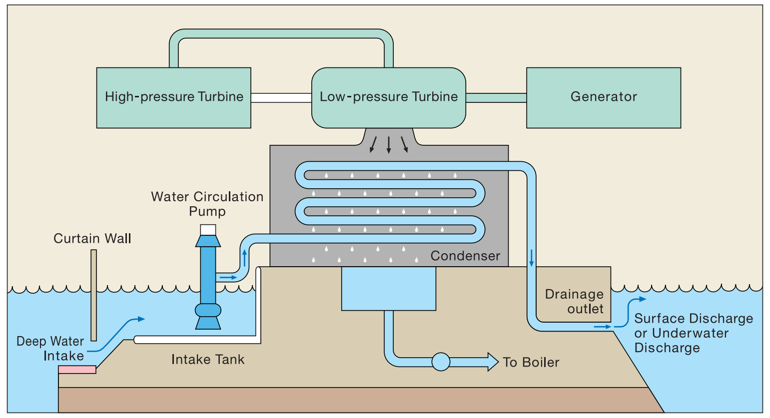
A thermal power station discharges approximately 40 -45m^3/s per 1 million kW of warm waste water. Combined-cycle power generation, employing a combination of gas and steam turbine, offers higher efficiency and produces only about 60% of the aforementioned quantity of warm waste water. A nuclear power 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.

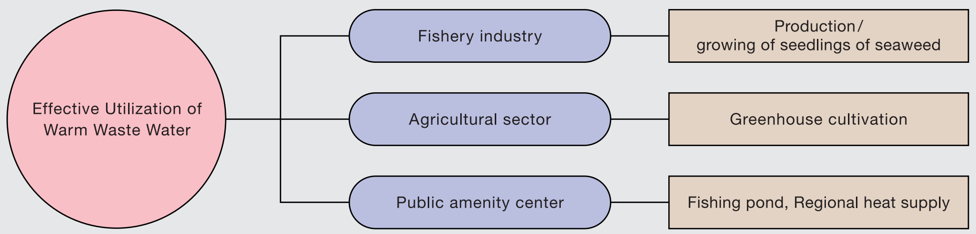
Ornamental plants grown in greenhouse
Takahama Power Station, The Kansai Electric Power Co.

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.

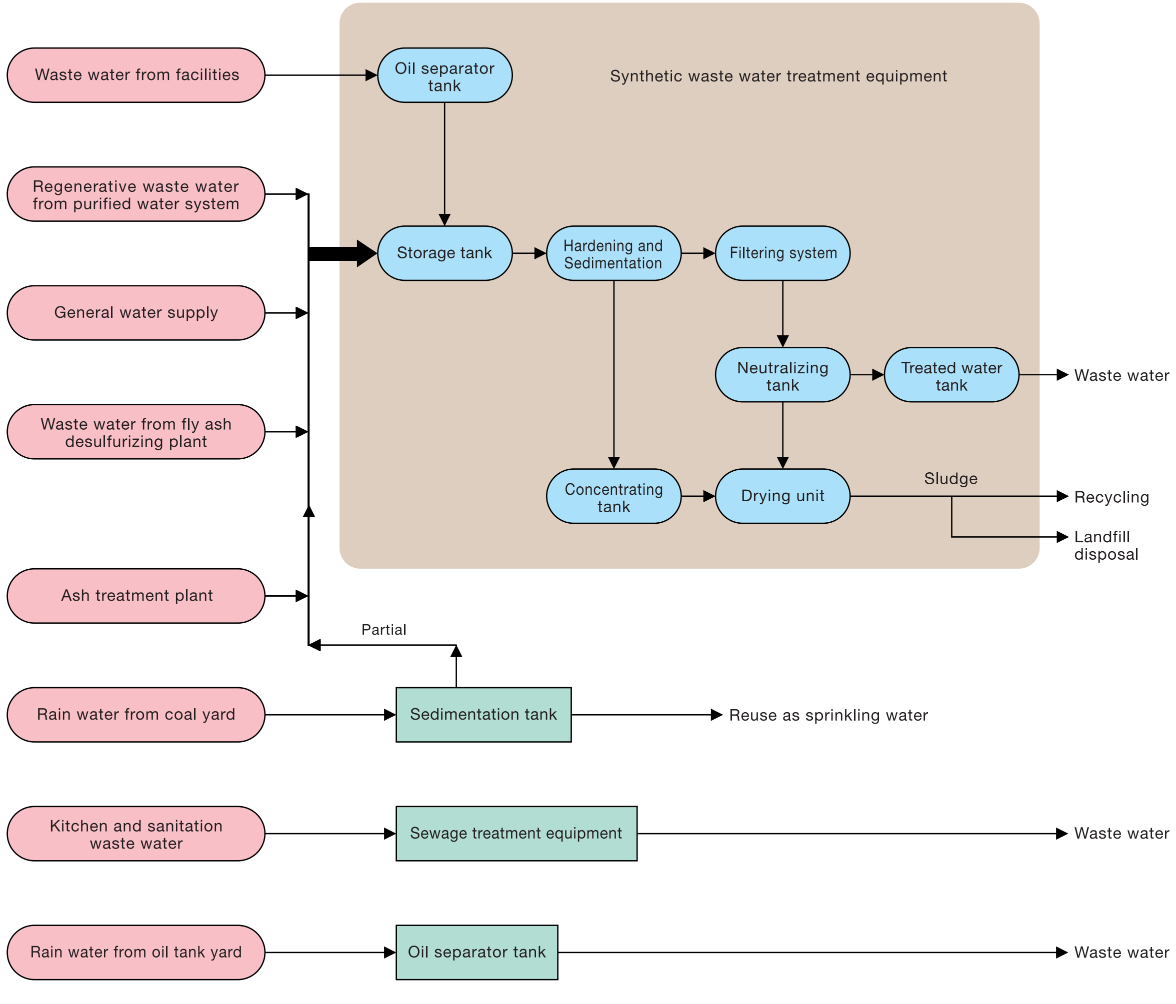
System for Warm Waste Water Utilization



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.

Waste Water Flow Chart

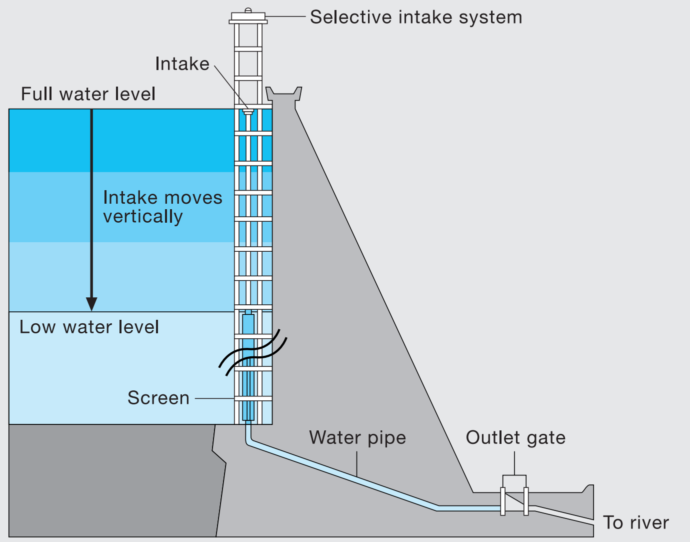


c. Water quality control at hydro power station

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.

Selective Intake System of a Hydro Power Station

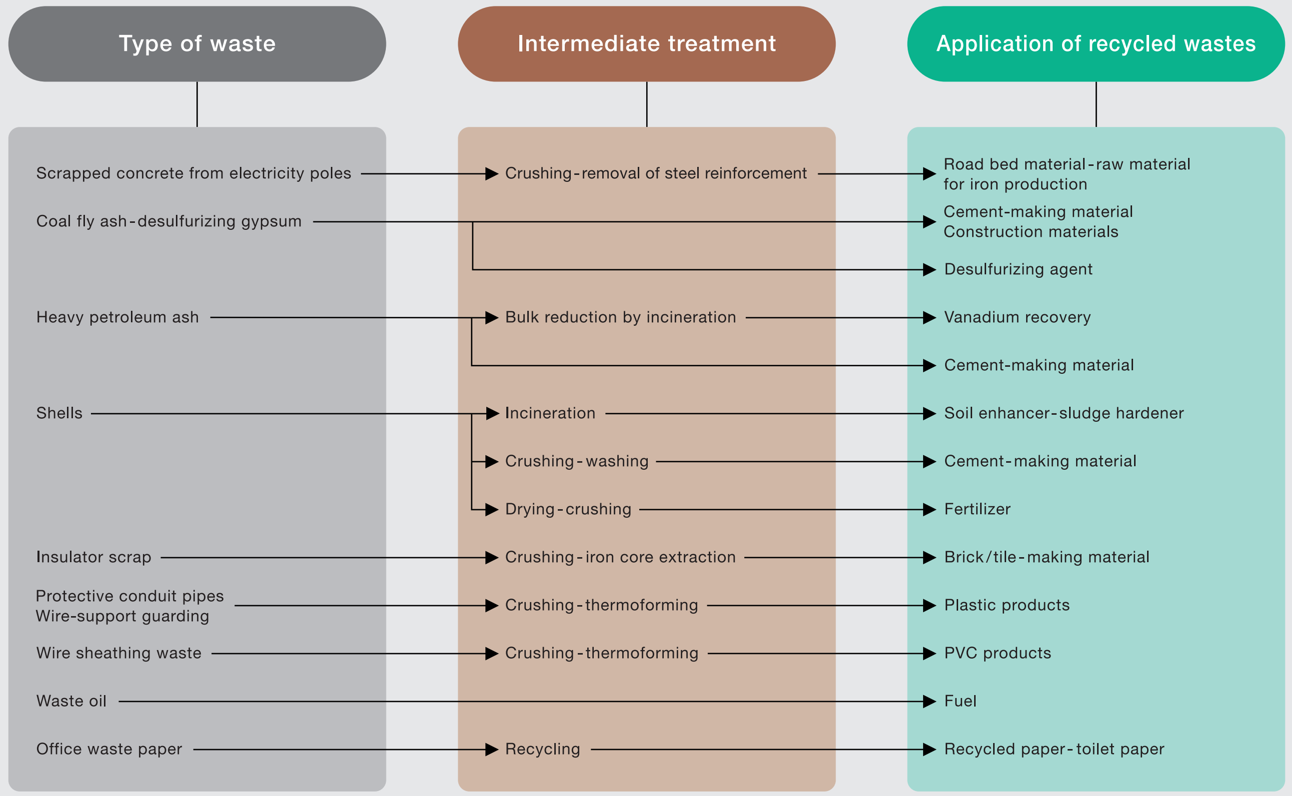


(3) Management of Waste

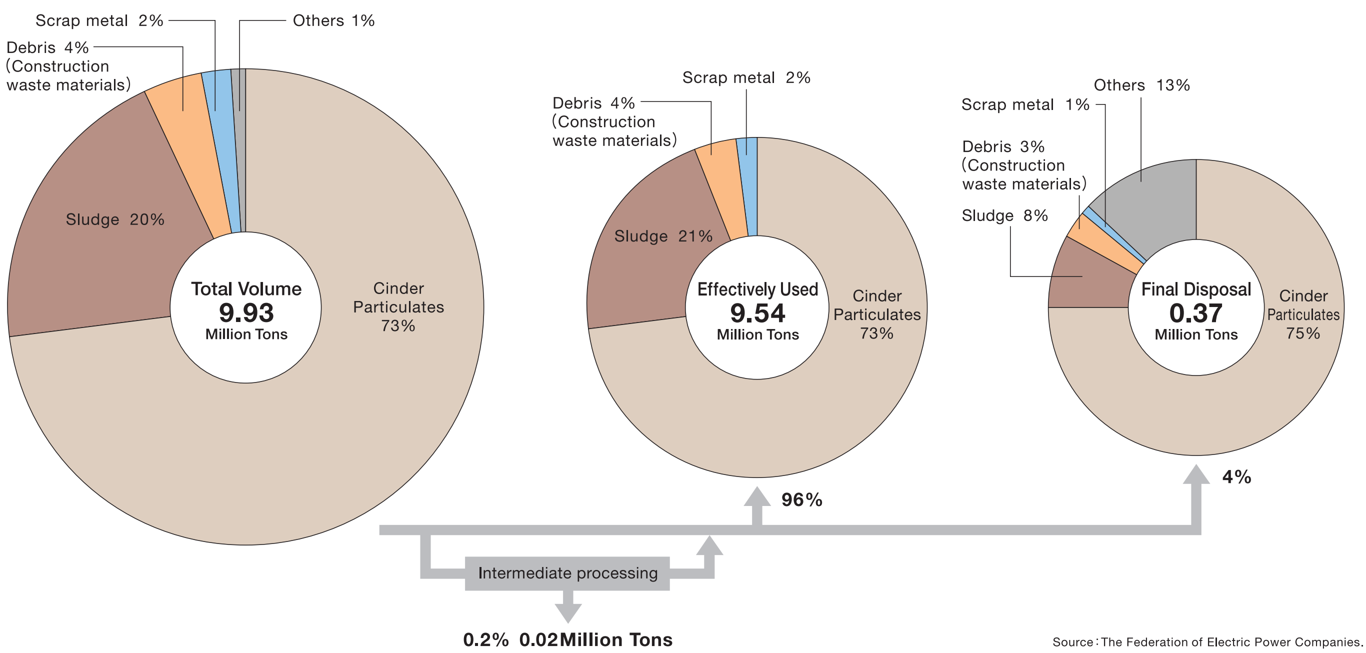
a. Recycling and Reuse of Wastes

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 96% 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



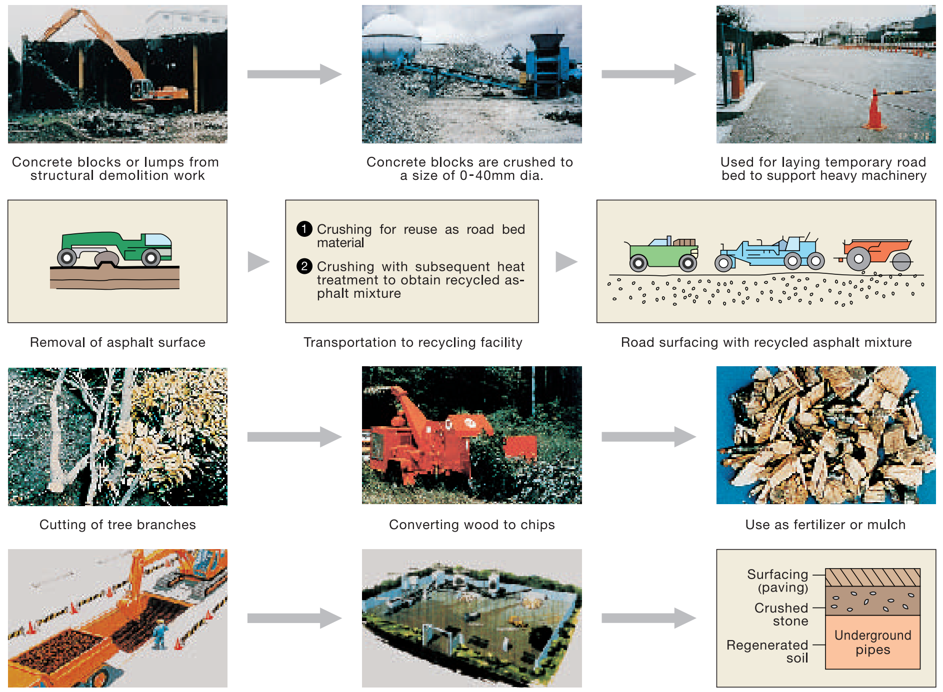
Waste Materials from Electric Power Industry Fiscal 2005



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 → ❶ Crushing for reuse as road bed material ❷ Crushing with subsequent heat treatment to obtain recycled asphalt mixture; Transportation to recycling facility → Road surfacing with recycled asphalt mixture

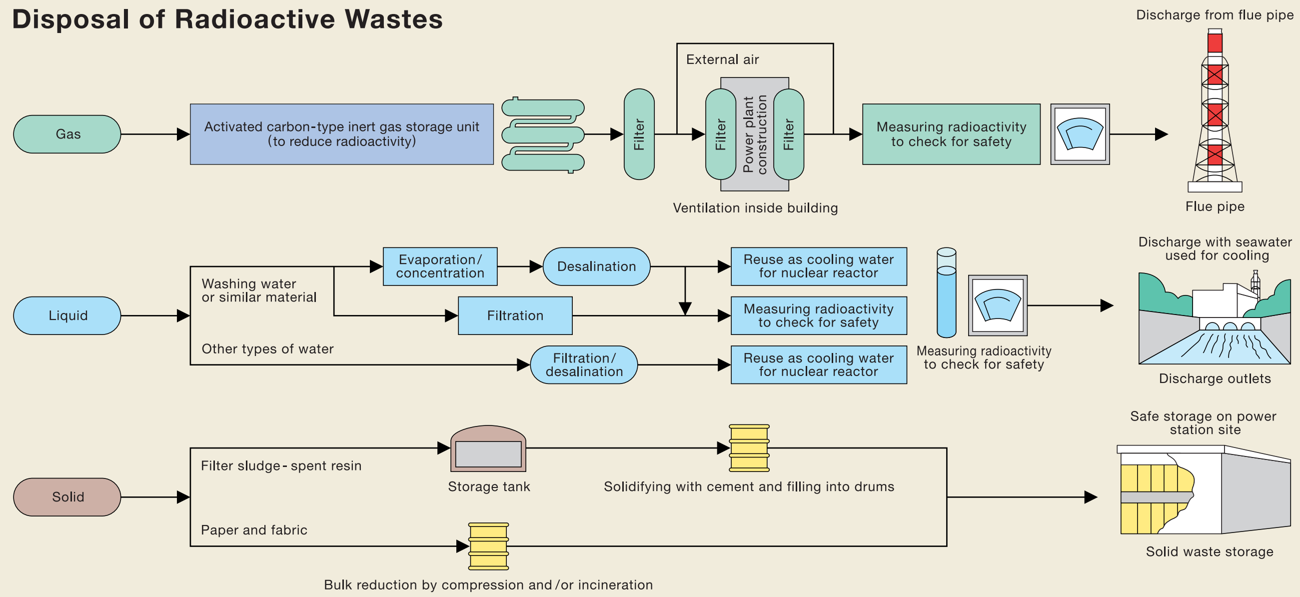
● Wood
Cutting of tree branches → Converting wood to chips → Use as fertilizer or mulch

● Recycling of Excavated Soil (Currently Under Study)
Trench excavation work → Recycling plant for excavated soil → Refilling of excavated trench

c. Treatment of Radioactive Wastes

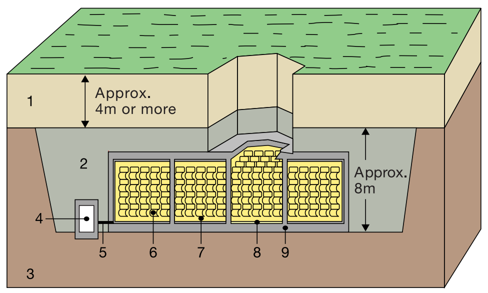
Because of radioactive content, wastes from nuclear power stations fall under a different category from ordinary industrial wastes, and are subject to very stringent control under current government regulations. Radioactive wastes are graded low-level or high-level, depending on radioactive concentration 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

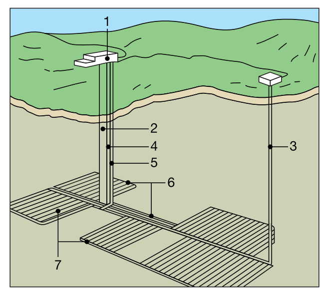
1. Top soil
2. Covering with bentonite-mixed soil
3. Rock bed
4. Inspection corridor
5. Waste water pipe
6. Drum
7. Cement-based filler
8. Porous concrete layer
9. Steel-reinforced concrete pit



Note: Bentonite is virtually impermeable to water.

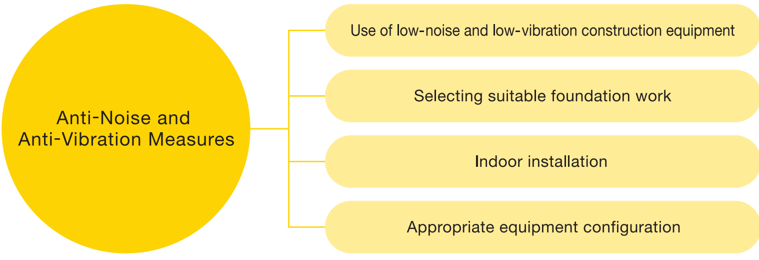
Concept of Underground Disposal of High-Level Radioactive Wastes

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 equipment and 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.

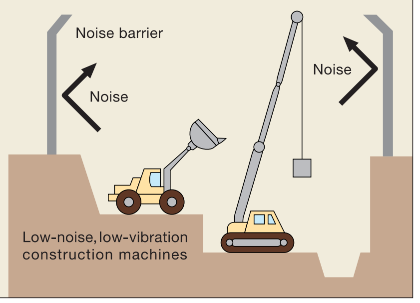


Safety valve silencer

Soundproofing wall

Principal Measures in Construction Work

- Measurement of noise and vibration levels
- Use of low-noise and low-vibration machines
- Erection of noise barrier
- Carefully planned time slot for construction work (voluntary refraining from nighttime work in residential areas)



(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

A Power Plant Surrounded by Rich Foliage

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

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

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

Nanko Thermal Power Station (LNG), The Kansai 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.

a. Screening

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. Scoping

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. Implementation of assessment

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. Report of environmental impact assessment specifications

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.

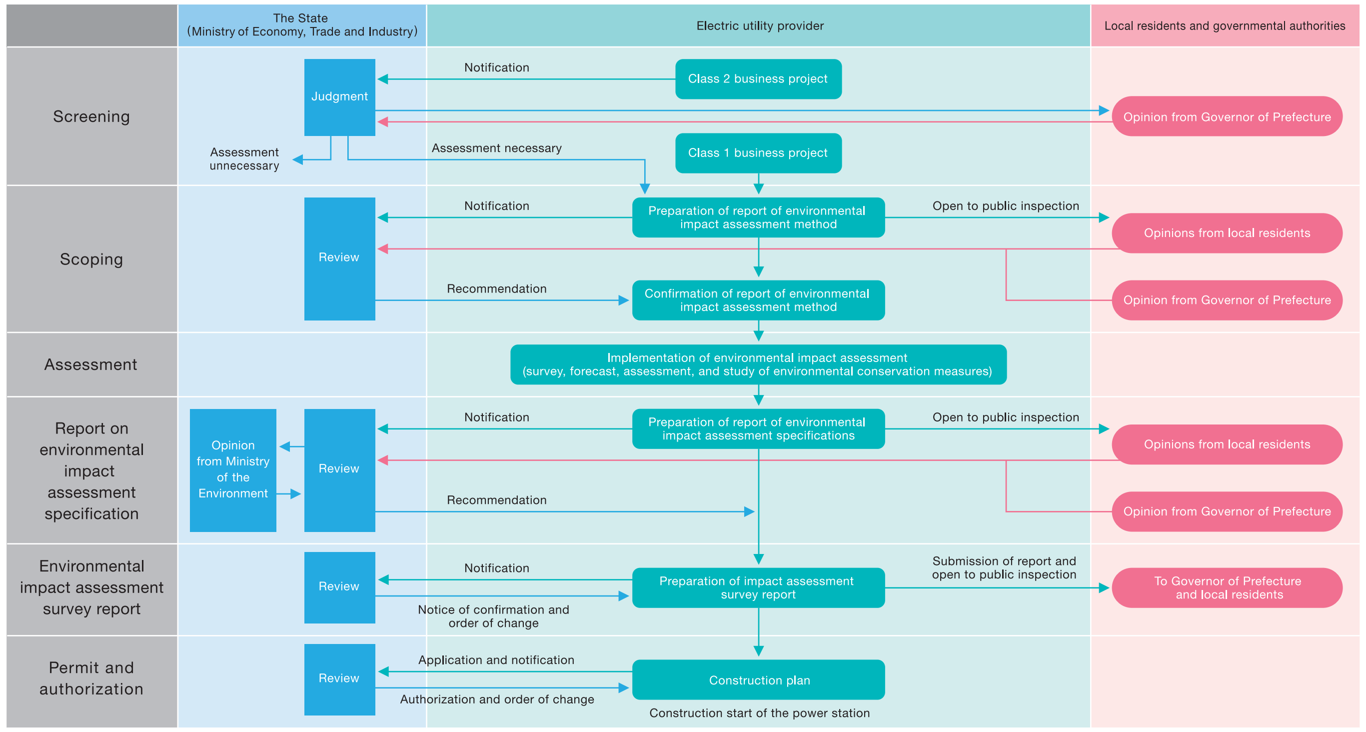
e. Environmental impact assessment survey report

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. Authorization of the construction plan

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

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



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	——

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

Air quality survey

Public meeting to explain environmental assessment to local residents

(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 2005 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.

* 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.

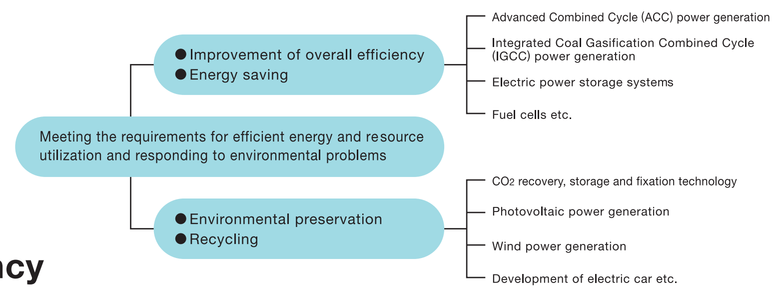
Total Release and Transfer of Chemical Substance (Results for fiscal 2005)

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	5,100	Feed water-processing agent
30	Bisphenol A type epoxy resin	181	0	0	0	0	0	Used in painting
40	Ethylbenzene	37,000	0	0	0	0	110	Used in painting
43	Ethylene glycol	7,900	0	0	0	0	0	Heat-source water for heat supply equipment
63	Xylene	140,000	0	0	0	0	430	Used in painting, power-generation fuel
85	Chlorodifluoro-methane (HCFC-22)	1,200	0	0	0	0	0	Air conditioning refrigerant
124	2,2-dichloro-1,1,1-Trifluoromethane (HCFC-123)	2,300	0	0	0	0	0	Air conditioning refrigerant
144	Dichloropentafluoro-propane (HCFC-225)	6,000	0	0	0	0	0	To launder clothing
162	Dibromotetrafluoro-ethane (Halon 2402)	0	0	0	0	0	1,800	Fire extinguishing material
177	Styrene	11,000	0	0	0	0	0	Used in painting, Plastic fixation agent
179	Dioxins	178	230	0	0.5	0	12	Waste incinerators
227	Toluene	16,000	0	0	0	0	0	Used in painting, power-generation fuel
253	Hydrazine	10	2,700	0	0	0.0	2,200	Feed water-processing agent
299	Benzene	190	0	0	0	0	0	Power-generation fuel, Painting
306	Polychlorobiphenyl	0	0	0	0	0	2,100	Insulating oil
311	Manganese and its compounds	0.0	0	0	0	0	520	Wastewater treatment agent
353	Tris-phosphate (dimethyl phenyl)	0	0	0	0	0	19,000	Turbine control oil

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

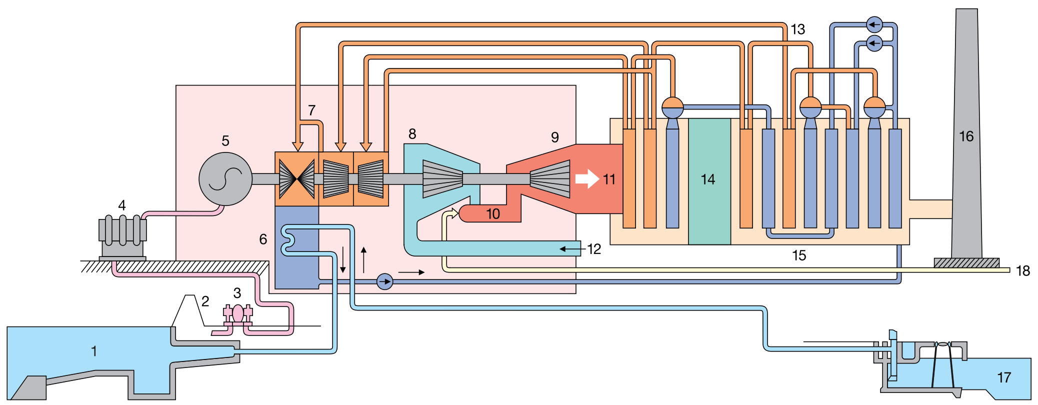


(1) Improvement of Overall Efficiency and Energy Saving

a. Advanced Combined Cycle (ACC) Power Generation

ACC is a power generation method that effectively uses thermal energy by driving a gas turbine with combustion gas and a steam turbine that uses the steam generated from the heat of the exhaust gas that was produced via combustion. This power generation system has improved thermal efficiency to 50% or more (a gas temperature range of 1450℃) compared with 42% thermal efficiency at conventional thermal power plants using a steam turbine. The construction of new plants is under way for higher thermal efficiency by increasing the gas combustion temperature to the 1500℃ range.

Energy Flow Diagram for ACC Power Generating Facility

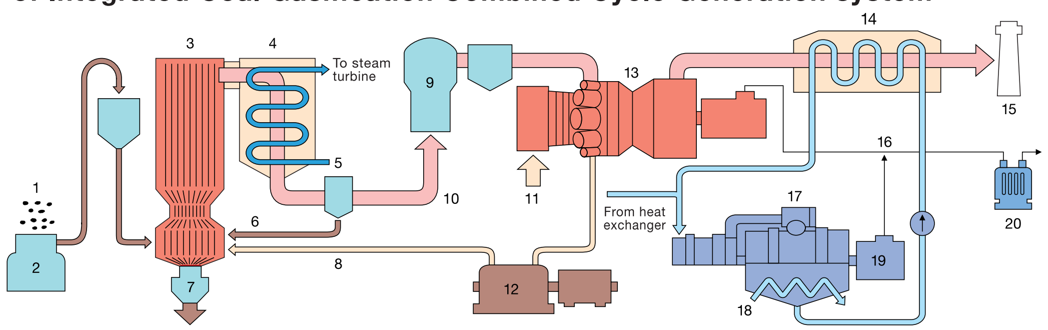


1. Sea	2. Underground power cables	3. Switch	4. Transformer	5. Generator	6. Condenser
7. Steam turbine	8. Air compressor	9. Gas turbine	10. Combustor	11. Flue gas	12. Air
13. Exhaust heat recovery boiler	14. Denitrator	15. Feed water	16. Stack	17. Sea	18. Natural gas

b. 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). Moreover, R&D efforts for a coal gas manufacturing technology suitable for fuel cells are under way with the aim of developing an integrated coal gasification combined-cycle with fuel cells (IGFC), which combines the IGCC process with fuel cells.

Structure of Integrated Coal Gasification Combined Cycle Generation system

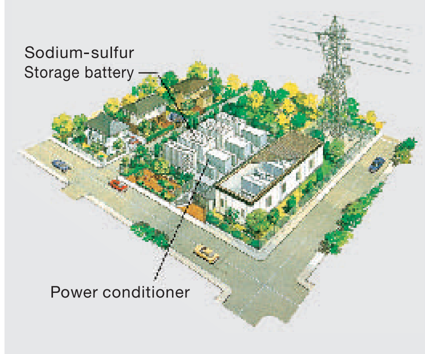


1. Coal	2. Pulverizer	3. Gasification furnace	4. Heat exchanger	5. Feed water
6. Char	7. Slug hopper	8. Gasifying air	9. Gas Purifier (sulfur and dust removal)	10. Char recovery
11. Air	12. Booster compressor	13. Gas turbine	14. Waste heat boiler	15. Stack
16. Electricity	17. Steam turbine	18. Cooling water	19. Generator	20. Transformer

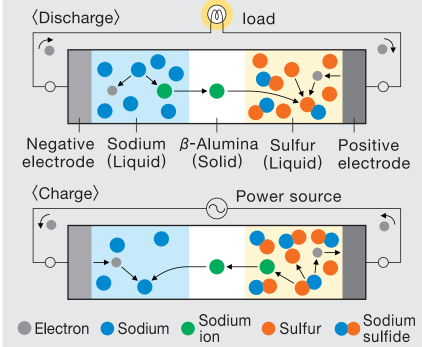
c. Power Storage System

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.

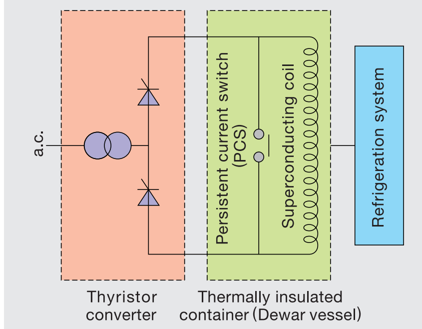
Electric Power Storage System using New Type of Battery



Operating Mechanism of a Sodium-sulfur Storage Battery



Principle of Superconducting Energy Storage



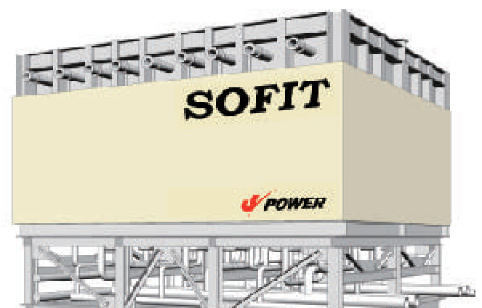
	Features	Present situation	Commercialization
Electric power storage using new types of batteries	Electric energy is converted to chemical energy for storage in a power storage system. When required, electric power is supplied through reverse reaction which converts chemical energy back to electric energy. 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

d. 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 attention 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

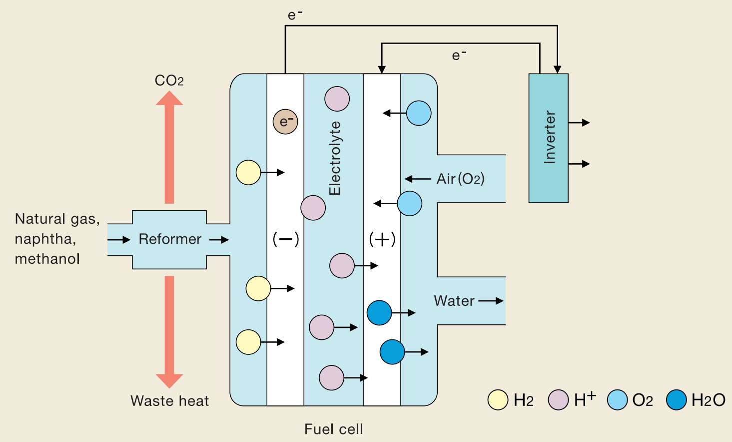
For MCFC, success was achieved in fiscal 2004 for the world's first high-pressure (1.2 MP) operation with those fuel cells by long-term operation of the pressurized small-scale power generation system and high efficiency modules, showing the potential for larger units. The electric power industry is developing a normal-pressure 150-kW class SOFC, among the largest in the world, with the goal of using it for the electricity business, among others, and plans call for conducting a year-long experiment beginning in January 2007.



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

Principle of Fuel Cell Power Generation (phosphoric acid type)

Hydrogen electrode: $H_2 \rightarrow 2H^+ + 2e^-$ (e^-: electron)　Oxygen electrode: $\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O$



The following is a simple explanation of the principle of the fuel cell power generation. Fuels such as natural gas, methanol or coal are reacted with steam for dehydrogenation. The released hydrogen is then sent to the negative electrode (cathode) of the fuel cell and the oxygen to the positive electrode (anode). Under the catalytic action of the electrodes, these two elements (hydrogen and oxygen) are ionized and the direct current thus generated is inverted to an alternating current power generation is then available for power supply.

(2) Environmental Conservation and Recycling

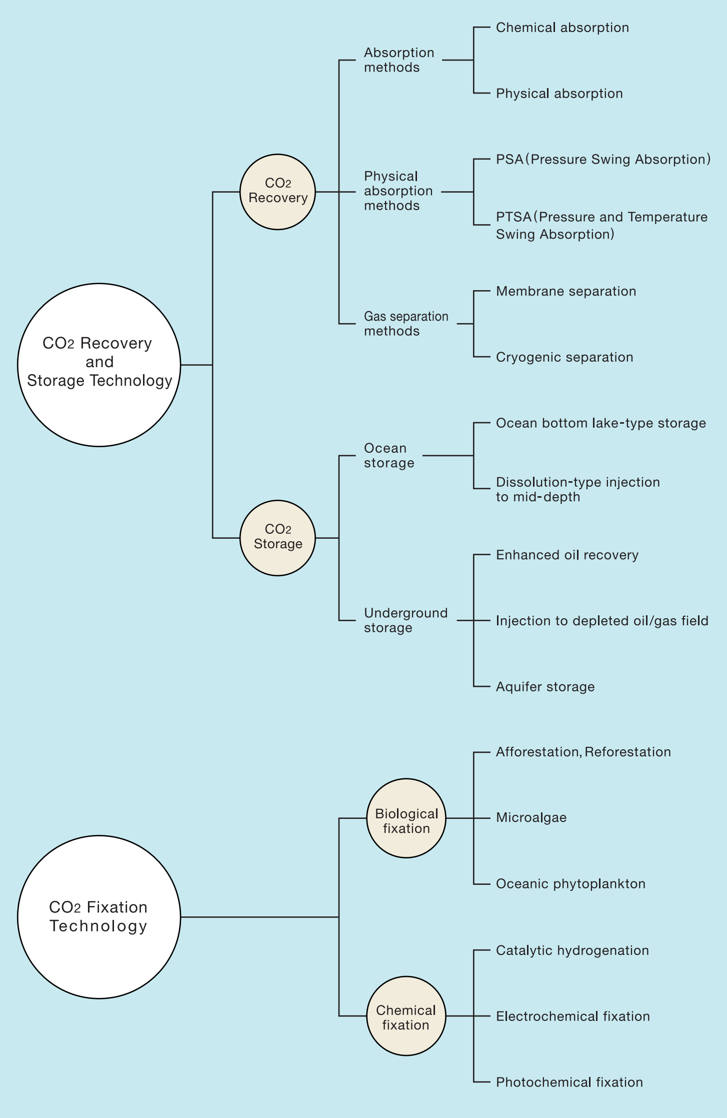
a. Development of CO_2 Recovery, Storage and Fixation Technologies

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.

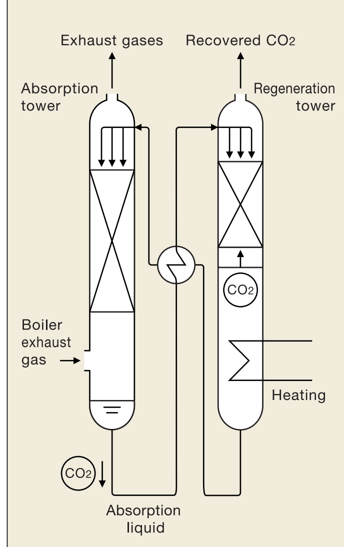
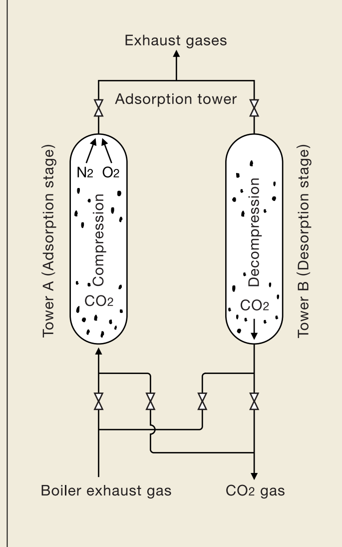
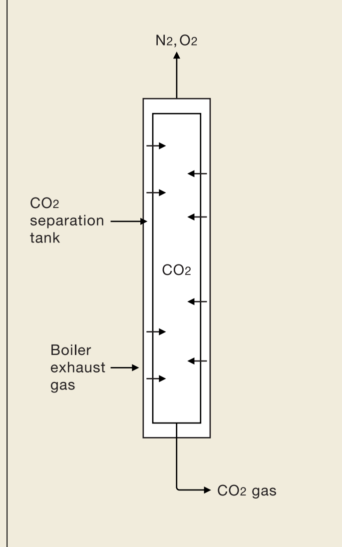
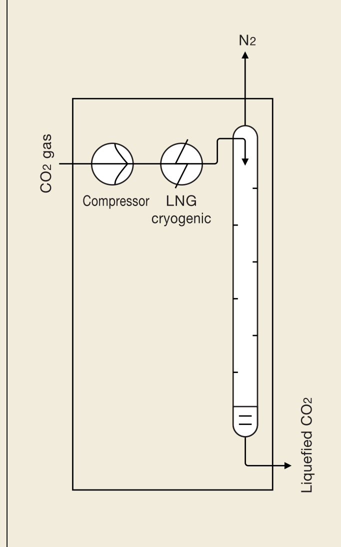
Flue Gas CO_2 Recovery Pilot Plant

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	Physical adsorption	Membrane separation	Cryiogenic separation
			
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.	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.	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.	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 2.0 m 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 power industry is actively introducing renewable power generating systems that use solar, geothermal, and wind energy.

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

Hatchobaru Geothermal Power Station, Kyushu 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. 4,288kW capacity achieved by the end of fiscal 2005.
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 497.1MW of power. (End of fiscal 2005)
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 14.124MW capacity achieved by the end of fiscal 2005.

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. Therefore, we promote researches on social infrastructure enhancement, including sharing system of electric vehicles toward diffusion of electric vehicles.

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

Current State

Although electric vehicles are considered to be a very promising part of the solution to global environmental problems and the depletion of energy resources, there are still issues with driving distance, recharging time and price. At this time, 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.

Specifications

Vehicle dimensions (Length × width × height)			3.285m × 1.475m × 1.510m
Passengers			2
Driving performance	Range		80km
	Maximum speed		100km/h
	Maximum output of electric motor		40kW
	Braking		Same as gasoline-powered car
Battery	Type		Laminated lithium ion battery
	Total voltage		346V
Charging	Ordinary charge	Battery usage	Uses single-phase 100V and single-phase 200V power source with on-board charger
		Charging time	About 8 hours at 100V, 6 hours at 200V
	Quick charge	Battery usage	Uses stand-alone 3-phase 200V power source
		Charging time	About 15 minutes from 0% charge to 80% charge

Quick charger

Features		Works with different types of batteries
Specifications	Switching-type	Constant current power source
	Connector	Contact type
	Input	3-phase, 200V
	Maximum output	50kW
	Maximum DC voltage	500V
	Maximum DC current	125A

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

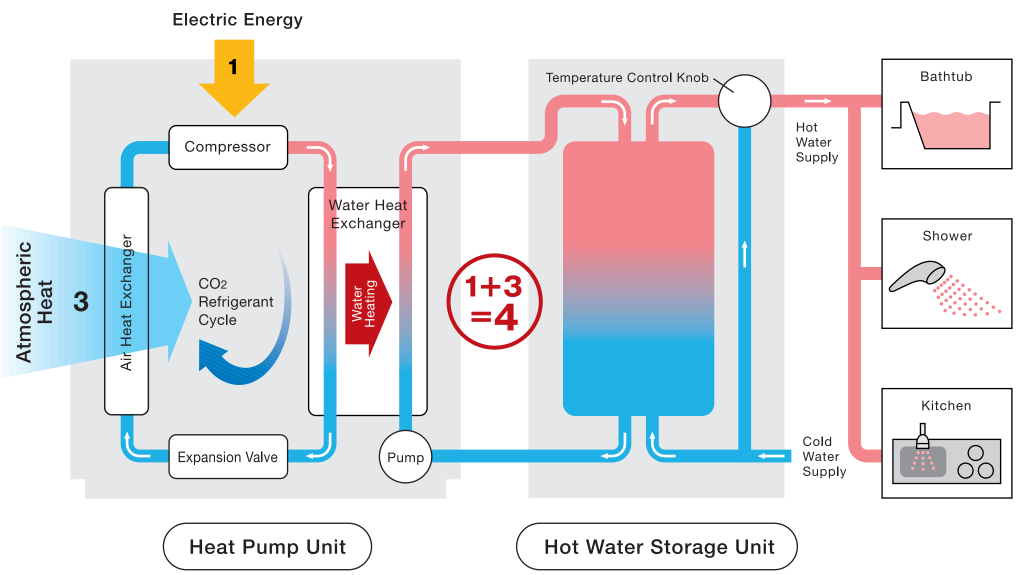
*1 COP (Coefficient of Performance) = Heating Capacity (kW) / Electric Power Consumption (kW)

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, 480,000 ECO CUTE units have been installed (as of the end of FY2005), accounting for an estimated 390,000 t-CO_2 saved.

EcoCute Hot Water Supply System Diagram

1 Electric Energy + 3 Atmospheric Heat = 4 Hot water supply energy obtained

Hot water supply with EcoCute saves energy! It dramatically improves efficiency!

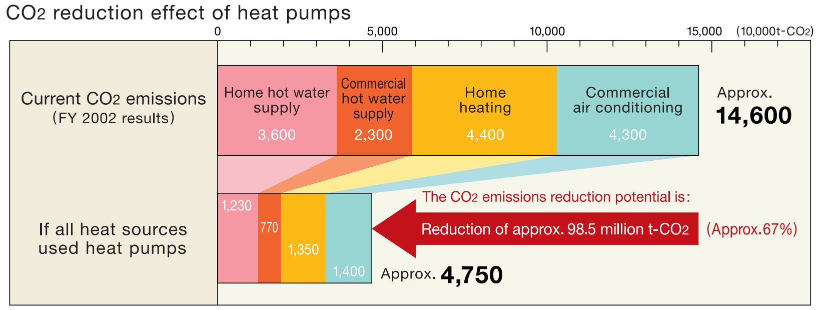


Possibility for home and business CO_2 reduction through heat pump use

Air conditioning and hot water supply make up more than 50% of energy consumption in Japan by the civilian sector—homes and businesses. A complete switch from traditional fuel combustion to highly efficient heat pump use for those would allow a CO_2 reduction of approx. 100 million t-CO_2 per year.

(Calculations by The Heat Pump & Thermal Storage Technology Center of Japan)

CO_2 reduction effect of heat pumps

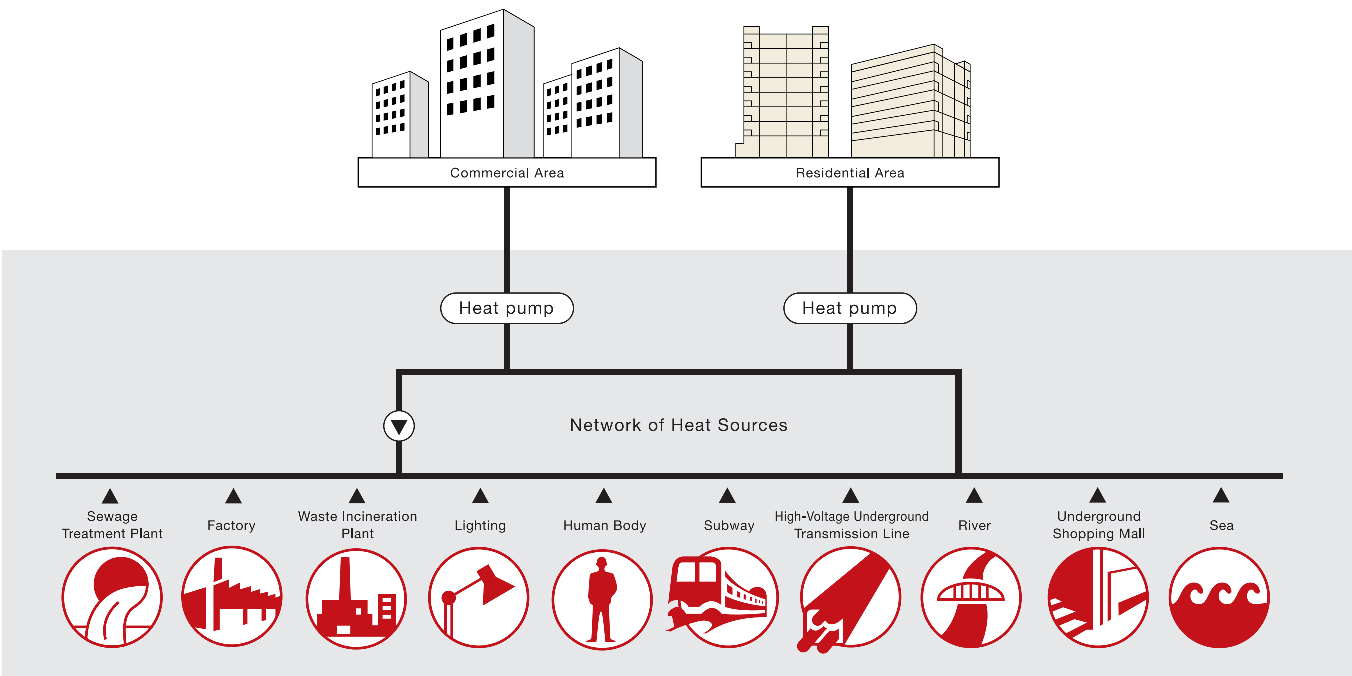


● A reduction of 100 million t-CO_2 is equivalent to approximately 150% of the target reduction of 60 million t-CO_2 from the consumer sector under the Kyoto Protocol Target Achievement Plan.

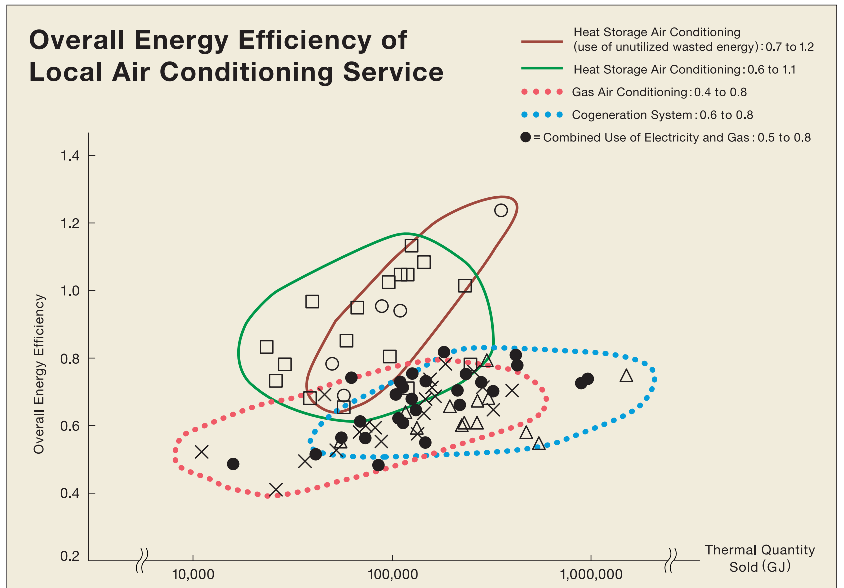
c. Promoting the Operation of Regional Heat Supply Services Using Untapped Energy

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.
Source: Fiscal 2004 Heat Supply Business Handbook Converted into electricity at 2,450 kcal/kWh and into town gas at 11,000 kcal/m³.
Overall Energy Efficiency = Thermal Quantity Sold / Primary Energy Input

Utility Service Center Plant

Regional heat supply service using river water
(Hakozaki area)

d. Power Generation Using Wind Power and Solar Energy

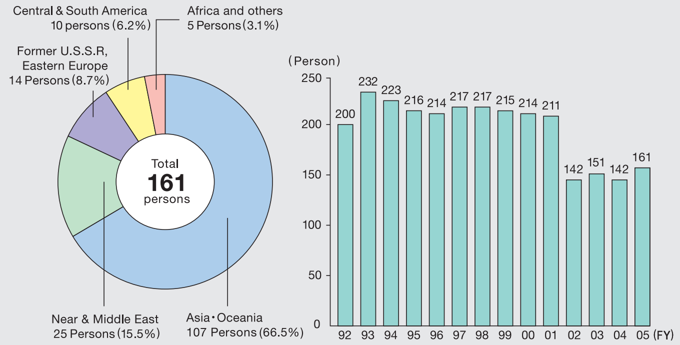
Electric power companies are purchasing surplus power so that environment-friendly power generation systems using no fossil fuels such as wind power, solar energy and other natural energies are used effectively. At the same time, they are introducing their own systems, working to promote popularization 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.

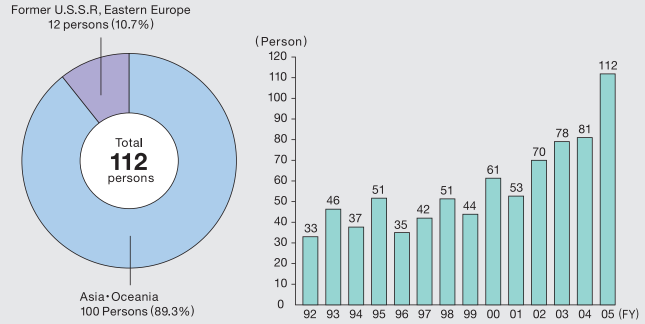
6. International Cooperation

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 2005)



Statistics for Japanese Specialists Sent to Developing Countries through the Japan Electric Power Information Center (FY 2005)



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 UN 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-of-the-art animal waste facilities approved by the CDM Executive Board.	2004
Landfill gas reduction project in Brazil	CDM project approved by the UN CDM Executive Board for recovering and incinerating biogas emitted by landfills, reducing greenhouse gasses.	2002
China micro hydro power CDM project	Japanese government approved CDM project to construct micro hydro power plant and sell the power to a local electric power company.	2003
Biopower rice husk power project in Thailand	Japanese government approved CDM project to effectively use rice husks that are disposed of through combustion as fuel for power generation.	2003
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	2005
Afforestation business projects in Australia	Afforestation projects designed to preserve the world's forest resources and fix atmospheric CO_2	Implemented multiple times
Participation in the various Carbon Fund	Prototype Carbon Fund established and operated by the World Bank and other institutions designed to provide accommodate for and invest in projects to reduce greenhouse gases in developing countries ●Japan GHG Reduction Fund (JGRF) ●World Bank Carbon Fund (PCF) ●World Bank Community Development Carbon Fund (CDCF) ●World Bank's BioCarbon Fund (BioCF) ●Eastern Europe Energy Efficiency Reserve Fund (EEERF) ●Greenhouse Gas-Credit Aggregation Pool (GG-CAP) ●Global Asia Clean Energy Service Fund (FEGACE)	JGRF: Dec. 2004 PCF: Apr. 2000 CDCF: July 2003 BioCF: June 2004 EEERF: Jan. 2000 GG-CAP: Feb. 2005 FEGACE: May 2004

Example of involvement in instruction on energy conservation technology in developing nations

Project	Outline	Period
Technical cooperation in thermal efficiency improvement at thermal power plants in China	Operation improvement training, equipment improvement proposals and other activities at the Huangtai thermal power plant of China's Shandong Electric Power Company resulted in improved thermal efficiency. That, in turn, caused reduction of 88,000-ton/year in coal used and 210,000 tons/year in CO_2 emitted.	Apr. 1996–Mar. 2000
Thermal efficiency recovery project through improvement of thermal power plant operations in Thailand	Providing operation management and technical knowledge to the Energy Generating Authority of Thailand (EGAT) South Bangkok Power Plant resulted in an approx. 5,000 ton reduction in fuel oil use and a 16,000 ton reduction in CO_2 emissions.	Sept. 1999–Jul. 2002
Model operation for thermal efficiency improvement at a thermal power plant in Indonesia	Equipment improvement and thermal efficiency management training held at Java-Bali Power Company's Muara Karang power plant resulted in an approx 6,000 ton/year reduction in fuel oil use and a 15,000 ton/year reduction in CO_2 emissions.	Jun. 1998–Mar. 2001

Environmental Action Plan of the Electric Utility Industry

September 2006

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 "By fiscal 2010, we aim to reduce CO_2 emissions intensity by 20% from the fiscal 1990 level, to about 0.34kg-CO_2/kWh." This would mean that total CO_2 emissions in fiscal 2010 would increase only about 9% from the fiscal 1990 level, even though the growth rate of electric power consumption for the same period is forecast to rise 36%.

[CO_2 Emissions Results]

The user-end CO_2 emissions intensity in fiscal 2005 was 0.425 kg-CO_2/kWh, or about the same level as in fiscal 2004. This is because nuclear power facilities were used more and generated more power, but at the same time lower hydropower generation (caused by drought conditions) and the increase in power demand during a record cold winter made it necessary to increase thermal power generation.

[CO_2 Emissions Control Measures]

The electric power industry's measures to control CO_2 emissions are roughly divided into supply-side and demand-side initiatives, which are summarized below.

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, and using untapped energy sources ● Promotion of load leveling by the use of thermal storage air conditioning systems, etc.

○ **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, obligated to use new energy sources by the Special Measures Law Concerning the Use of New Energy by Electric Utilities (RPS Law), the 10 general electric utilities made the utmost effort and succeeded in securing the mandated volume in fiscal 2005. The industry will continue to fulfill this obligation.

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

Because improving thermal power's efficiency directly contributes to reducing CO_2 emissions intensity, the industry is working to install and expand high-efficiency facilities including LNG combined-cycle systems when old equipment is replaced or new equipment is built, and it is also developing integrated coal gasification combined cycle (IGCC) power for the efficient use of coal, a fossil fuel essential for Japan's long-term fuel supply stability. The industry is also 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 on the supply side. The industry further develops and popularizes CO_2 heat pump water heaters and high efficiency commercial air conditioners that use heat pump technology. It is also conducting verification tests on the Home Energy Management System, or HEMS, which helps households conserve energy through optimal operation of home electronic devices and other means.

○ **International Initiatives**

The electric power 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 continue use of the Kyoto Mechanisms, reforestation projects and so on while monitoring trends in detailed system design in Japan and abroad and examining strategies for meeting its targets.

○ **Approach to office use and in-house distribution/transport**

CO_2 emissions from the consumer and transport sector are increasing, requiring immediate measures. Electric power companies are endeavoring to control CO_2 emissions by promoting consumption reduction strategies targeting their own office electric power use and fuel use from in-house distribution and transport.

○ **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 that help customers conserve energy, technologies for the recovery and fixing of CO_2 in the gas emitted by thermal power plants, nuclear technologies, and technology in the area of forests as carbon sinks.

[Future Efforts and Issues]

The targets found in the electric industry's environmental action plans were set using supply and demand forecasts from 1996 and assumed full-scale efforts based on nuclear power development plans of the time. Since then, however, plans for nuclear power through fiscal 2010 have been gradually scaled back for several reasons: the greater lead time needed to develop nuclear power in an unfavorable environment, the incremental expansion of the scope of deregulation, and the reconsideration of power source development plans in light of stagnating growth in demand. As a result, current outlooks indicate that development will actually fall to a level less than half that envisioned in the original plans, making it exceedingly difficult to meet industry targets. In spite of the challenges, however, the industry is holding fast to its original target, which it is striving to meet by increasing the capacity factor of nuclear power facilities with various original innovations, and by taking new measures, such as using the Kyoto Mechanisms and working with CO_2 reduction projects. It is studying and actively promoting various measures on both the supply and demand side. Going forward, the electric power industry plans to commit its full efforts to achieving 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.**

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 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]

The total volume of waste produced by the electric power industry in fiscal 2005 was 9.93 million tons, an increase of 0.41 million tons over fiscal 2004. This resulted from increasing demand for electricity. However, the volume of waste recycled in fiscal 2005 was 9.56 million tons, which represents an increase of 0.80 million tons compared to fiscal 2004. As a result, the recycling rate was 96% in fiscal 2005, an increase of 4% compared to fiscal 2004. By category of waste, coal ash was the most voluminous at 7.24 million tons, of which 6.97 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 Japanese electric power industry will continue to practice the three R's—reduction, reuse and recycling—on the road to achieving a recycling-based society. The recycling of coal ash, the type of waste generated in the greatest volume, continues to be an important issue, and therefore the industry is actively working to develop applications using this material at a constant and high volume, and research into effective usage technologies is ongoing. In addition, we will work to fully recycle desulfurization gypsum and promote the three R's with other waste as well.

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

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 independent 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. 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 long established their in-house environmental management systems with the creation of a dedicated environment department, and their involvement in efforts to protect the environment has been disclosed and published in Environmental Action Reports and by other means. As for environmental management systems, each power company actively and voluntarily commits to various measures based on 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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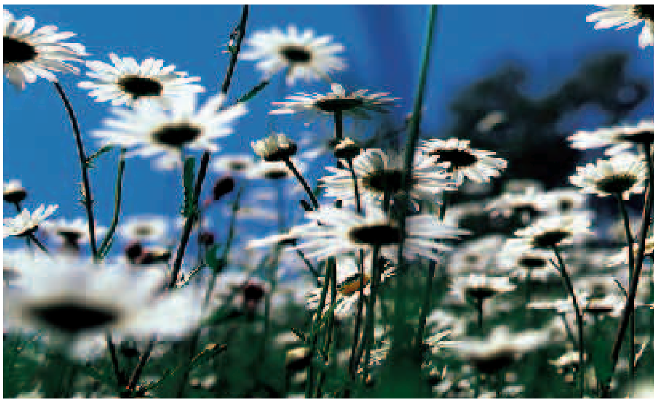

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