

ELECTRICITY REVIEW JAPAN

The Federation of
Electric Power Companies of
Japan

2019



History of Japan's Electric Utility Industry

Electricity was first used in Japan on March 25, 1878 at the Institute of Technology in Toranomon, Tokyo when an arc lamp was switched on in commemoration of the opening of the Central Telegraph Office. In those days, electricity was still unfamiliar and uncommon not only in Japan but also in Europe and the United States. In 1886, Tokyo Electric Lighting, a private company, commenced operations as the nation's first electric power company, and began supplying electricity to the public in the following year.

In the early days, use of electricity grew primarily for lighting because of its safety and cleanness, and gradually found broader applications as a power source to replace the steam engine. By 1896, the number of electric utilities established throughout the nation reached a total of 33. The early 20th century marked the establishment of long-distance transmission technology. As larger thermal and hydro-power plants were introduced, generation costs fell and electricity came into wider use throughout the country. Consequently, electricity became an indispensable energy source for peoples' lives and industry.

In the years that followed, the electricity utility business grew in tandem with the modernization of Japan and development of its industry. At the same time, the electric utility industry experienced a major restructuring that led to the dissolution of 700 electric utilities, which merged to create five major electric utilities after the First World War. During the Second World War, the electric utility industry was completely state-controlled and utilities were integrated into Nihon Hatsusoden Co. (a nationwide power generating and transmitting state-owned company) and nine distribution companies.

After the end of World War II in 1945, supply and

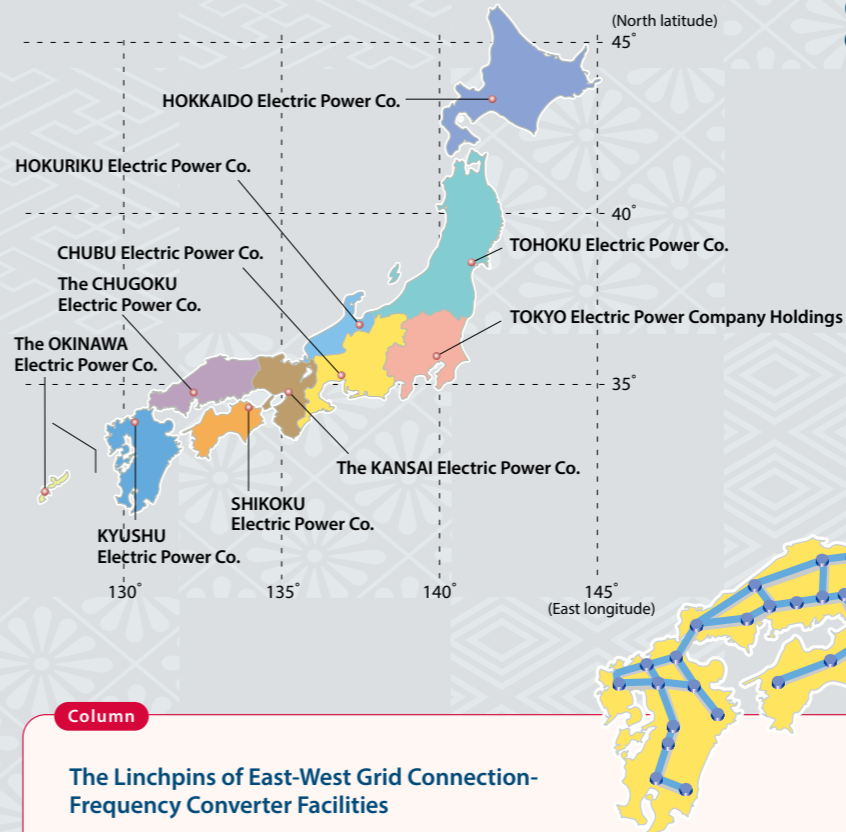
demand for electricity remained very tight in Japan. A series of intense discussions were held on restructuring the electric utility industry as one of the measures for democratizing the economy. As a result, nine regional privately owned and managed General Electricity Utilities— Hokkaido, Tohoku, Tokyo, Chubu, Hokuriku, Kansai, Chugoku, Shikoku and Kyushu Electric Power Companies — were established in 1951 and assumed the responsibility of supplying electricity to each region.

The Okinawa Electric Power Co. was established with the return of Okinawa to Japan in 1972.

At the end of the 20th century, a trend toward deregulation and competition took hold throughout society, and the electric utility industry started to be liberalized. In December 1995, organizations such as independent power producers (IPP) were allowed to provide electricity wholesale services, and in March 2000, electricity retail supply for extra-high voltage users (demand exceeding 2MW) was liberalized. The scope of retail liberalization was then expanded in April 2004 to users of more than 500kW, and subsequently in April 2005 to users of more than 50kW. Thus, a Japanese model of liberalization based on fair competition and transparency, while maintaining the vertical integration of generation, transmission and distribution to ensure a stable supply of electricity, was established.

With the Fukushima Daiichi Nuclear Power Station accident and subsequent tight demand and supply brought about by the Great East Japan Earthquake in March 2011 as a turning point, numerous discussions were held to maintain a stable supply and reduce energy costs, and in November 2013, the policy to implement three-phase reforms of the electric power system was adopted.

The Ten Electric Power Companies by Main Service Area



The Linchpins of East-West Grid Connection-Frequency Converter Facilities

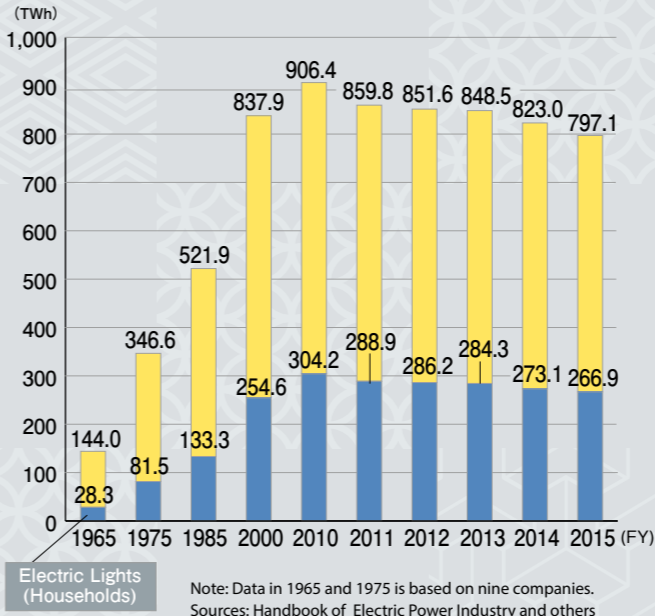
The frequency of grid power differs between eastern and western Japan, namely 50 Hz and 60 Hz respectively. This difference has a historical root in that the Tokyo area adopted German-made generators at the beginning of the electricity business while Osaka chose US-made ones. Therefore, Frequency Converter Facilities (FCF) are necessary to connect the eastern and western power grids. Three FCFs, namely Sakuma FCF and Higashi-Shimizu FCF in Shizuoka Pref. and Shin-Shinano FCF in Nagano Pref., operate to convert the frequency.

After the Great East Japan Earthquake, to strengthen the east-west grid connection, the capacity of FCFs is planned to be expanded to 3,000 MW by FY2027.



Higashi-Shimizu FCF

Power Demand for Ten Companies



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Note: Nine Companies include Hokkaido, Tohoku, Tokyo, Chubu, Hokuriku, Kansai, Chugoku, Shikoku and Kyushu. Ten Companies include the above Nine Companies plus Okinawa.

Japan's Energy Supply Situation

Resource-poor Japan is dependent on imports for more than 90% of its energy. Thus, Japan's energy supply structure is extremely vulnerable. Following the two oil crises in the 1970s, Japan has diversified its energy sources through increased use of nuclear energy, natural gas and coal, as well as the promotion of energy efficiency and conservation. Despite these improvements, oil still accounts for about 40% of Japan's primary energy supply, and more than 80% of imported oil comes from the politically unstable Middle East. Moreover, although Japan has one of the highest proportions of electricity demand in total energy demand at over 40%, prospects for importing electricity from neighboring countries are very poor because Japan is an island nation. In addition, there is an urgent need for global warming countermeasures such as reduction of carbon

dioxide emissions from the use of energy. To ensure Japan's stable electricity supply, it is crucial to establish an optimal combination of power sources that can concurrently deliver energy security, economic efficiency, and environmental conservation, while making safety the top priority.

For the future, it is important for Japan's energy mix to continue to include a certain level of nuclear energy premised on ensuring safety, while maximizing the use of renewable energy and using a reasonable proportion of thermal power considering the stability of fuel supply.

The "5th Strategic Energy Plan" revised by the government in July 2018 also states that nuclear power is an important base load power source that can, strictly premised on safety, contribute to the stability of the supply and demand structure of energy.

Development of 2030 Energy Mix

After the Great East Japan Earthquake, almost all nuclear power stations have been halted and thermal power generation accounts for most of the energy mix. As a result, Japan's energy self-sufficiency ratio has dropped from 20.2% at the time before the Earthquake to 6.4% in FY2014 and fuel costs have nearly doubled from 3.6 trillion yen to 7.2 trillion yen in the same time period. The increase in thermal power generation has also increased CO₂ emissions.

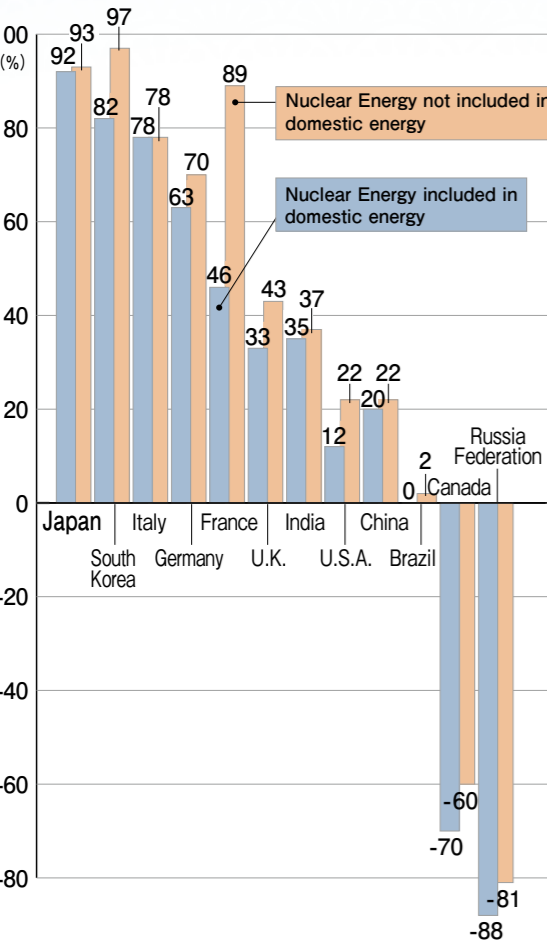
In July 2015, reflecting these observations, the Government decided the "Energy Mix" of FY2030 with the basic objectives of raising the nation's energy self-sufficiency ratio higher than that even before the earthquake, lowering

the electricity cost from the current level, and setting a CO₂ emission reduction target comparable to those of western nations.

The Energy Mix proposes, in addition to a firm commitment to reduce overall energy consumption, that nuclear should account for 22-20%, thermal power for 56% (27% LNG, 26% coal, and 3% oil), and renewable energy for 22-24%.

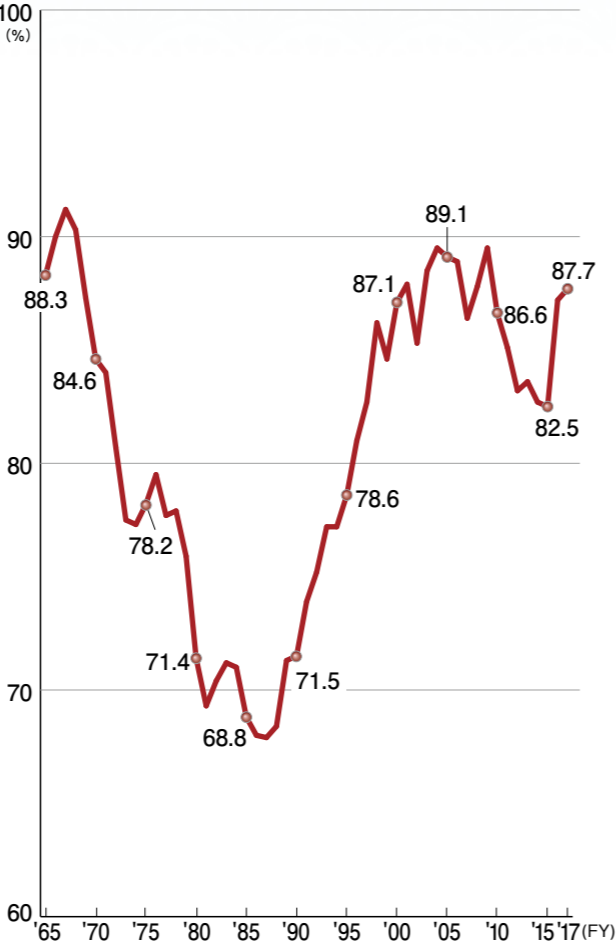
In view of the Energy Mix decided by the Government, the electric power companies will strive to achieve energy security, economic efficiency, and environmental conservation, while putting top priority on safety.

Dependence on Imported Energy Sources by Major Countries (2016)



Source: IEA "World Energy Balances 2018 Edition"

Japan's Reliance on Middle East Crude Oil of Total Imports



Source: Petroleum Association of Japan

Three Viewpoints Concerning Development of the Energy Mix

Securing safety
Major premise

Energy self-sufficiency rate:

Only 6% at 2014 → Target: About 25%, surpassing the pre-earthquake level of about 20%

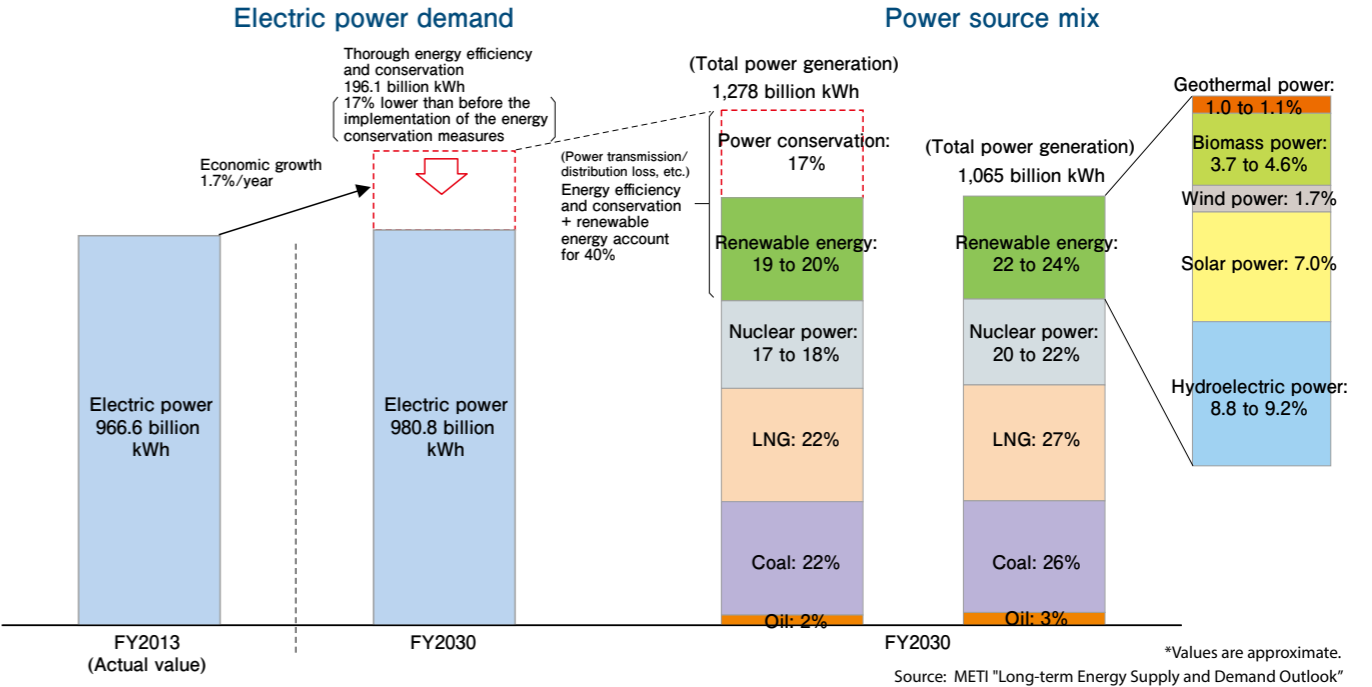
Electricity cost:

Electricity rates have risen since the earthquake. The surcharge for purchasing renewable energy in FY 2018 is 2.4 trillion yen. → Target: Bring it down from the present level*

Greenhouse gas emissions:

Due to NPP shutdowns and the increase of thermal power generation, the CO₂ emissions (from energy sources) in FY2013 were the worst ever. → Target: A reduction comparable with those of western nations

* (FY 2013 9.7 trillion yen ⇒ FY 2030 9.5 trillion yen)



Electric Power Companies' Commitment to Safety Measures at Nuclear Power Plants

The Great East Japan Earthquake on March 11, 2011 led to a nuclear accident at the Fukushima Daiichi Nuclear Power Station, resulting in the release of radioactive materials into the environment.

Determined to avoid a repeat of this accident, the electric power companies have been taking both tangible and intangible measures since immediately after the accident, starting with emergency safety measures including the installation of additional emergency power source vehicles and fire engines, as well as upgrading procedure manuals and conducting drills.

Even after implementing the emergency safety measures, the electric power companies are making further efforts to improve safety, including installing air-cooled emergency power generators, filtered ventilation systems and earthquake-isolated emergency response centers.

To enable these efforts to be constantly and objectively evaluated, the Japan Nuclear Safety Institute(JANSI), which evaluates the safety improvement activities of electric power companies and gives them technical advice, and the Nuclear Risk Research Center(NRRC), which uses Probabilistic Risk Assessment(PRA) and proposes solutions based on R&D, were established. The electric power companies take to heart

the evaluations and recommendations and are striving to achieve the highest safety level in the world.

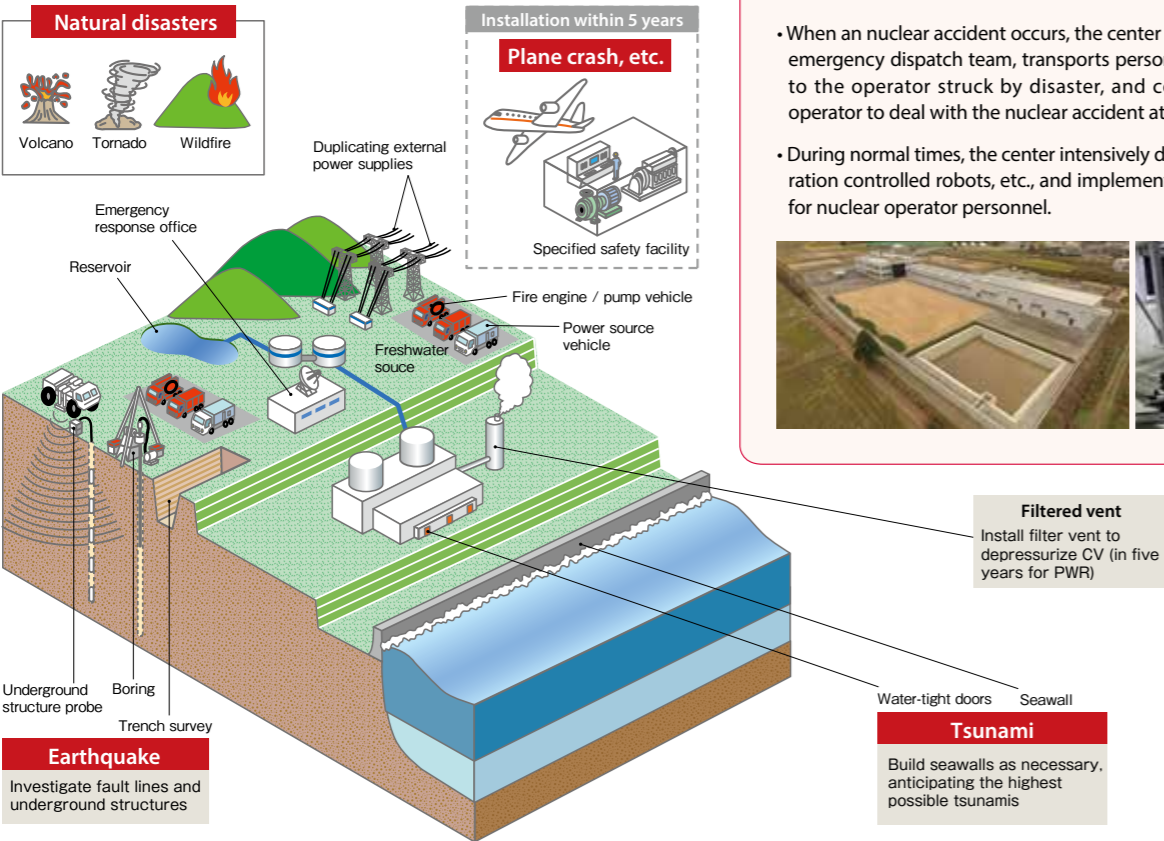
In July 2018, so that these autonomous and continuous initiative of the nuclear industry become established practices, a new organization, the Atomic Energy Association (ATENA), was established to effectively utilize the knowledge and resources of the entire nuclear industry, formulate effective measures while engaging in a continuing dialogue with regulators and others, and encourage nuclear operators to incorporate these measures in their plant operations. The electric power companies will work to reliably incorporate the safety measures decided by ATENA in their safety improvement initiatives to continuously reduce risk and recover the trust of society.

Also, in July 2013, the new regulatory requirements set forth by the Nuclear Regulation Authority (NRA) were put into effect. As of September 2019, electric power companies have applied for a review of conformance with the new regulatory requirements for 27 units out of their 16 power stations. Thirteen units have passed the review and nine of them have restarted commercial operation.

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Start of full operation of Mihama Nuclear Emergency Assistance Center in December 2016

- When an nuclear accident occurs, the center swiftly assembles an emergency dispatch team, transports personnel and equipment to the operator struck by disaster, and cooperates with the operator to deal with the nuclear accident at high radiation dose.
- During normal times, the center intensively deploys and manages ration controlled robots, etc., and implements operating training for nuclear operator personnel.



Fair Competition and Transparency

The electric power market in Japan has been progressively liberalized to ensure competitive neutrality on the basis of a stable power supply by the former ten General Electricity Utilities, which consistently handle all functions from power generation to distribution.

In 1995, a law was revised to enable IPPs to participate in the electricity wholesale market in addition to conventional general electrical utilities. Then, in March 2000, use of the transmission/distribution network owned by the electric power companies was liberalized, and the retail market was partially liberalized to allow power producers and suppliers (PPSs) to sell electricity to extra-high voltage users requiring more than 2MW. The scope of liberalization was then expanded in April 2004 to users requiring more than 500kW, and subsequently in April 2005 to users requiring more than 50kW. Then, in April 2016, all users including individual households and retail stores were included in the scope of this liberalization so that everyone is free to choose an electric power company and price menu. Electric power companies have responded to this trend of liberalization by increasing their business efficiency while lowering electricity prices and offering a variety of pricing plans.

With the three goals of ensuring supply stability, suppressing electricity rates to the maximum extent possible, and expanding the options for consumers and the business opportunities for operators, the government is planning to advance the reforms in three phases through the three key measures of enhancing nationwide grid operation, full deregulation of the electricity retail and generation sectors, and further ensuring neutrality in the transmission / distribution sector through the legal unbundling while thoroughly inspecting each phase to solve any issues and taking necessary measures based on the results of the inspections.

As practitioners, the electric power companies would like to continue taking an active role in the deliberation so the markets will be organized to secure the stable supply of electricity, including the market transactions that are already active, and so that the electric power system reform will truly bring benefits to the customers.

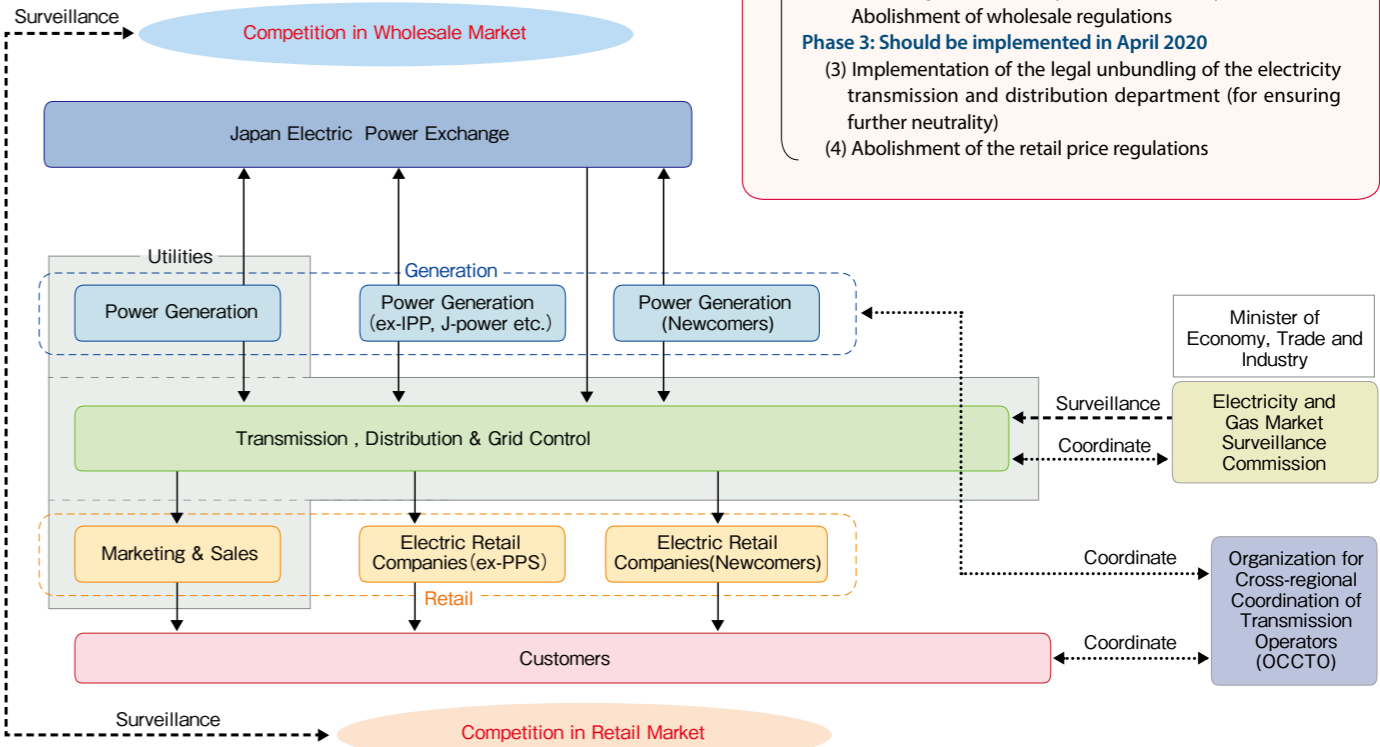
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Overview of the Reforms of the Electric Power System

The following revisions to the Electricity Business Act related to the reforms of the electric power system were passed into law in November 2013.

- Phase 1: Enforced in April 2015**
 - (1) Establishment of the "Organization for Cross-regional Coordination of Transmission Operators, JAPAN" (Enhancement of nationwide grid operation)
- Phase 2: Enforced in April 2016**
 - (2) Full deregulation of entry into the electricity retail sector
 - Abolishment of wholesale regulations
- Phase 3: Should be implemented in April 2020**
 - (3) Implementation of the legal unbundling of the electricity transmission and distribution department (for ensuring further neutrality)
 - (4) Abolishment of the retail price regulations

The New Electricity Supply System (from April 2016)



Optimal Combination of Power Sources

Electric power companies in resource-poor Japan are committed to developing an optimal combination of power sources including hydro, thermal and nuclear power in order to provide electricity, which is essential for modern living, in a stable manner at the lowest prices.

As electricity is nearly impossible to store in large quantities, electric power companies generate electricity by combining various power sources, considering optimal operational and economic performance, to ensure that fluctuating demand, such as during the daytime in the height of summer, can always be met.

Hydroelectric Power

Hydroelectric power has been one of the few self-sufficient energy resources in resource-poor Japan for more than 100 years. Hydroelectric power is an excellent source in terms of stable supply and generation cost over the long term. Though it used to compare unfavorably with thermal power for some time, hydroelectric power saw a renaissance following the oil crisis.

Although the steady development of hydroelectric power plants is desired, Japan has used nearly all potential sites for constructing large-scale hydroelectric facilities, and so recent developments have been on a smaller scale. As the gap in demand between daytime and nighttime continues to widen, electric power companies also has developed pumped-storage power generation plants to meet peak demand. As a result, the share of pumped-storage generation facilities of the total hydroelectric power capacity in Japan has grown year-by-year.

Thermal Power

Initially, coal was the dominant fuel for thermal power generation in Japan, but it later lost that place to oil. Today, a diverse range of fuels including coal, oil, and LNG are used for the important generating role that thermal power plants play. In particular, electric power companies are promoting the introduction of LNG fired plants in response to global environmental concerns, as they emit less CO₂ and other pollutants.

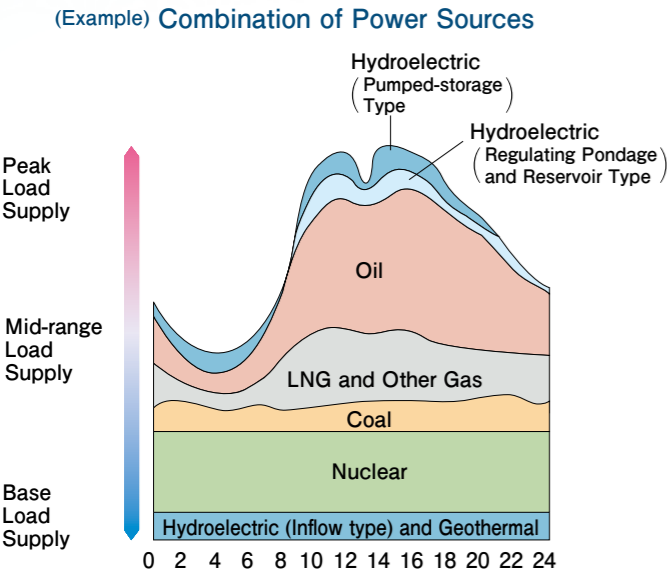
To enhance thermal efficiency further, combined-cycle power plants with both gas and steam turbines have been installed. As a result, gross thermal efficiency (maximum designed value) has exceeded 60%. In the future, we will continue to research and develop new technologies in order to increase thermal efficiency as well as the use of integrated coal gasification combined cycle (IGCC) power generation.

Nuclear Power

Japan's first commercial nuclear power plant started operation in Ibaraki Prefecture in 1966. The electric utility industry believes that nuclear power generation will retain an important position in the optimal combination of power sources from the viewpoint of assuring energy security and mitigating global warming.

Electric utilities are firmly committed to implementing extensive voluntary safety measures by adopting best practice from both Japan and overseas, while also complying with the new regulatory requirements following the accident at the Fukushima-daiichi Nuclear Power Station.

We will also continue to publish the latest information to contribute to the safety of nuclear power generation throughout the world.



Hydroelectric and nuclear power provides base load supply, while coal and LNG are major power sources for mid-range load supply. Oil-fired and pumped-storage hydroelectric power respond to peak demand fluctuation and contribute to the consistent, stable supply of electricity.



Okumino Hydroelectric Power Station (Pumped-storage)



Takami Hydroelectric Power Station



Kawasaki Thermal Power Station (LNG Combined-cycle)



Yoshinoura Thermal Power Station (LNG-fired)



Ohi Nuclear Power Station (PWR)



Ohma Nuclear Power Station (ABWR, Under Construction)

Japan's Nuclear Fuel Cycle

The nuclear fuel cycle is a series of processes consisting of reprocessing spent fuel that has been used at nuclear power plants and recovering and recycling plutonium and residual uranium as nuclear fuel.

Japan has chosen a closed nuclear fuel cycle policy since the dawn of its nuclear power generation development. Having few resources, Japan decided to recycle spent nuclear fuel domestically in order to establish nuclear power as a homegrown energy source. The benefits of a closed nuclear fuel cycle for Japan are significant: it conserves uranium resources; and it reduces the volume of high-level radioactive waste that must be disposed of.

Reprocessing is a chemical process that recovers plutonium and reusable uranium from spent fuel and separates radioactive wastes into more manageable forms. Once recovered, the plutonium is ready to be re-introduced into the nuclear power plants in the form known as uranium-plutonium mixed oxide (MOX) fuel. Under the policy of possessing no plutonium reserves without specified purposes, Japan's electric power companies have sincerely committed to a plan to utilize recovered plutonium – in the

form of MOX fuel – as soon as possible.

In the past, Japan has relied on countries such as the U.K. and France to reprocess most of the spent fuel it produced. However, to place Japan's domestic nuclear fuel cycle on a firmer footing, Japan Nuclear Fuel Limited (JNFL) is preparing for completion of construction of a reprocessing plant at a site in Rokkasho-mura in the northern prefecture of Aomori. JNFL has applied for a review of compliance with the new regulatory requirements, which came into effect in December 2013, and the plants are currently undergoing reviews by the Nuclear Regulation Authority. JNFL expects the construction to be completed in the first half of FY2021. In addition, JNFL engages in uranium enrichment, temporary storage of vitrified waste, and disposal of low-level radioactive waste. JNFL has also begun construction of a MOX fuel fabrication plant.

Electric utilities regard nuclear power as an important power source for Japan from viewpoints such as assuring energy security and mitigating global warming. We will make the utmost effort to establish the nuclear fuel cycle on the premise of securing thorough safety.

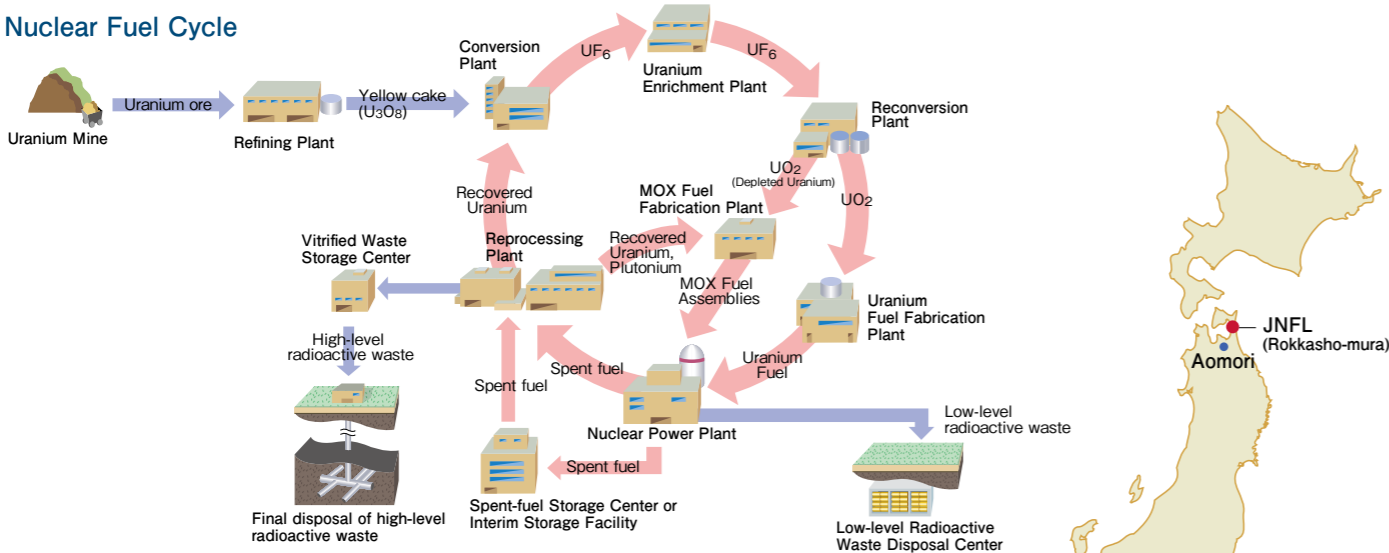
Outline of JNFL's Nuclear Fuel Cycle Facilities (as of January 31, 2018)

Facility	Reprocessing Plant	MOX fuel fabrication plant	Vitrified waste storage center	Uranium enrichment plant	Low-level radioactive waste disposal center
Site	Iiyasakatai, Rokkasho, Kamikita-gun, Aomori Prefecture			Oishitai, Rokkasho, Kamikita-gun, Aomori Prefecture	
Capacity	Maximum capacity: 800 ton-U/year Storage capacity for spent fuel: 3,000 ton-U	Maximum capacity: 130 ton-HM/year (*)	Storage capacity for wastes returned from overseas plants: 2,880 canisters of vitrified waste	Design capacity 1,500 ton-SWU/year (*)	Planned to be expanded to 600,000m ³ (equivalent to 3 million 200 liter drums)
Current Status	Under construction	Under construction	Cumulative number of received canisters: 1,830	In operation using the new centrifuge	Cumulative number of received drums: about 298,251
Schedule	Start of construction: 1993 Completion of construction: The first half of FY2021 (planned)	Start of construction: 2010 Completion of construction: The first half of FY2022 (planned)	Start of construction: 1992 Start of storage: 1995	Start of construction: 1988 Start of operation: 1992	Start of construction: 1990 Start of operation: 1992

(*) "ton-HM" stands for "tons of heavy metal" which indicates the weight of plutonium and uranium metallic content in MOX. "SWU" stands for "Separative Work Unit" which is a measure of the work expended during an enrichment process of uranium

Sources: JNFL's website and others

Nuclear Fuel Cycle



The Peaceful Use of Nuclear Energy

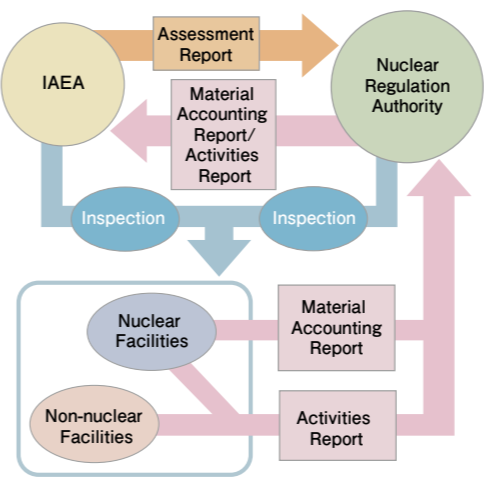
Japan's electric power companies are fully committed to implementing the closed nuclear fuel cycle and plutonium utilization consistent with all domestic laws and international nonproliferation standards. Since 1955, the domestic laws of Japan require that all nuclear activities, including commercial activities, be conducted only for peaceful purposes. Also, since 1968, Japan has embraced the "Three Non-Nuclear Principles," which state that Japan will not possess, produce, or permit the entry of nuclear weapons into its territory.

In addition, in 1976, the Government of Japan ratified the Nuclear Non-Proliferation Treaty (NPT) and thereby obligated itself to a national policy not to produce or acquire nuclear weapons. In order to ensure the application of more extensive safeguards, Japan signed the IAEA Additional Protocol in 1998, which allows the IAEA to carry out a range of additional inspection measures. In accordance with national laws, Japan's electric power companies submit reports on material accounting and safeguards activities to the Minister of Education, Culture, Sports, Science and Technology, and accept joint inspections by the IAEA and Japanese regulatory authorities to check the reports.

The results of each of these Japanese initiatives were reflected in the IAEA's conclusion in June 2004, which stated that all the nuclear materials in Japan are protected under IAEA safeguards and are not being diverted to the manufacture of nuclear weapons. As a result, more effective and efficient IAEA safeguards known as integrated safeguards came into effect in Japan in September 2004.

Furthermore, the 5th Strategic Energy Plan states the following concerning the handling of plutonium. Japan will maintain the policy of possessing no plutonium reserves without specified purposes and using it only for peaceful purposes, while steadily advancing the use of plutonium in order to reduce the plutonium stockpile while contributing to nuclear non-proliferation and gaining the understanding of the international community. To make these efforts effective, Japan will manage and use plutonium appropriately by further promoting MOX fuel generation while paying due consideration to the balance of plutonium collected and utilized, and promote R&D of fast reactors through international cooperation with the United States and France.

The Safeguards Program



Column

Enactment of the Spent Nuclear Fuel Reprocessing Fund Act

In May 11, 2016, the Spent Nuclear Fuel Reprocessing Fund Act was passed in the Diet. The objective of the legislation is to provide a framework for pursuing the national policy of reprocessing spent fuel in a most reliable and efficient manner even under a new business environment characterized by the liberalized electricity market and reduced dependence on nuclear energy.

The new bill is to implement a series of institutional measures, which include creating a new funding system aimed at securing adequate funds, organizing a government-authorized corporation (the spent fuel reprocessing organization) which, as a principal business entity, conducts the reprocessing business both appropriately and efficiently, and establishing an authorized corporation acting as a decision-making organization (a management committee) from a proper governance viewpoint. The law also ensures a certain level of involvement of the National Government.

Furthermore, the supplemental resolution to the legislation reaffirms the policy of possessing no plutonium reserves without specified purposes. Also, according to the bill, the Governmental instructs the nuclear operators to conduct reprocessing business while upholding this policy, and if an implementing body should make reprocessing plans that go against this policy, the Minister of Economy, Trade and Industry can withhold approval of such plans.

Status of MOX Fuel Utilization

The electric power industry in Japan intends to introduce MOX fuel in 16 to 18 nuclear reactors.

So far 27 units have applied for a review of conformance with the new regulatory requirements, out of which 9 units have received permission to introduce MOX fuel and have gained the understanding of the local municipalities. 4 units have restarted operation using MOX fuel thus far. The electric power companies recognize the importance of improving the transparency of the MOX fuel project. Based on the outlook of individual companies toward restarting nuclear power plants and considering the schedule and other details of the plan to start up the reprocessing plant, we shall compile and announce the MOX fuel project before restarting plutonium recovery operations.

*As of September 30, 2019

"International Roundtable on Final Disposal of High-Level Radioactive Waste"

The Energy Ministers' Meeting (G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth) was held in Karuizawa, Nagano on June 15 and 16, 2019. The energy ministers reached an agreement on establishing the "International Roundtable on Final Disposal of High-Level Radioactive Waste" for the first time in order to realize the final disposal of high-level radioactive waste which is a common concern for all countries that make use of nuclear power generation. A basic strategy for international cooperation in realizing final disposal was formulated and best practices were compiled at this "International Roundtable on Final Disposal of High-Level Radioactive Waste".

Measures by the Electric Utility Industry to Suppress CO₂ Emissions

Regarding global warming measures, the “Paris Agreement” was adopted in December 2015 at the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21), and it entered into force in November 2016, building a framework that all countries and regions of the world participate for global warming measures. In COP 24, held in December 2018, countries adopted a “rulebook” to implement the 2015 Paris Agreement starting in 2020. This set in motion an international framework for tackling climate change spanning all countries including major greenhouse emitting countries. COP 25 was subsequently held in December 2019. In July 2015, the Japanese Government announced its “Intended Nationally Determined Contributions(INDC)”, with the objective of reducing greenhouse gas emissions in 2030 by 26% from 2013 levels. In May 2016, in accordance with INDC, the plan for Global Warming Countermeasures was adopted. In June 2019, the cabinet adopted a “Long-term Strategy under the Paris Agreement” which aims to realize a “decarbonized society” that is carbon neutral as early as possible in the latter half of this century. The Strategy sets out an ambitious vision to make radical changes to reduce greenhouse gases by 80% by 2050. Emissions of carbon dioxide(CO₂), a major cause of global warming, are closely related to energy utilization in economic activities and daily life, and so the reduction of CO₂ emissions is a major challenge for the industry.

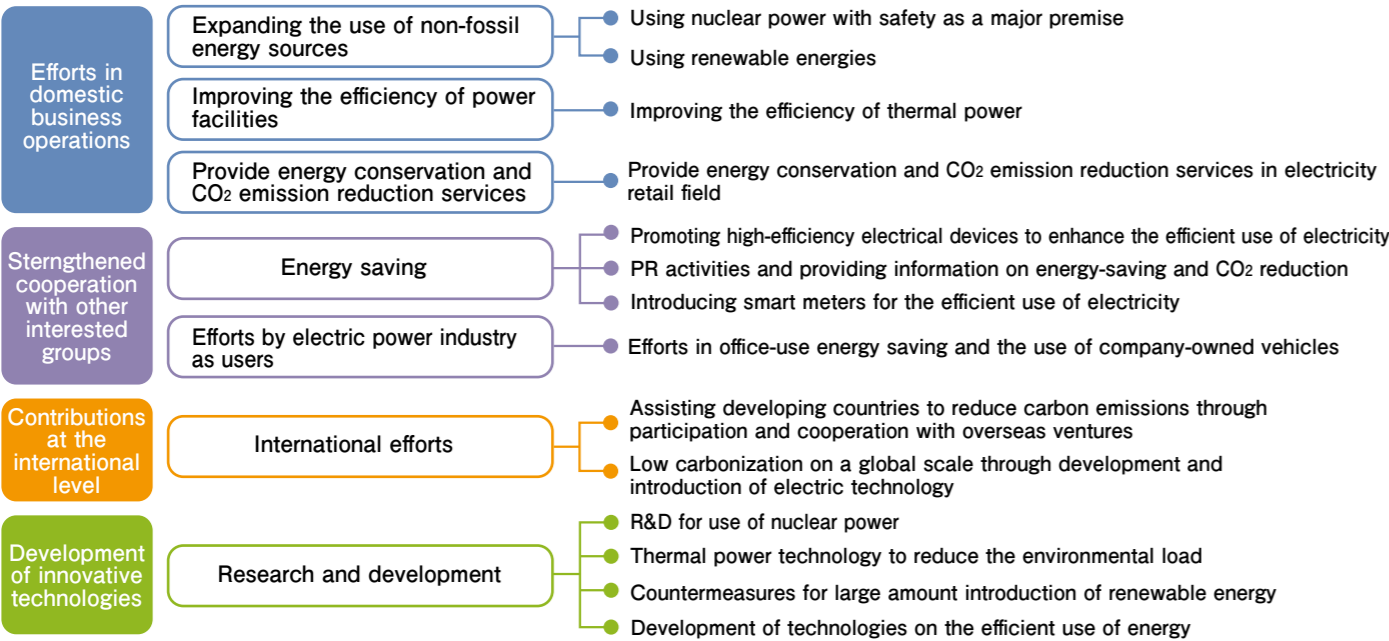
The electric power companies are trying to reduce CO₂ emissions mainly through attaining the optimal energy mix, seeking to simultaneously achieve Energy security, Economic efficiency and Environmental conservation, under the major premises of Safety (S+3Es).

In July 2015, 35 electricity utility companies jointly constructed a voluntary framework for a low carbon society and prepared an “Action Plan for a Low-Carbon Society” that laid out specific efforts to be made. In February 2016, “the Electric Power Council for a Low-Carbon Society (ELCS)” was founded to facilitate efforts toward this goal (a membership of 47 companies as of the end of September 2019).

According to the Action Plan, an end-user CO₂ emission factor of about 0.37kg- CO₂/kWh will be targeted in light of the Government’s 2030 energy supply and demand outlook. Moreover, as the maximum reduction potential, a reduction of about 11 million t- CO₂ will be expected by using economically achievable best available technologies(BATs) in light of the construction of new thermal power plants, etc.

The member companies will make efforts towards a low carbon society by utilizing nuclear power generation premised on ensuring safety or renewable energy, raising the efficiency of thermal power plants and optimizing their appropriate maintenance and control, and promoting energy-conservation or CO₂ reduction services on both the supply and demand sides.

International efforts- Assisting developing countries to reduce carbon emissions through participation and cooperation with overseas ventures



Decarbonization of Energy on the Supply-side

Promoting nuclear power generation while assuring safety, and improving the thermal efficiency of thermal power plants further

Nuclear power emits no carbon dioxide (CO₂) in the process of power generation, and even considering CO₂ emissions over the entire life cycle of various energy sources, those from nuclear power are lower than those from thermal power, and are even lower than those from solar or wind power. However, because of the extended shutdown of nuclear power plants following the Great East Japan Earthquake, and subsequent increase in thermal power generation, the CO₂ emission factor has remained higher than that before the earthquake.

Considering that nuclear power generation will continuously play a key role in combating global warming, the industry is committed to making the utmost effort to improve the safety of nuclear power generation and to restore the trust of citizens.

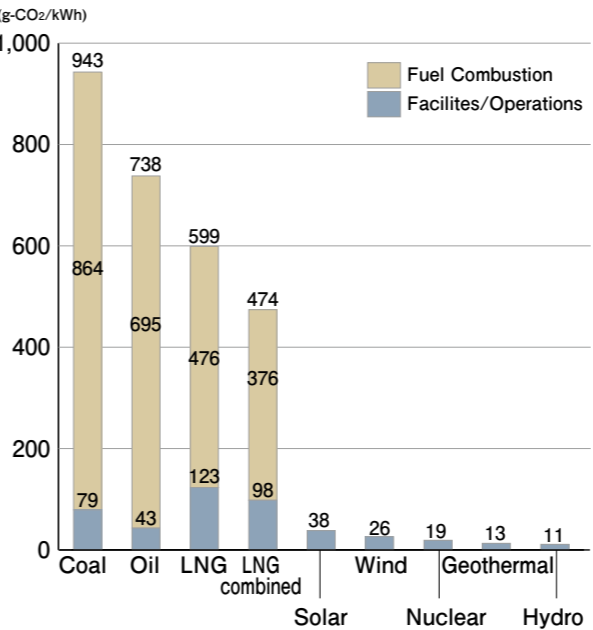
The electric power companies are also striving to maintain and improve the efficiency of thermal power plants through the introduction of highly efficient plants of the latest design or through appropriate operation and maintenance of the existing plants.

Currently operating state-of-the-art gas turbine combined cycle power plants have achieved the world’s highest level of

62% (LHV) in thermal efficiency by, for example, raising the combustion temperature at the gas turbines. (JERA’s Nishi-Nagoya Thermal Power Station Unit 7-1 has achieved the world’s highest thermal efficiency of 63.08% (LHV) (as of March 2018))

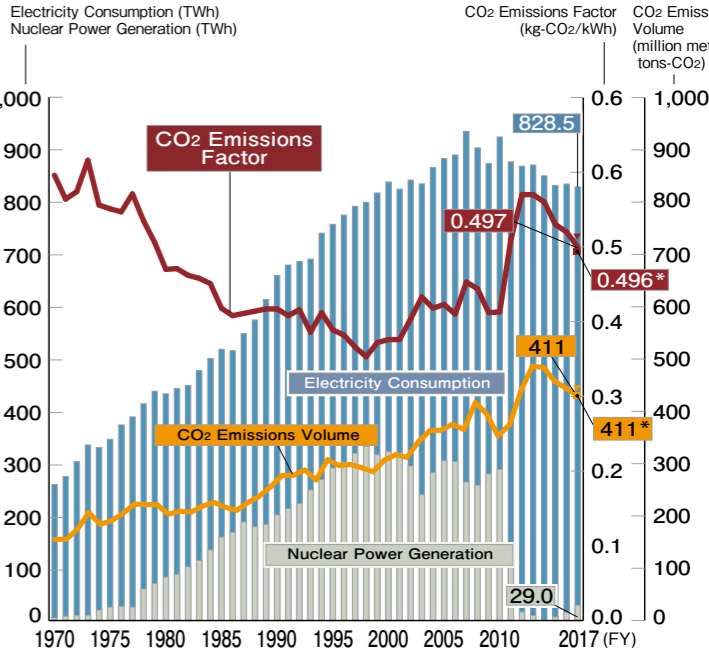
As to the conventional coal-fired power plants, the adoption of enhanced steam conditions (temperature and pressure) is being promoted to improve thermal efficiency. Presently, ultra-supercritical (USC) thermal power generation with the main steam temperature of 600°C is commercially available. Moreover, research and development of Integrated coal Gasification Combined Cycle (IGCC) has been conducted, in which gasified coal is used in combination with gas turbines and steam turbines to generate electricity. Joban Joint Power’s Nakoso Power Station Unit 10, which previously was conducting operational tests as a demonstration facility in Fukushima Prefecture, started operation as Japan’s first commercial IGCC plant in June 2013. Overall, low carbonization initiatives continue to progress steadily--large scale IGCC plants are being constructed in plots next to the Nakoso Power Station and in Hirono-cho, also in Fukushima Prefecture.

CO₂ Emissions Intensity over the Entire Lifecycle by Source



Note: (1)Based on total CO₂ emissions from all energy consumed in energy extraction, transportation, refining, plant operation and maintenance, etc. in addition to burning of the fuel.
(2)The figure of nuclear power generation is calculated including the reprocessing of spent fuel, use of MOX fuel, and the disposal of high-level radioactive waste.
Source: Report of the Central Research Institute of Electric Power Industry, etc.

Historical Trends in CO₂ Emissions from Power Generation



Note: Data up until 2007 is reported by FEPC.
Data from 2007 to 2014 is reported by FEPC and some PPSS.
Data from 2014 onward is reported by ELCS.
Up until 2014, the figures for nuclear power generation are on a gross-output basis as reported by FEPC, whereas the figures from 2015 onward are on a net-output basis as reported by ELCS.
The figures with an asterisk are adjusted values taking into account CO₂ credits and other adjustments.

Decarbonization of Energy on the Supply-side

Development and expansion of the use of renewable energy sources

The feed-in tariff system for renewable energy began in July 2012, whereupon the electric power companies are obliged to buy such electricity at a fixed price for a certain period. The cost of purchasing this electricity is finally borne by customers in the form of a surcharge, which in principle is proportional to the amount of electricity consumed.

The Revised FIT Act was enacted in April 2017, making changes to the FIT system including creating a new authorization system, revising the method of setting purchase prices, and revising businesses obliged to purchase FIT electricity, under the policy of “maximizing the amount of renewable energy to be introduced while suppressing the burden on the public”.

However, renewable energy such as solar power has problems involving efficiency, cost of power generation and stability of output. R&D on the latest power system control technologies for combining existing power plants and storage batteries will be actively conducted to help stabilize

the system, when introducing large amounts of wind and photovoltaic power, which are susceptible to the weather.

Electric utilities will keep striving to develop and improve renewable energy sources.

In March 2017, the Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO) significantly shifted the approach taken toward electricity network operation and facility configuration by presenting a direction where “maximum use would be made of existing electricity networks to comprehensively minimize long-term electricity source and distribution costs while continuing to meet electric source connection needs through expanded adoption of renewable energies and other measures”. Given this new policy, discussions are being held on flexibly utilizing existing transmission lines’ capacity to enable connection under certain conditions.

Electric utilities will keep striving to develop and improve renewable energy sources.

Sharing Japan’s Top-level Power Generation Technologies with the World

Japan has achieved the world’s top-level in energy efficiency by introducing various technologies for higher energy efficiency to thermal power plants. Based on this achievement, the electric utility industry in Japan has been making efforts to establish a mechanism for sharing such advanced technologies with electric power industries in other countries.

With high-efficiency plants to be introduced and the improvement of operation and maintenance technologies, coal-fired plants’ CO₂ reduction potential in OECD countries and developing countries in Asia in FY 2030 is estimated to be a maximum of 900 million t- CO₂/year. The electric utility industry of Japan will contribute to the reduction of global CO₂ emissions with Japan’s expertise and advanced technologies.

Column

Development of Innovative Technology—Carbon dioxide Capture and Storage (CCS) Technology

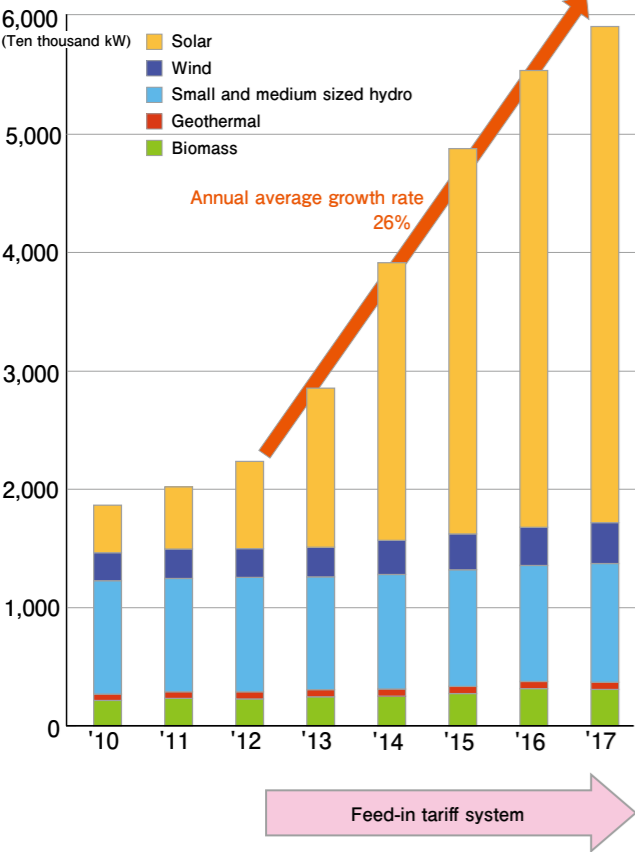
CCS is a technology for capturing carbon dioxide given off in the combustion of fossil fuels at electric power plants and other facilities before it is emitted into the atmosphere and storing it deep underground. It is positioned in Japan and other countries as an innovative technology that is effective as a global warming countermeasure. However, there are many issues related to its actual implementation, so FEPC-related companies are promoting CCS technology development while actively cooperating in large-scale verification experiments led by the government in order to overcome the issues involved and clarify latent ones.

Carbon dioxide Capture and Utilization (CCU), a technology in which separated and recovered CO₂ is considered a resource and reused in chemicals, fuel, and minerals, is also being researched as a potentially important method in reducing the amount of CO₂ emitted. The Chugoku Electric Power Company has developed environmentally-friendly concrete (product name “CO₂-SUICOM”) that uses special cement additives that harden in reaction to CO₂ in addition to other common materials.



Use of CO₂-SUICOM at Ube Photovoltaic Power Station (The Chugoku Electric Power)

Introduction amount of Generating Capacity (Renewable energy)*



* Excludes large-scale hydroelectric power generation
Source: METI

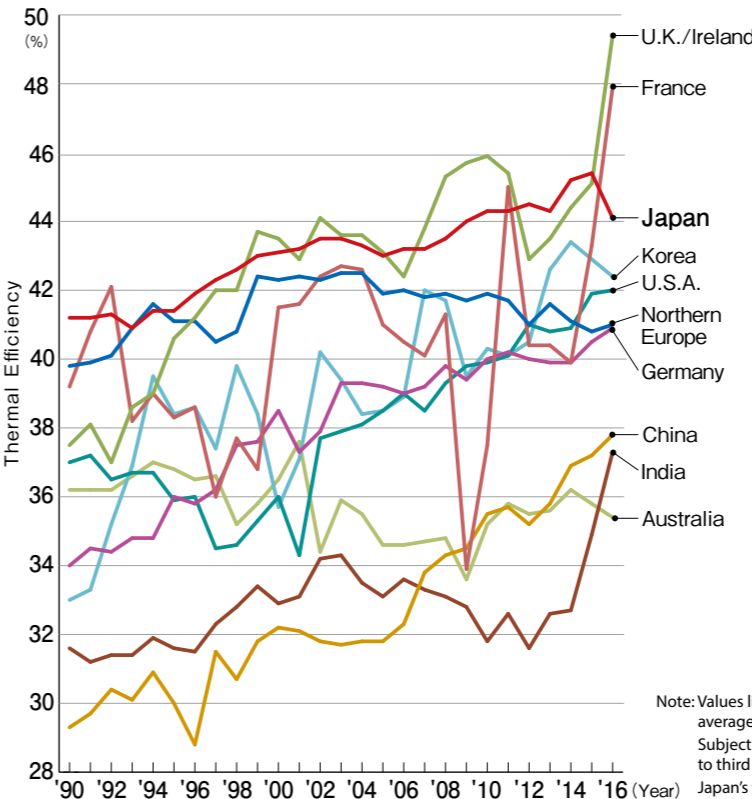


Mikuni Solar Power Station



Wind Power

Comparison of Thermal Power Plant Efficiency in Japan and Other Countries



Note: Values listed for heat efficiency are gross thermal efficiency values: a weighted average of the heat efficiency of coal, oil, and gas (lower heating value standard). Subject facilities are those of operators whose main business is selling electricity to third parties. Japan's values are fiscal year values.

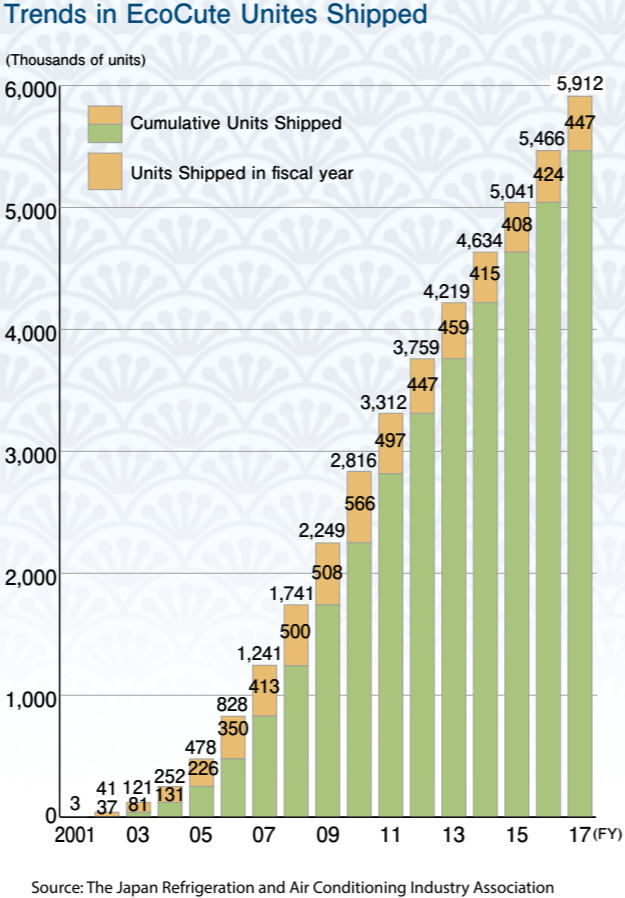
Source: ECOFYS "INTERNATIONAL COMPARISON OF FOSSIL POWER EFFICIENCY AND CO₂ INTENSITY (2018)"

Demand-side Efforts for CO2 Reduction

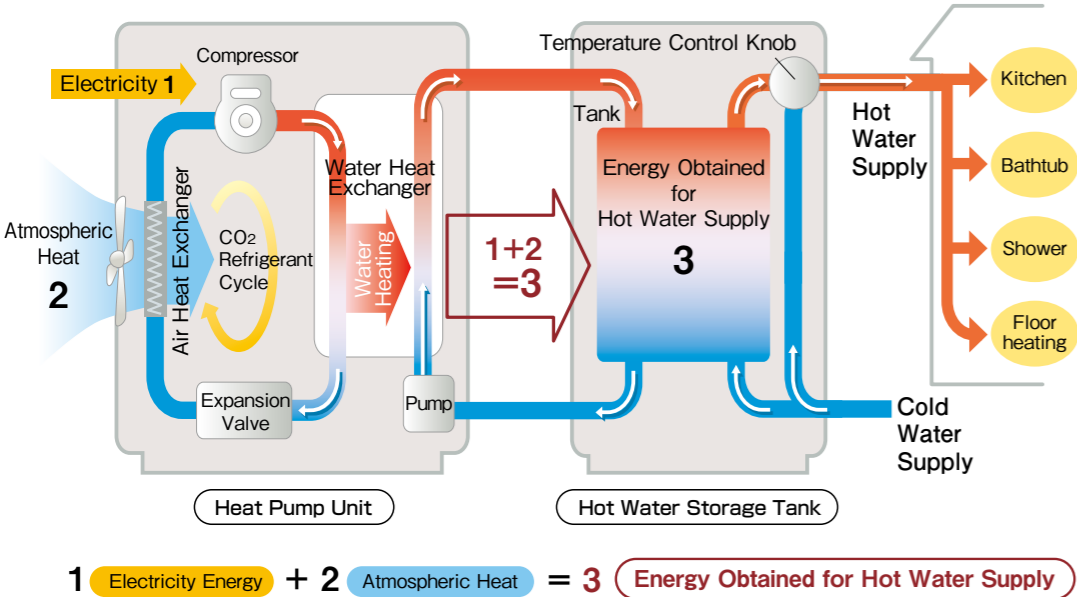
Along with working to promote further use of hot water supply systems (EcoCute) with CO2 refrigerant heat pumps, which significantly reduce CO2 emissions compared to conventional water heaters, the industry is actively working to promote more widespread use of high-efficiency commercial air conditioners and other appliances that utilize heat pump technology.

EcoCute heats water by transferring the thermal energy in air, which is freely available, to water by means of refrigerants. With a single unit of electric energy for heat pump operation and two units of thermal energy from air, it produces three units of thermal energy.

If the heat demand for the consumer division (households and commercial divisions) and industrial division currently being fulfilled through boilers can be met with heat pumps, CO2 emissions in 2030 are estimated to be reduced by 21.74 million t-CO2/year compared to 2015 levels.



EcoCute Hot Water Supply Structure: CO2 Refrigerant Heat Pump Hot Water Heater



EcoCute Heat Pump Unit (left) and Hot Water Storage Tank

Strengthening International Communication and Cooperation

Japan's electric power companies remain active on a worldwide basis. In order to cope with global warming and to ensure the safety of nuclear power generation, international cooperation is indispensable. Each of the electric power companies in Japan has individual agreements with overseas utilities in order to facilitate exchanges on a wide range of information such as power generation, customer relations, distribution and quality

control. The industry's top executives actively participate in international meetings such as the International Electricity Summit and the World Association of Nuclear Operators (WANO) to exchange views, while we also accept trainees from overseas. We import most of our fuel such as oil and coal from overseas countries and also keep our doors open to foreign companies for the purchase of equipment such as generators.

Overseas Offices

Please feel free to contact your nearest office.

WASHINGTON, D.C.

The Federation of Electric Power Companies of Japan, Washington Office

The Federation's Washington Office was established in January 1994. Its principal objectives are to study U.S. energy policies and to exchange information with U.S. energy opinion leaders in order to promote a greater understanding of the Japanese electric power industry.

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Tel: (202) 457-0790 Fax: (202) 457-0810
Established in 1978

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Tel: (202) 775-1960 Fax: (202) 331-9256
Established in 1982

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Established in 2017

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Established in 1982

Chubu Electric Power Co., Inc., London Office

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Established in 1985

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Established in 2008

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Established in 2007

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Established in 2016

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Tel: (021)2751-0048 Fax: (021)2751-0047
Established in 2016



Major Power Plants

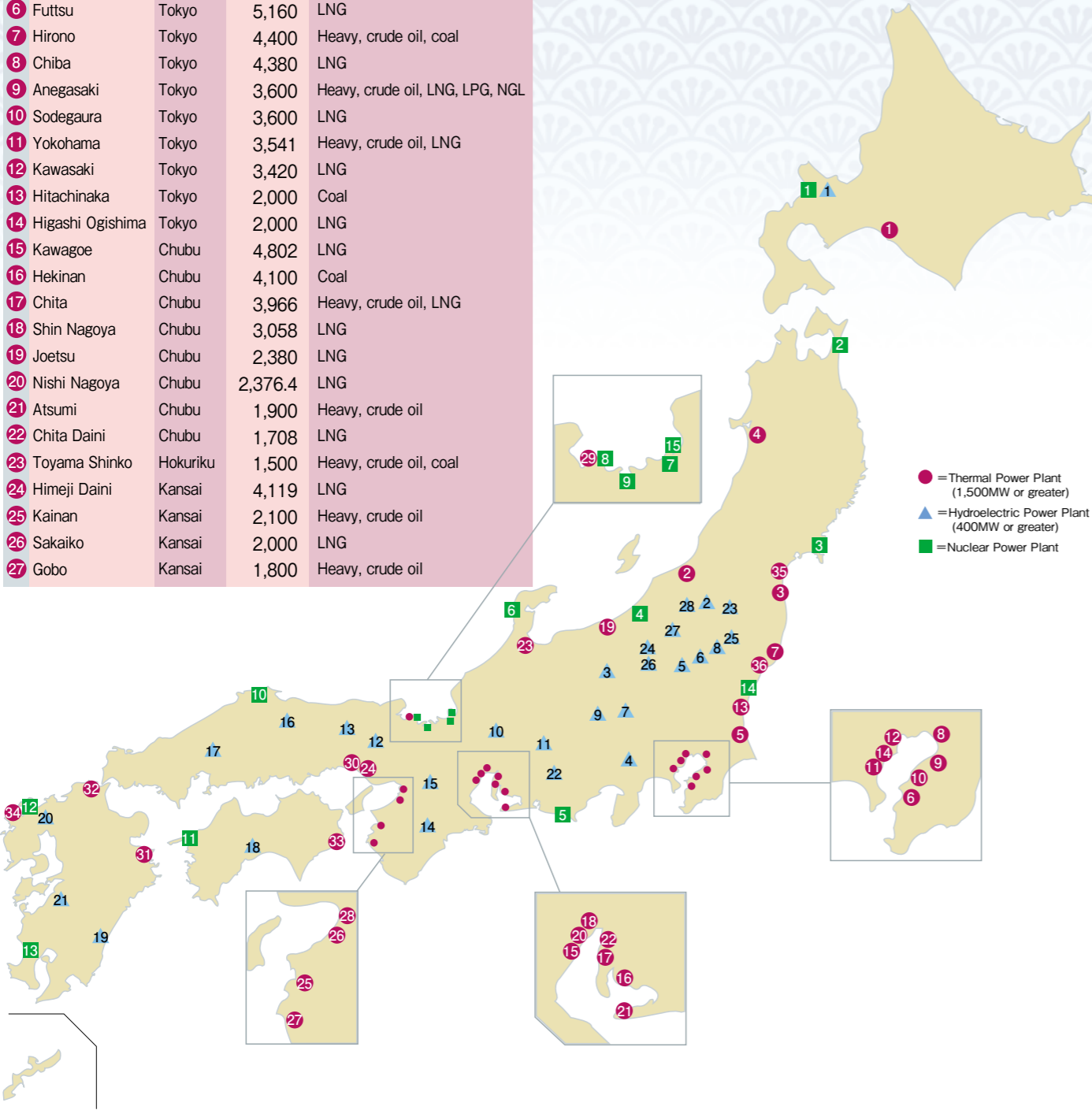
Here is a list and map of the country's major power plants:

Principal Thermal Power Plants (1,500MW or greater)

As of March 31, 2018

Name of Plant	Company	Installed Capacity (MW)	Fuel
1 Tomato-atsuma	Hokkaido	1,650	Coal
2 Higashi Niigata	Tohoku	5,149	Heavy, crude oil, LNG, natural gas
3 Haramachi	Tohoku	2,000	Coal
4 Akita	Tohoku	1,633	Heavy, crude, light oil
5 Kashima	Tokyo	5,660	Heavy, crude oil, city gas
6 Futtso	Tokyo	5,160	LNG
7 Hirono	Tokyo	4,400	Heavy, crude oil, coal
8 Chiba	Tokyo	4,380	LNG
9 Anegasaki	Tokyo	3,600	Heavy, crude oil, LNG, LPG, NGL
10 Sodegaura	Tokyo	3,600	LNG
11 Yokohama	Tokyo	3,541	Heavy, crude oil, LNG
12 Kawasaki	Tokyo	3,420	LNG
13 Hitachinaka	Tokyo	2,000	Coal
14 Higashi Ogishima	Tokyo	2,000	LNG
15 Kawagoe	Chubu	4,802	LNG
16 Hekinan	Chubu	4,100	Coal
17 Chita	Chubu	3,966	Heavy, crude oil, LNG
18 Shin Nagoya	Chubu	3,058	LNG
19 Joetsu	Chubu	2,380	LNG
20 Nishi Nagoya	Chubu	2,376.4	LNG
21 Atsumi	Chubu	1,900	Heavy, crude oil
22 Chita Daini	Chubu	1,708	LNG
23 Toyama Shinko	Hokuriku	1,500	Heavy, crude oil, coal
24 Himeji Daini	Kansai	4,119	LNG
25 Kainan	Kansai	2,100	Heavy, crude oil
26 Sakaiko	Kansai	2,000	LNG
27 Gobo	Kansai	1,800	Heavy, crude oil

Name of Plant	Company	Installed Capacity (MW)	Fuel
28 Nanko	Kansai	1,800	LNG
29 Maizuru	Kansai	1,800	Coal
30 Himeji Daiichi	Kansai	1,507.4	LNG
31 Shin Oita	Kyushu	2,804	LNG
32 Shin Kokura	Kyushu	1,800	LNG
33 Tachibanawan	J-Power	2,100	Coal
34 Matsuura	J-Power	2,000	Coal
35 Shinchi	Soma JP	2,000	Coal
36 Nakoso	Joban JP	1,625	Heavy oil, coal



Nuclear Power Plants

• In Operation

As of September 30, 2019

Name of Plant	Unit Number	Company	Installed Capacity (MW)	Type of Reactor	Start
1 Tomari	1	Hokkaido	579	PWR	1989.6
	2		579	PWR	1991.4
	3		912	PWR	2009.12
2 Higashi-Dori	1	Tohoku	1,100	BWR	2005.12
3 Onagawa	2	Tohoku	825	BWR	1995.7
	3		825	BWR	2002.1
4 Kashiwazaki Kariwa	1	Tokyo	1,100	BWR	1985.9
	2		1,100	BWR	1990.9
	3		1,100	BWR	1993.8
	4		1,100	BWR	1994.8
	5		1,100	BWR	1990.4
	6		1,356	ABWR	1996.11
	7		1,356	ABWR	1997.7
5 Hamaoka	3	Chubu	1,100	BWR	1987.8
	4		1,137	BWR	1993.9
	5		1,380	ABWR	2005.1
6 Shika	1	Hokuriku	540	BWR	1993.7
	2	Kansai	1,206	ABWR	2006.3
	3		826	PWR	1976.12
7 Mihama	3	Kansai	826	PWR	1974.11
8 Takahama	1	Kansai	826	PWR	1974.11
	2		826	PWR	1975.11
	3		870	PWR	1985.1
	4		870	PWR	1985.6
9 Ohi	3	Kansai	1,180	PWR	1991.12
	4		1,180	PWR	1993.2
10 Shimane	2	Chugoku	820	BWR	1989.2
11 Ikata	3	Shikoku	890	PWR	1994.12
12 Genkai	3	Kyushu	1,180	PWR	1994.3
	4		1,180	PWR	1997.7
13 Sendai	1	Kyushu	890	PWR	1984.7
	2		890	PWR	1985.11
14 Tokai Daini		Japan Atomic Power Co.	1,100	BWR	1978.11
15 Tsuruga	2	Japan Atomic Power Co.	1,160	PWR	1987.2
Total	33	Units	33,083MW		

• Under Construction

(Estimated start)

Higashi-Dori	1	Tokyo	1,385	ABWR	U.D
Shimane	3	Chugoku	1,373	ABWR	U.D
Ohma		J-Power	1,383	ABWR	U.D
Total	3	Units	4,141MW		

• Preparing for Construction

(Estimated start)

Higashi-Dori	2	Tohoku	1,385	ABWR	U.D
Kaminoseki	1	Chugoku	1,373	ABWR	U.D
	2		1,373	ABWR	U.D
Sendai	3	Kyushu	1,590	APWR	U.D
Tsuruga	3	Japan Atomic Power Co.	1,538	APWR	U.D
	4		1,538	APWR	U.D
Total	6	Units	8,797MW		

• Others

Name of Plant	Company	Installed Capacity (MW)	Type of Reactor
Fugen	Japan Atomic Energy Agency	165	ATR(Prototype) End of Operation
Monju	Japan Atomic Energy Agency	280	FBR(Prototype) End of Operation

Principal Hydroelectric Power Plants (400MW or greater)

As of March 31, 2018

Name of Plant	Company	Installed Capacity (MW)	Type
1 Kyogoku	Hokkaido	400	Pumped Storage
2 Daini Numazawa	Tohoku	460	Pumped Storage
3 Shin Takasegawa	Tokyo	1,280	Pumped Storage
4 Kazunogawa	Tokyo	1,200	Pumped Storage
5 Tanbara	Tokyo	1,200	Pumped Storage
6 Imaichi	Tokyo	1,050	Pumped Storage
7 Kannagawa	Tokyo	940	Pumped Storage
8 Shiobara	Tokyo	900	Pumped Storage
9 Azumi	Tokyo	623	Pumped Storage
10 Okumino	Chubu	1,500	Pumped Storage
11 Okuyahagi Daini	Chubu	780	Pumped Storage
12 Okutataragi	Kansai	1,932	Pumped Storage
13 Okawachi	Kansai	1,280	Pumped Storage
14 Okuyoshino	Kansai	1,206	Pumped Storage
15 Kisenyama	Kansai	466	Pumped Storage
16 Matanogawa	Chugoku	1,200	Pumped Storage
17 Nabara	Chugoku	620	Pumped Storage
18 Hongawa	Shikoku	615	Pumped Storage
19 Omarugawa	Kyushu	1,200	Pumped Storage
20 Tenzan	Kyushu	600	Pumped Storage
21 Ohira	Kyushu	500	Pumped Storage
22 Shin Toyone	J-Power	1,125	Pumped Storage
23 Shimogo	J-Power	1,000	Pumped Storage
24 Okukiyotsu	J-Power	1,000	Pumped Storage
25 Numappara	J-Power	675	Pumped Storage
26 Okukiyotsu Daini	J-Power	600	Pumped Storage
27 Okutadami	J-Power	560	Pumped Storage
28 Tagokura	J-Power	400	Pumped Storage

• End of Operation

(End)

Onagawa	1	Tohoku	524	BWR	2018.12
Fukushima Daiichi	1	Tokyo	460	BWR	2012.4
	2		784	BWR	2012.4
	3		784	BWR	2012.4
	4		784	BWR	2012.4
	5		784	BWR	2014.1
Fukushima Daini	6	Tokyo	784	BWR	2014.1
	1		1,100	BWR	2019.9
	2		1,100	BWR	2019.9
	3		1,100	BWR	2019.9
Hamaoka	4	Chubu	1,100	BWR	2019.9
	1		540	BWR	2009.1
	2		840	BWR	2009.1
Mihama	2	Kansai	340	BWR	2015.4
	2		500	PWR	2015.4
Ohi	1	Kansai	1,175	PWR	2018.3
	2		1,175	PWR	2018.3
Shimane	1	Chugoku	460	BWR	2015.4
Ikata	1	Shikoku	566	PWR	2016.5
	2		566	PWR	2018.5
Genkai	1	Kyushu	559	PWR	2015.4
	2		559	PWR	2019.4
Tokai		Japan Atomic Power Co.	166	GCR	1998.3
Tsuruga	1	Japan Atomic Power Co.	357	BWR	2015.4
Total	24	Units	17,423MW		

Note: PWR=Pressurized Water Reactor, BWR=Boiling Water Reactor, APWR=Advanced Pressurized Water Reactor, ABWR=Advanced Boiling Water Reactor, GCR=Gas Cooled Reactor, ATR=Advanced Thermal Reactor, FBR=Fast Breeder Reactor

The Federation of Electric Power Companies

Close cooperation among electric utilities is essential to effectively supply Japan's electricity. In 1952, the nine electric power companies established the Federation of Electric Power Companies (FEPC) to promote smooth operations within the industry. Since then, FEPC has played an important role as a base for close communication between the electric power companies and as a forum for

exchanging views to create the electric power industry of the future. Moreover, FEPC undertakes various activities to ensure stable operations of the electric power industry, with an awareness of its role in the energy industry of Japan.

With the return of Okinawa to Japan in 1972, the Okinawa Electric Power Company rejoined Japan's electric power industry, becoming an FEPC member in March 2000.

Board of Directors



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Vice Chairman
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Hiroya Harada



Vice Chairman
Head of Nuclear Waste
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Head of Fukushima Support
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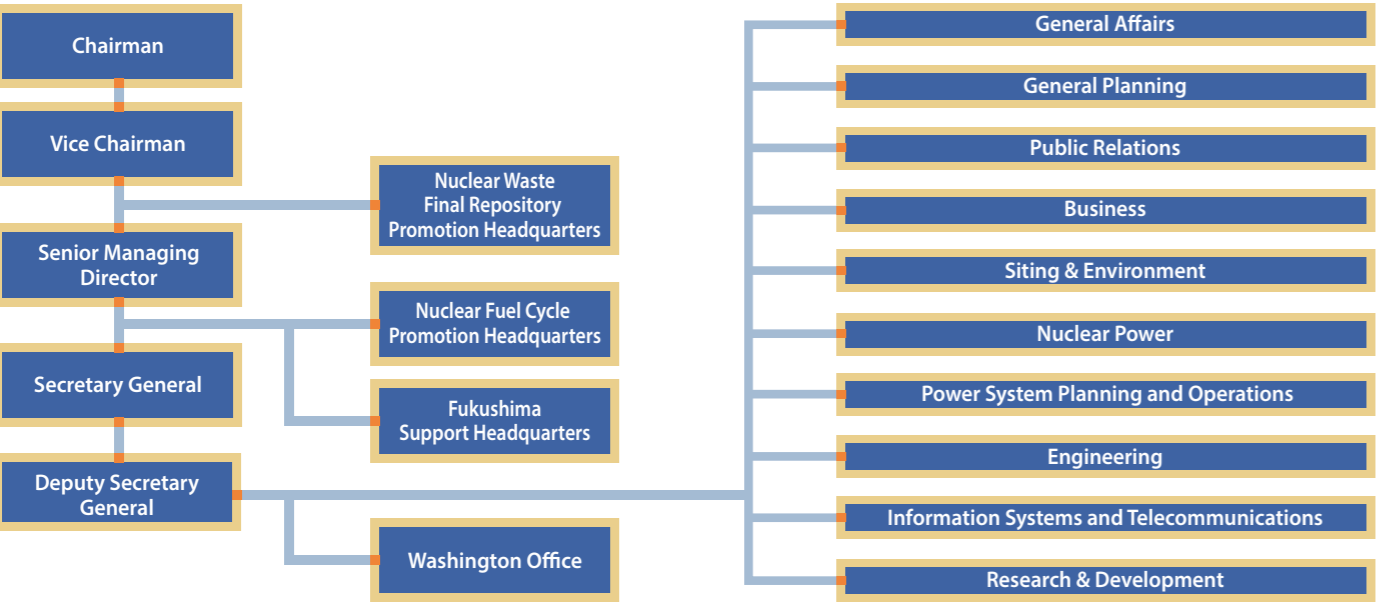


Director
Secretary General
Satoshi Ohmori



Director
Deputy Secretary General
Yoshihiro Tomioka

Organization of FEPC



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6-15-1, Ginza, Chuo-ku, Tokyo 104-8165, Japan
Tel: (03) 3546-2211 URL <http://www.jpowers.co.jp>

The Japan Atomic Power Company (JAPC)
5-2-1, Ueno, Taito-ku, Tokyo 110-0005, Japan
Tel: (03) 6371-7400 URL <http://www.japc.co.jp>

Japan Nuclear Fuel Limited (JNFL)
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Tel: (0175) 71-2000 URL <https://www.jnfl.co.jp>

Japan Atomic Energy Agency (JAEA)
765-1, Funaishikawa, Tokai-mura, Naka-gun, Ibaraki 319-1184, Japan
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Japan Electric Power Information Center, Inc. (JEPIC)
15-33, Shibaura 4-chome, Minato-ku, Tokyo 108-0023, Japan
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World Association of Nuclear Operators Tokyo Centre (WANO-TC)
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Tel: (03) 6722-5900 URL <https://www.wano.info>

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