Creating the Future of Coal-Fired Power Generation

Developing Clean Coal Technologies at the World's Highest Levels

Coal-fired power generation accounts for about 40% of electric power supplies worldwide and about 30% in Japan, and use of coal-fired power generation is expected to grow, particularly in Asia, where power demand is rising in conjunction with economic growth. In Japan, the new Energy Basic Plan adopted by the Cabinet in April 2014 positions coal-fired power generation as an important baseload power source that offers stable supplies and outstanding economy. Replacement of existing facilities and construction of new power plants with state-of-the-art technologies as well as the development of new technologies for controlling CO_2 emissions are being promoted, and policies for the overseas development of cutting-edge higher-efficiency coal-fired power generation are being carried out.

The J-POWER Group has continuously developed, introduced, and operated clean coal technology for coal-fired power generation for a half century in Japan and is working to transfer cutting-edge technology and put it into widespread application overseas.

This feature presents information on our contributions to stable energy supplies through the introduction of ultra-supercritical (USC) technologies at the world's highest levels at new higher-efficiency coal-fired power stations and the J-POWER Group's efforts to address the issue of global warming with a focus on research and development of clean coal technologies.

The entire J-POWER Group is working together with the aim of creating clean coal technologies at the world's highest levels in order to make the concept of harmonizing energy supply with the environment a reality in Japan and around the world.

Executive Managing Director
Hitoshi Murayama

Reducing CO_2 emissions from coal-fired power (pp. 8-10)

- Advance Replacement Plan
- Maintain high operating efficiency and reduce CO_2 emissions at existing thermal power plants
- Transfer and promote the widespread application of clean coal technologies overseas

Conducting research and development of next-generation low-carbon technologies (pp. 11-12)

- Implementation of the Osaki CoolGen Project
- Proceed with development of storage (CCS) technologies

Making efforts to reduce CO_2 Emissions

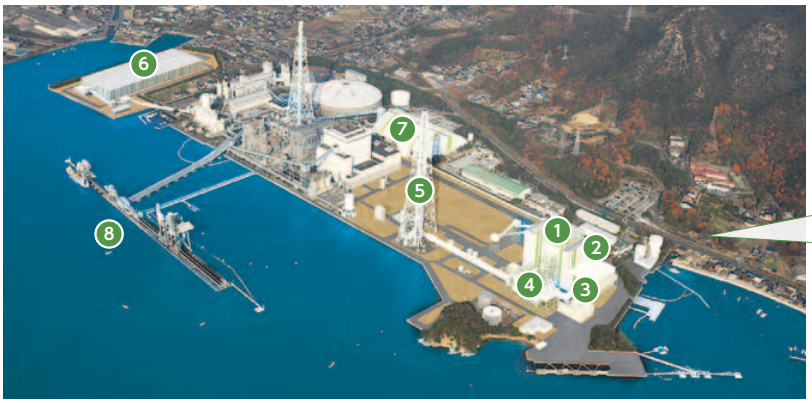
Expanding CO_2-free power generation facilities

- Measures under the Ohma Nuclear Power Station Plan (pp. 13-16)
- Expand use of renewable energies (pp. 21-24)

Takehara Thermal Power Station Replacement Plan: Pursuing the World's Highest Levels as USC Technology

The J-POWER Group is carrying out a plan to replace Takehara Thermal Power Station Units No. 1 (250 MW) and No. 2 (350 MW), which went into operation some 40 years ago, with a New Unit No. 1 (600 MW). The environmental assessment procedures have been completed, and construction began in March 2014, with operations scheduled to begin in 2020.

By introducing the latest power generation technologies and environmental pollution control equipment, we will create a coal-fired power station with the world's highest-level ultra-supercritical (USC) technologies.



Rendering of completed Takehara Thermal Power Station Replacement Project (Hiroshima Prefecture)

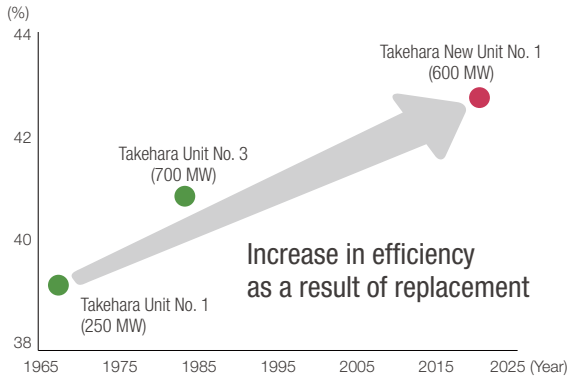
New Unit No. 1 Facilities

1. Boiler Building
2. Flue-gas denitrification system
3. Electrostatic precipitator
4. Flue-gas desulfurization system
5. Chimney stack
6. New indoor coal yard
7. Existing indoor coal yard
8. New Unit No. 1 and Unit No. 3 coal unloading and transport units

World's Most Efficient Power Generation Technologies

The new Unit No. 1 will produce steam conditions at the world's highest level and will be one of Japan's most efficient power stations. Raising power generation efficiency will reduce the consumption of coal, the station's energy source, making it possible to curtail CO_2 emissions and substantially reduce carbon.

Figure 1. **Comparison of Power Generation Efficiency after Replacement of the Takehara Station (at generation point, HHV)** * See note on p. 9.



Contribution to Stable Electric Power Supply

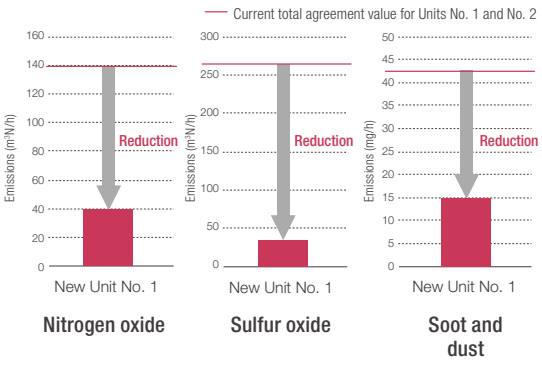
We are enhancing our role as a baseload power source that provides stable energy supplies through increases in energy efficiency achieved by replacing aging facilities with new facilities.

To minimize the power supply suspension period resulting from the replacement construction, we introduced a build and scrap construction method whereby Units No. 1 and No. 2 will be removed after construction of New Unit No. 1.

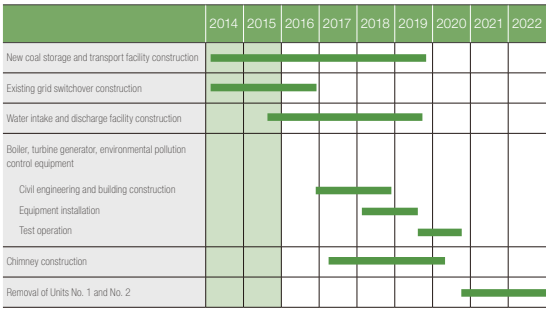
Clean Environmental Technology at the World's Highest Level

New Unit No. 1 will be equipped with the latest flue-gas denitrification system, flue-gas desulfurization system, and electrostatic precipitator, greatly reducing emissions of nitrogen oxides (NOx), sulfur oxides (SOx), soot and dust (see Figure 2). The Isogo Thermal Power Station, which is already equipped with similar equipment, boasts emissions that are extremely low compared to other thermal power plants in Europe, the U.S., and Japan (see p. 9).

Figure 2. **Comparison of Emissions Agreement Values of Current Takehara Units No. 1 and No. 2 and New Unit No. 1**



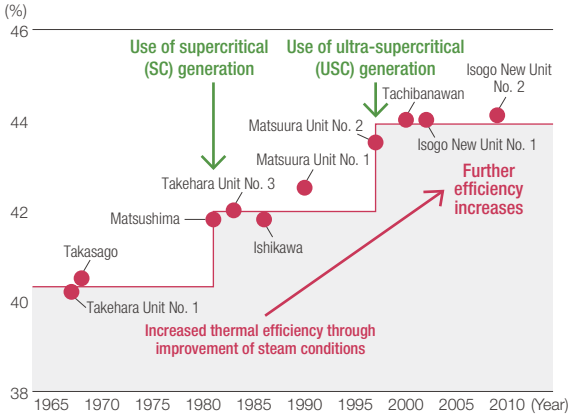
Main Construction Processes



Cutting Carbon Emissions

Even since the J-POWER Group started operating the Matsushima Thermal Power Station using imported coal, a first in Japan, in 1981, we have developed a number of large-scale thermal power stations using imported coal while improving power generation efficiency and reducing carbon emissions by enhancing steam conditions and increasing station size.

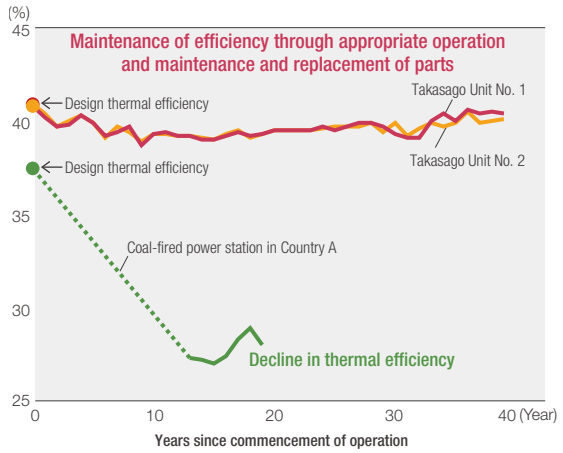
History of improvements in generating efficiency of J-POWER coal-fired power stations (at generation point, LHV) * See note on p. 9.



Maintaining High-Efficiency Operation

The J-POWER Group's coal-fired power stations play an important role as economical and stable baseload power supplies. Thermal efficiency declines as generating facilities age. Operating management and facility updates make it possible to continue operating with high levels of thermal efficiency. One example of this is the Takasago Thermal Power Station, which even now, maintains nearly the same power generation efficiency more than 40 years after it began operating.

Changes in thermal efficiency of Takasago Thermal Power Station (at generation point, LHV) * See note on p. 9.



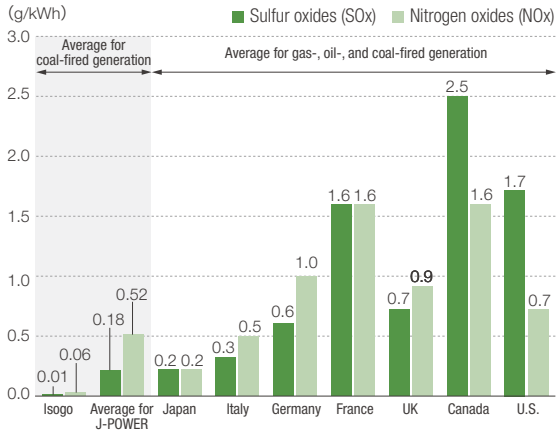
Implementation of Replacement Plans

The replacement of aging power stations leads to higher power generation efficiency and environmental preservation through the introduction of the latest technologies.

The Isogo Thermal Power Station, which underwent replacement, now has the latest ultra-supercritical (USC) generating technologies and boasts power generation efficiency at the world's highest levels. Sulfur oxide, nitrogen oxide, soot and dust have been reduced to levels far below those of thermal power stations in other leading developed countries, becoming the world's cleanest coal-fired power station.

The J-POWER Group plans to follow replacement of the Isogo Thermal Power Station and the Takehara Thermal Power Station, construction for which has already begun, with further measures to replace aging coal-fired power stations.

International Comparison of SOx and NOx Emissions Intensity for Thermal Generation



Overseas: Emissions volume: OECD StatExtracts Complete Databases Available Via OECD's Library
Volume of power generated: IEA Energy Balances of OECD Countries (2012)
Japan: Materials published by The Federation of Electric Power Companies of Japan
(10 electric power company and J-POWER)
Figures for Isogo and J-POWER are formulated from results for 2013

Isogo Thermal Power Station (Yokohama City)

* At generation point: the power generation efficiency calculated by using the amount of electric power at the point of generation (amount of electric power at the time of generation by the generator).
* At transmission point: the power generation efficiency calculated by using the amount of electric power at the point of transmission (amount of electric power at point of generation minus internal power (power used in the generation process)).

Seeking Further Reductions in Carbon Emissions

In fiscal 2013, the J-POWER Group's electric power business in Japan produced approximately 47.84 million t-CO_2 (the domestic and overseas electric power business produced approximately 56.33 million t-CO_2), a year-on-year increase of approximately 0.6%. Electric power sold was approximately 65,100 GWh, about the same as the previous year, but the hydroelectric power station water flow rate fell, and as a result, thermal power stations were maintained at high operating rates. CO_2 emissions per unit of electric power sold remained flat at 0.74 kg-CO_2/kWh (emissions in the domestic and overseas electric power business were 0.68 kg-CO_2/kWh).

In consideration of the importance of global environmental issues, the J-POWER Group is working to maintain and improve high operating efficiency including the replacement of existing thermal power stations and is taking measures to introduce mixed combustion (combusting a different fuel with the coal boilers) at coal-fired power stations by using biomass fuels, a renewable energy source that has recently been attracting attention (see p.24).

See pages 11 and 12 for further information on high-efficiency power generation such as advanced ultra-supercritical (A-USC) generation, integrated coal gasification combined-cycle (IGCC), integrated coal gasification fuel cell (IGFC), and other technologies and research and development of next-generation technologies such as CO_2 capture and storage (CCS), which is expected to greatly reduce CO_2 emissions.

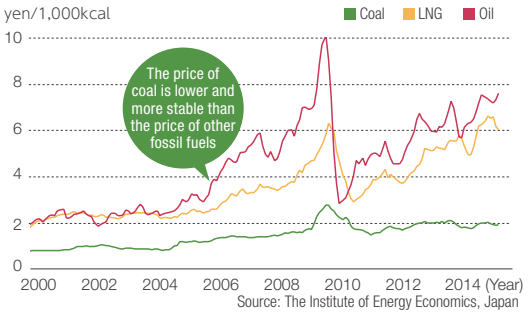
Coal-Fired Power Generation and Clean Coal Technologies Needed Around the World

Coal-Fired Power Generation Used Globally

Compared to oil and natural gas, which are also fossil fuels, coal is lower in cost and economically more efficient (see Fig. 1); has more abundant reserves; and is distributed widely around the world, so that it is also superior in terms of energy security.

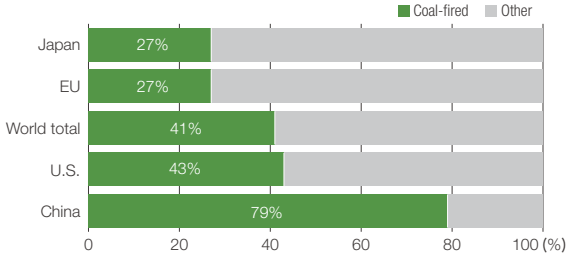
For these reasons, coal supports stable electric power supplies in many countries as a primary electric power generating fuel, and coal-fired power generation accounts for more than 40% of global electric power supplies (see Figure 2).

Figure 1. **Trends in Fuel Prices**



Source: The Institute of Energy Economics, Japan

Figure 2. **Ratio of coal-fired generation in total power generation (2011)**



Source: IEA World Energy Outlook 2013

Cutting CO_2 Emissions Using Clean Coal Technology

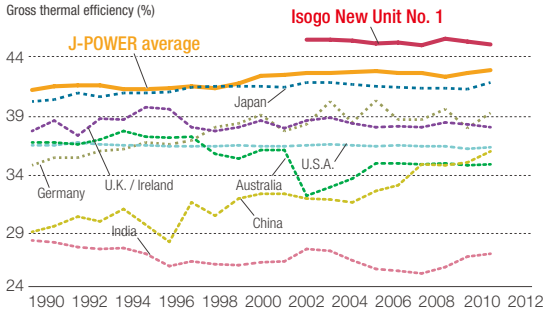
Global measures are needed to respond to the issue of global warming caused by CO_2 and other greenhouse gases generated from the combustion of coal and other fossil fuels.

Coal-fired power generation accounts for the majority of electric power supply in China, India, Indonesia, and other areas of Asia where demand for electric power is expected to remain robust in the future, and curtailing CO_2 emissions and coal consumption has become an important issue.

If the power generation efficiency of the J-POWER Isogo Thermal Power Station, which is at the world's highest levels (see Figure 3), were achieved at all coal-fired power stations in China, India, and the United States, which currently account for about 50% of global CO_2 emissions, we estimate that CO_2 emissions would be cut by approximately 1.47 billion t-CO_2, which is more than Japan's total annual emissions.

Transferring USC and other clean coal technologies that were developed and put into use in Japan to countries around the world and contributing to the reduction of global greenhouse gas emissions is positioned as a core policy in the Energy Basic Plan, and the J-POWER Group is taking active measures to support this policy.

Figure 3. **Comparison of thermal efficiency of coal-fired power around the world (at generation point, LHV)** * See note on p. 9.

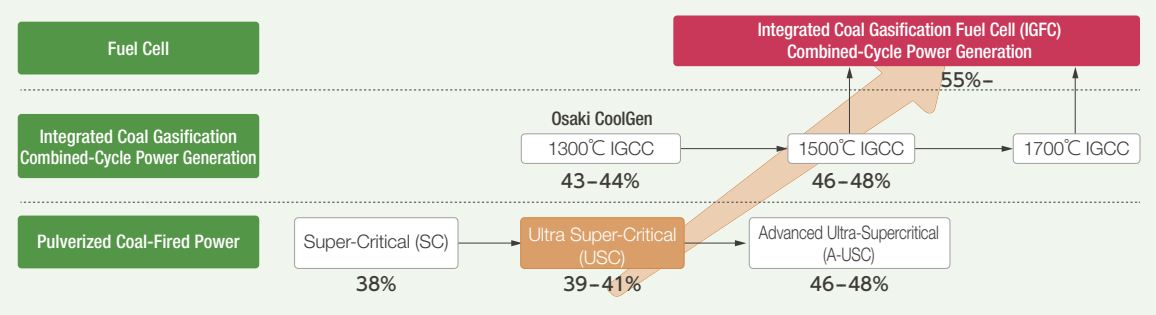


Source: Compiled from Ecofys International Comparison of Fossil Power Efficiency and CO_2 intensity Update 2013

Research and Development of Next-Generation Low-Carbon Technologies: For the Sake of the Earth's Future

The J-POWER Group is pursuing cutting-edge clean coal technologies and employing USC power generation at the world's highest levels, and by conducting further research and development, we are promoting additional reductions in carbon from coal-fired power. We are committed to continuing active research and development in Japan and overseas on next-generation, higher-efficiency coal-fired power generation that can reduce CO_2 emissions through even higher power generation efficiency, CCS to capture and store CO_2 produced by power generation so it is not released into the atmosphere, and other technologies.

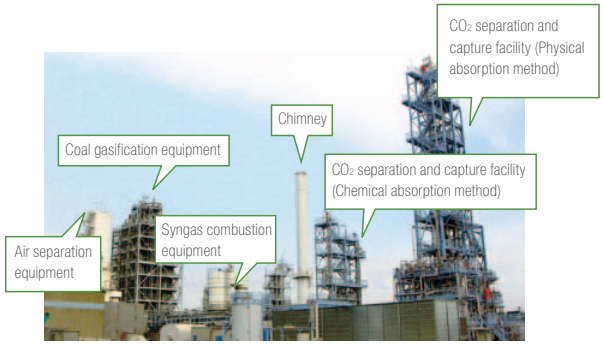
Thermal Efficiency Improvement by Technical Development (at transmission point, HHV) * See note on p. 9.



Higher-Efficiency Coal-Fired Power Generation Technologies

The higher-efficiency coal-fired power generation technologies on which the J-POWER Group is conducting R&D include integrated coal gasification combined-cycle (IGCC) power generation, which combines conversion of coal into a flammable gas for combustion in a gas turbine with a steam turbine that uses the waste heat; integrated coal gasification fuel cell (IGFC) combined-cycle power generation, which adds triple-combined-cycle generation to fuel cell power generation using IGCC; and advanced ultra-supercritical power generation, which improves USC steam conditions even further.

R&D on IGCC is the most advanced, and trial operations at a pilot plant facility were conducted for more than 10 years starting in 2002 under the EAGLE Project in collaboration with the New Energy and Industrial Technology Development Organization (NEDO) (the project ended in June 2014). The knowledge and results obtained from the project will be used, and the technology is entering the testing phase under the Osaki CoolGen Project.



External view of EAGLE Pilot Plant test facility (Kitakyushu City)

The EAGLE Project tested a physical collection method and a chemical collection method for separating and collecting CO_2, and information was gained on the properties of each.

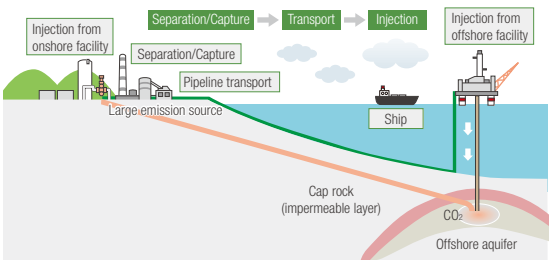
CO_2 Capture and Storage (CCS) Technology

CO_2 capture and storage (CCS) separates and collects CO_2 produced from the combustion of coal and other fossil fuels without releasing it into the atmosphere and transports the CO_2 for storage deep in the earth. R&D on CCS is being conducted around the world as a promising technology for achieving substantial reductions in CO_2 emissions.

At this time, there are issues of lower power generation efficiency during the separation and collection phase as well as securing suitable sites and creating infrastructure and legal systems in the transport and storage phases, and as a result, CCS is not in practical use anywhere in the world.

The J-POWER Group plans to continue conducting research and development on separation and collection as a part of the Osaki CoolGen Project by using the results from the EAGLE Project. In addition, we are participating in the Callide Oxyfuel Combustion Project, a joint Japanese-Australian public and private sector initiative that is conducting trials of an integrated separation, collection, and storage system in Australia.

CCS Concept



Osaki CoolGen Project: Seeking IGCC at the World's Highest Levels

In order to curtail CO_2 emissions from coal-fired power generation beyond what is possible with current clean coal technologies, the Energy Basic Plan expresses expectations for development and application of next-generation, higher-efficiency coal-fired power generation technologies such as IGCC as well as research and development in the pursuit of application of CCS technologies.

The J-POWER Group is conducting the Osaki CoolGen Project in collaboration with Chugoku Electric Power Co., Inc. to test these advanced clean coal technologies. For the project, an oxygen-blown IGCC trial power station with output of 166 MW is being built at the Chugoku Electric Power Osaki Power Station, and tests will be conducted in three phases.

Osaki CoolGen Project Schedule

(Fiscal Year)

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Phase 1	Oxygen-blown IGCC demonstration	Design, manufacture, installation					Proving trials				
Phase 2	CO_2 separation and capture type IGCC demonstration					Design, manufacture, installation			Proving trials		
Phase 3	CO_2 separation and capture type IGFC demonstration							Design, manufacture, installation		Proving trials	

Construction for the start of the first phase of testing in the 2016 fiscal year began in March 2013, and basic construction of the principal facilities has entered the busiest period. J-POWER and Chugoku Electric Power established Osaki CoolGen Corporation in 2009 to carry out the project. The "CoolGen" name is derived from the Cool Gen Plan proposed to carry out the Japanese government's Cool Earth-Innovative Energy Technology Program and was created from "cool" and "generation."

Planned Completion of Testing Facilities (Hiroshima Prefecture)