

Making Coal Use Compatible with Measures to Counter Global Warming

The J-POWER Group is one of the biggest coal users in Japan, consuming nearly 20 million tons of coal per year at eight coal-fired power stations with a total capacity of 7950 MW, which account for approximately 20% of Japan's total coal-fired generating capacity. The J-POWER Group is working as the leading company in the field to balance the effective use of coal with responsiveness to global environmental issues.



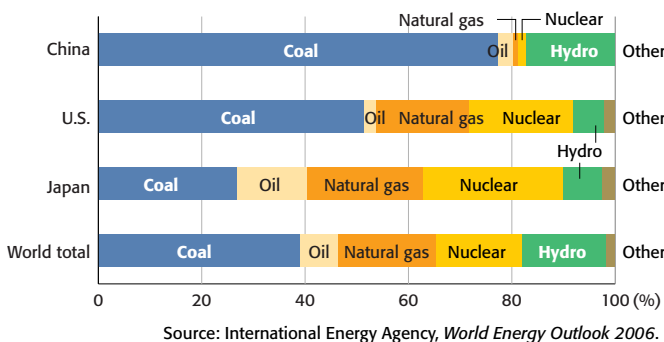
松浦火力発電所

The Significance of the Effective Use of Coal for Today

People may think that coal has been replaced by oil and natural gas and is no longer a major fossil fuel. However, around 30% of total electric power generated in Japan comes from coal-fired power stations, even though Japan places priority on balancing the energy mix in power generation as a country heavily dependent on overseas sources for natural energy resources. Furthermore, coal continues to be the main fossil-fuel in use around the world, accounting for around 80% of power generated in China and around 50% in the United States. It is widely used in Europe as well.

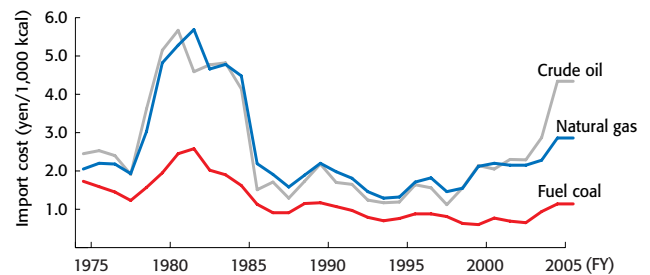
In this way, coal is indispensable as the biggest electric power source, supplying approximately 40% of the world's electric power.

Electricity Generation by Source



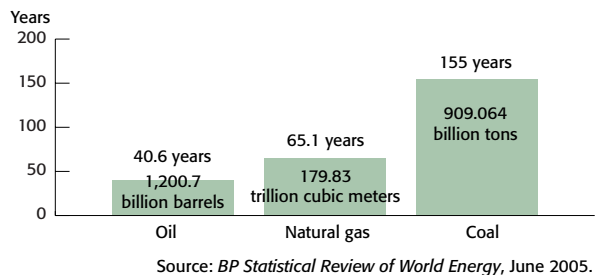
Global energy consumption is expected to nearly double by 2030 from the 2002 level. Oil, one of the main energy resources, is vulnerable to political instability because production is so heavily concentrated in the Middle East. On the other hand, coal is widely distributed throughout the world and can be easily obtained at a stable price.

Trends in Fuel Costs

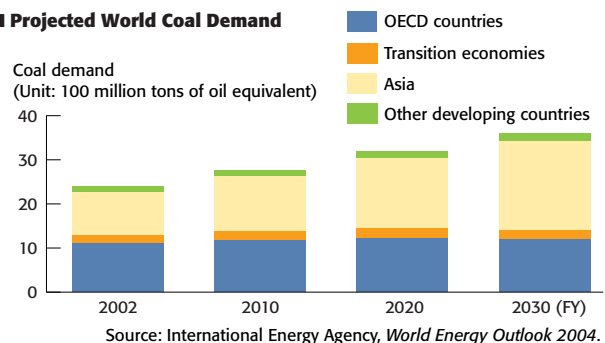


Moreover, because coal has the most abundant reserves of all the major energy resources—estimated at about four times that of oil and three times that of natural gas—it will continue to be an important fuel in meeting the ever-rising global energy demand.

Proved Reserves



Projected World Coal Demand



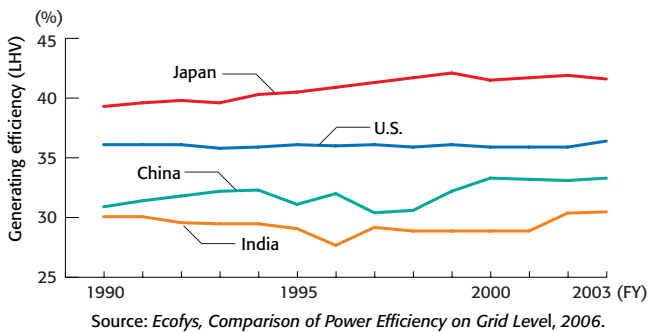
J-POWER's Efforts to Address Global Warming

Improving Efficiency of Coal-Fired Power Generation

A problem with coal-fired power generation is that it results in the emission of relatively large amounts of CO₂ compared with other fossil fuel-fired power generation. As the concentration of greenhouse gases (GHGs) including CO₂ in the atmosphere rises, the heat stored in the atmosphere builds up as well, causing the global temperature to climb. Today, with global warming, or climate change, giving rise to serious problems, the Intergovernmental Panel on Climate Change (IPCC) has concluded with near certainty that the increase in anthropogenic greenhouse gas emissions has caused global warming. We are now facing a situation where we need to reduce emissions of CO₂ and other GHGs.

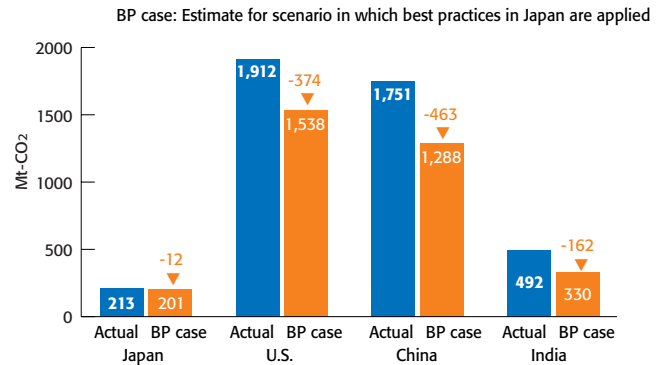
To reduce CO₂ emissions it is necessary to lower the ratio of CO₂ emissions per unit of production and to reduce the absolute amount of emissions. In generating electricity through fossil fuel combustion, coal results in twice the amount of CO₂ emissions compared to natural gas. In Japan, however, coal-fired power stations are generating electricity with higher energy efficiency by raising the temperature and pressure in steam turbines to above the critical point, or to ultra supercritical (USC) conditions. This technology is contributing to the reduction of CO₂ emissions. If this high performance technology were introduced in the United States, China, and India, the world's big CO₂ emitters, it is estimated that CO₂ emissions in these three countries could be reduced by around 1 billion tons annually, which is around 80% of Japan's annual total CO₂ emissions. Therefore, it is important to transfer and disseminate of these clean coal technologies.

Trends in Coal Generation Efficiency by Country



In addition, J-POWER Group is a pioneer in clean coal technology, and we are making efforts to develop two next-generation technologies aiming at higher energy efficiency: integrated coal gasification combined cycle (IGCC) and integrated coal gasification fuel cell combined cycle (IGFC). The combination of gas and steam turbines with fuel cells that use hydrogen from coal gasification could reduce CO₂ emissions by a third.

CO₂ Emissions from Coal-Fired Power Generation and Potential for Reduction



Source: International Energy Agency, CO₂ Emissions from Fuel Combustion 2005 Edition.

What Is the Intergovernmental Panel on Climate Change (IPCC) ?

The IPCC was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 as a forum for international deliberation on the issue of global warming. Participants include Japan, the United States, China, Russia, and numerous other developed and developing countries. The IPCC collects and assesses a wide range of research involving scientific knowledge on global warming, its impacts, and the measures to be taken, and publishes the results in assessment reports. As part of the IPCC Fourth Assessment Report (AR4), Working Group I, studying the physical science basis of climate change, released a report in February 2007. This report concluded that warming of the climate system is unequivocal and also stated with very high confidence that the increase in anthropogenic greenhouse gas emissions is the cause. The Synthesis Report of the IPCC Fourth Assessment Report is expected to be adopted at the IPCC plenary session in November 2007.

Asia-Pacific Partnership on Clean Development & Climate (APP)

The Asia-Pacific Partnership on Clean Development & Climate (APP), which consists of six countries (Japan, the United States, Australia, South Korea, China, and India), held a peer review for the maintenance and improvement of energy efficiency of coal-fired thermal power stations during April 16–19, 2007.

Participants, including 37 representatives from the United States, Australia, South Korea, China, and India, visited J-POWER's Takasago Thermal Power Station in Hyogo Prefecture to exchange information on such topics as global

warming, efforts to maintain and improve the energy efficiency of coal-fired thermal power stations, and the maintenance factors causing declines in energy efficiency, and shared their recognition of the current situation and some issues to be addressed. J-POWER made efforts to promote the transfer and dissemination of technology among the countries by holding discussions on operation, maintenance, and the environment while viewing the existing facilities at the power station.

The participating representatives seemed



amazed by the efforts made to maintain the high energy efficiency of Takasago Thermal Power Plant, which is nearly 40 years old.



Fukuoka Prefecture

The EAGLE Project

Eiji Arimori

EAGLE Research and Engineering Group
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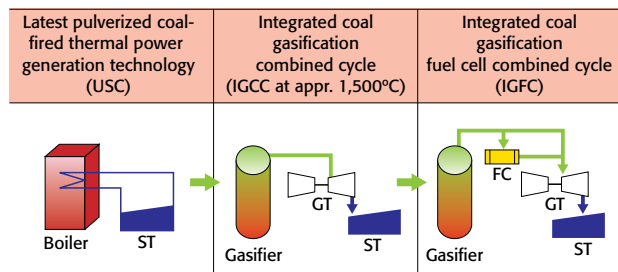


Further Advances in Coal Use through Gasification

J-POWER Group is working on a variety of new technologies aimed at making our use of this precious natural resource coal higher in efficiency and lower in environmental load. One of our development initiatives that has attracted the most notice is the EAGLE* Project, which was launched in 1995 with the goal of developing technology to produce coal gas for use in fuel cells.

The power generation efficiency of pulverized coal-fired thermal power generation with only steam turbines is about 40%. However, this figure can be boosted to around 48% when the coal is gasified and both steam and gas turbines are used—a method called integrated coal gasification combined cycle (IGCC) generation. Moreover, with the integrated coal gasification fuel cell combined cycle (IGFC) method, which adds fuel cells as a third mode of generation, the generating efficiency can be raised even further, to 55%. If successfully put into practice, the new technology could bring about major reductions in CO₂ emissions (a decrease of about one-third from conventional coal-fired generation).

Next-Generation Coal-Fired Power Generation Technology



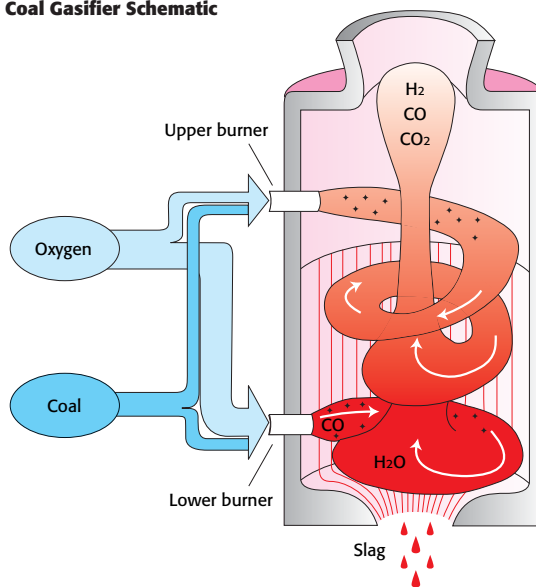
ST: Steam turbine
GT: Gas turbine
FC: Fuel cell

To convert coal to gas, the EAGLE Project is also applying a new technology known as “oxygen-blown” gasification. One advantage of oxygen-blown gasification over other methods is that it makes CO₂ capture relatively easy; another is that it makes possible the production of hydrogen and such synthetic fuels as methanol.

“Coal gasification technology itself has existed for some time. The commercialization of the technology has made progress in the United States and Europe ahead of other countries. The EAGLE Project is taking an original approach to this technology and attempting to transform it into something more efficient, reliable, and widely applicable. In 2002 we began trials at a pilot plant. It was all terra incognita, hitting one impasse, finding a way around it, and then hitting another, until we finally achieved the desired target level” (Eiji Arimori, in charge of test planning and assessment).

* EAGLE stands for Coal Energy Application for Gas, Liquid, & Electricity.

Coal Gasifier Schematic



Making High-Efficiency Coal-Fired Power Generation a Reality

EAGLE Achieves 1,000+ Hours Continuous Operation

EAGLE achieved the project’s initial goals by fiscal 2006, and on May 2, 2007, it reached the equipment reliability benchmark of 1,000+ hours of continuous operation.

“We’re approaching this from the standpoint of the users who will actually be operating the equipment and developing technology for operating and maintaining the plant at the same time that we’re developing the equipment. Coal gasifiers reach extremely high temperatures, so it called for operation and monitoring methods different from those used at conventional plants, but we’ve steadily accumulated know-how until we achieved continuous prolonged operation” (Kenichi Yamaguchi, in charge of gasification equipment maintenance).

Having achieved this giant step toward commercialization, the EAGLE Project has entered a new phase. The next challenge is to increase the range of coal types (coal comes in many forms) that can be used in the coal gasifier so as to make fuel procurement easier and more flexible. Also in the works are steps to further enhance the plant’s reliability and continue to conduct studies to assess the environmental impact. In this way we are working to make high-efficiency power generation a reality.



Operation Center

Ultimate Goal: Zero CO₂ Emissions

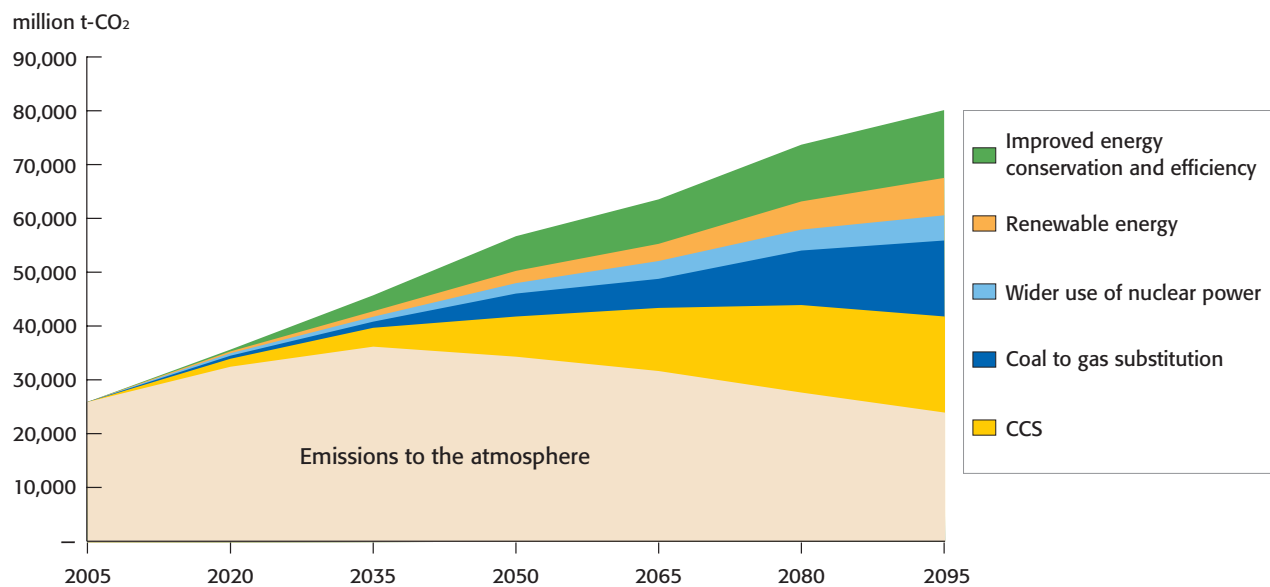
The combustion of fossil fuels inevitably produces CO₂. For this reason, efforts are under way around the world to develop carbon capture and storage (CCS) technology.

According to the *Special Report on Carbon Dioxide Capture and Storage* (released September 26, 2005) of the Intergovernmental Panel on Climate Change (IPCC), capture and storage of CO₂ has a major role to play in fighting global warming. According to the report, CCS has the potential to reduce by 30% or more the costs that mitigating

climate change will entail over the next 100 years and to reduce much of the CO₂ emissions that will have to be cut between now and 2100.

Conscious of the potential that CCS holds as the ultimate weapon against global warming, J-POWER Group is working to develop technologies relating to CO₂ capture and storage, and we intend to continue these efforts with the aim of using such technologies to reach the goal of zero CO₂ emissions.

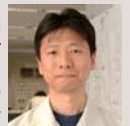
■ Contribution of Methods for Reducing CO₂ Emissions with Concentrations Stabilized at 550 ppm (estimates by Pacific Northwest National Laboratory)



Fukuoka Prefecture

CO₂ Capture Technology (capture from oxygen-blown gasifier gas)

Kyouhei Nakamura
 Gasification/CO₂ Capture Equipment Test Assessment Supervisor
 EAGLE Research Group
 Wakamatsu Research Institute
 Technology Development Center



"As the next step in the EAGLE Project, we've begun working to establish a technology for capturing CO₂. We'll divert some of the gas produced through coal gasification from our present gasification equipment and use it to carry out CO₂ capture testing. The EAGLE Project makes use of the oxygen-blown method, which has the merit of facilitating efficient CO₂ capture. CO₂ capture is going to be one of the key technologies for achieving our ultimate goal of coal use with zero CO₂ emissions.

"At this time, we're considering the design of our CO₂ capture system and a testing plan. With EAGLE's oxygen-blown method, the coal gas has low nitrogen content and consists primarily of CO and H₂. First, we'll use the shift reaction to convert the CO to CO₂. Then we'll capture the CO₂ in the next stage of the capture process.

"There are a lot of technological issues involved in applying CO₂ capture technology to coal gas, but by beginning our

R&D effort at the pilot plant, we can gain the insights that are going to be needed to apply it to large-scale equipment. I believe reducing CO₂ emissions from coal use is a key issue today, and having the opportunity to be involved in the development of this technology gives me a sense of doing something important and worthwhile as an engineer."

Four Strategies to Fight Global Warming

The J-POWER Group intends to continue to reduce CO₂ emissions intensity by combining the four strategies described below, including CO₂ emissions control efforts for coal-fired thermal power generation. For further details on each of these strategies, see “Environment” (page 33 ff.).

In addition, in keeping with the Basic Policy of our Environmental Management Vision (page 25), We have formulated an Action Program (page 27) that clearly defines

targets and approaches for key challenges and issues relative to Group business activities, and we are working together to achieve these Group targets.

As a world leader in the use of coal, we believe that we have a social responsibility to make coal use compatible with efforts to stem global warming. By fulfilling this responsibility, we are determined to contribute to the sustainable development of Japan and the world.

1. Maintenance and Improvement of Energy Use Efficiency

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In addition to promoting increased efficiency in coal-fired thermal power generation, we are further boosting the power generation efficiency of CO₂-emission-free hydropower by continually upgrading our facilities and making them more efficient.

Total upgrade of major facilities in the Tagokura Power Station (Fukushima Prefecture)



2. Development of Low-CO₂-Emission Power Sources

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The J-POWER Group is working to develop power generation using fuels that emit little or no CO₂, including nuclear power, wind power (a natural energy source), and biomass that utilizes living resources.



Biosolid fuel

Biosolid supply facility, Matsuura Thermal Power Station (Nagasaki Prefecture)



3. Utilization of the Kyoto Mechanisms

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J-POWER is making use of its technological and financial resources to apply such Kyoto Mechanisms as the Clean Development Mechanism (CDM), whereby its member countries are allowed to count the amount of emissions reduced by projects they conduct in other countries for cutting greenhouse gases as their own reductions. In this way we are contributing to efficient reduction of CO₂ emissions on a global scale.



CDM project at Caieiras Landfill in Brazil (combustion of landfill gas)

4. Development, Transfer, and Dissemination of New Technologies

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The J-POWER Group is developing coal gasification technology to improve power generation efficiency as well as technology for capturing CO₂. We intend to continue our quest for next-generation technologies and lead the world in the improvement of coal-fired power generation.

EAGLE Pilot Plant J-POWER Wakamatsu Research Institute (Fukuoka Prefecture)

