Special Feature

2 Coal Use and Measures to Counter Global Warming

The J-POWER Group is one of the biggest coal users in Japan, consuming approximately 20 million tons of coal per year at eight coal-fired power stations. With a total capacity of 7.95 GW, these stations account for approximately 20 percent of Japan's total coal-fired generating capacity. We are endeavoring seriously as a leading company in the industry to balance the effective use of coal with responsiveness to global environmental issues.

The Significance of Effective Coal Use in Today's World

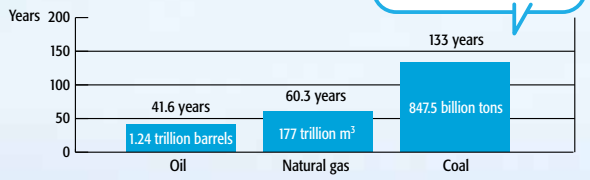
The world today depends on fossil fuels for most of its energy needs. Among these fuels, coal has more abundant reserves than oil or natural gas. Moreover, it is available globally including Asia rather than being concentrated in the Middle East, and is therefore used throughout the world as a main energy source. Coal-fired power generation accounts for around 40 percent of the world's current electricity production, and coal is expected to continue to be a major source of energy, helping to meet ever-rising global energy demands in China, India and elsewhere.

For Japan, dependent on overseas sources for the majority of its energy resources, aiming for a robust and flexible energy mix is a must. The advantages of coal will continue to make it essential in forming that mix.

At the same time, when coal and other fossil fuels are burned they generate CO_2, a greenhouse gas. In the midst of growing energy demand, the world faces the issue of how to reduce emissions of CO_2 and other greenhouse gases.

Fossil Fuel Energy Resource Reserves

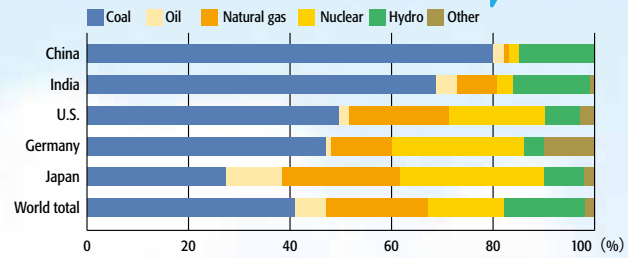
Coal has ample reserves.



Source: Compiled by J-POWER using data from BP *Statistical Review of World Energy 2008*

Electricity Generation Worldwide by Source

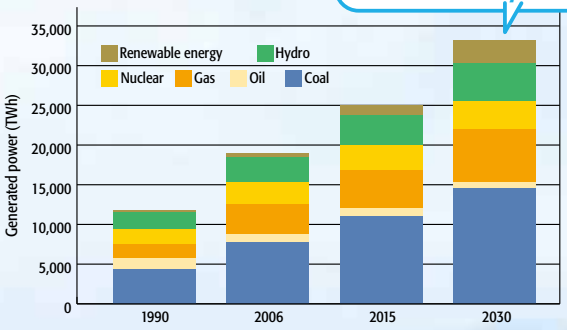
Approximately 40% of the world's electricity comes from coal.



Source: Compiled by J-POWER using data from IEA *World Energy Outlook 2008*

Global Power Generation Trends and Outlook by Energy Source

Coal-fired power will continue to be essential as a main source of the world's electricity



Source: Compiled by J-POWER using data from IEA *World Energy Outlook 2008*

The J-POWER Group's Four Strategies for the Problem of Global Warming

The J-POWER Group in Japan is the source of approximately 3 percent of this country's total CO_2 emissions. This is something we take very seriously. As a leader in the use of coal, we recognize our social responsibility to deal with global warming, making it one of the top priority issues for our corporate management. The four strategies outlined below are helping to shape our short-term, mid-range, and long-range efforts to continue reducing CO_2 emissions intensity. Further details are given in the section on Environment (pp. 42 ff.). See also p. 55 for fiscal 2008 emissions data.

1 Maintenance and Improvement of Energy Use Efficiency

In addition to promoting increased efficiency in thermal power generation, we are further boosting the power generation efficiency of hydropower facilities, which do not emit CO_2, by continually upgrading them.

2 Development of Low CO_2 Emission Power Sources

The J-POWER Group is working to develop power generation that emits little or no CO_2, including nuclear power, wind power, and solar energy. We are also actively working to take effective advantage of biomass as an energy source.

3 Development, Transfer, and Dissemination of New Technologies

The J-POWER Group is developing coal gasification technology to improve power generation efficiency as well as technology for capturing CO_2. We also intend to continue our quest for next-generation technologies and lead the world in coal-fired power generation, while transferring and promoting the spread of our ultra super critical technology.

4 Utilization of the Kyoto Mechanisms and Other Measures

J-POWER is making use of its technological and financial resources to apply such Kyoto Mechanisms as the Clean Development Mechanism (CDM), which allows member countries 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 effective reduction of CO_2 emissions on a global scale.

The Significance of Improving Coal-Fired Power Generation Efficiency

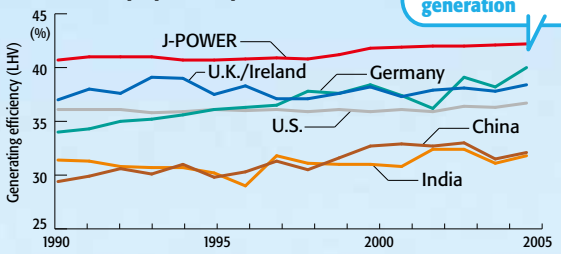
To reduce CO_2 emissions it is necessary both to lower the ratio of CO_2 emissions per unit output and to reduce the absolute amount of emissions. In generating electricity, coal results in higher CO_2 emissions than oil and natural gas. In Japan, however, coal-fired power stations generate electricity with higher energy efficiency than in Europe or Asian countries by raising the temperature and pressure in steam turbines to ultra super critical (USC) conditions.

If this high-performance technology were introduced in the United States, China, and India, which together emit a large portion of the world's CO_2, it is estimated that CO_2 emissions in these three countries could be reduced by around 1.3 billion tons annually, an amount equivalent to Japan's annual total of CO_2 emissions and five percent of the world total. It is therefore important to transfer and disseminate these clean coal technologies.

In addition, the J-POWER Group is pioneering efforts to develop next-generation coal-utilization technologies aiming at higher energy efficiency, including integrated coal gasification combined cycle (IGCC) and integrated coal gasification fuel cell combined cycle (IGFC) systems.

Japan boasts the world's highest thermal efficiency in coal-fired power generation

Trends in Coal Generation Efficiency by Country

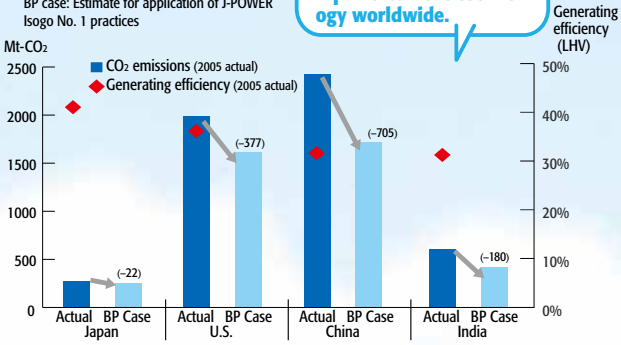


Source: Compiled using data from Ecofys *Comparison of Power Efficiency on Grid Level 2008*

CO_2 Emissions from Coal-Fired Power Generation and Potential for Reduction

Annual reduction of 1.3 billion tons CO_2 could be achieved by adopting Japan's current technology worldwide.

BP case: Estimate for application of J-POWER Isogo No. 1 practices



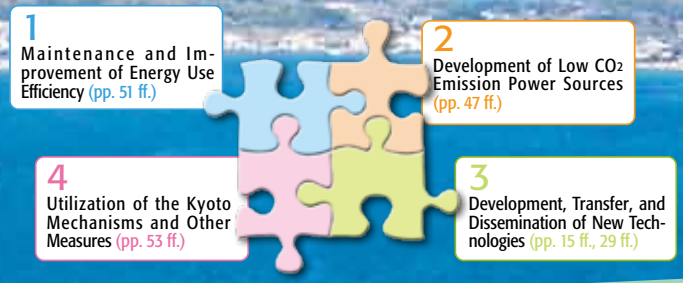
LHV: Lower heating value

Source: Compiled using data from IEA *World Energy Outlook 2007* and Ecofys *Comparison of Power Efficiency on Grid Level 2008*

Ultimate Goal: Zero CO_2 Emissions

Projects are under way around the world to develop carbon dioxide capture and storage (CCS) technology, and the J-POWER Group is also engaged in developing such technology. According to the *Special Report on Carbon Dioxide Capture and Storage* (released September 26, 2005) of the Intergovernmental Panel on Climate Change (IPCC), CCS has a major role to play in fighting global warming.

The IEA Energy Technology Perspectives 2008 concludes that the required reduction in CO_2 emissions will be achieved with improvement in energy efficiency and the combined use of renewable energy generation, nuclear power generation, and power generation at fossil fuel power stations equipped with CCS. The report claims that large-scale deployment of CCS will be needed for reducing CO_2 emissions.



We are advancing the fight against global warming by effectively combining the four strategies in an appropriate way, from a long-term standpoint.

>>Present

- **Implementing the Ohma Nuclear Power project**
- **Promoting the development of wind power and other forms of renewable energy**
- **Utilizing Kyoto credits and domestic credits**
- **Making older thermal power stations more efficient**
- **Effective use of biomass fuel**
- **Enhancing hydropower facilities and operation**

Future >>

- **Technological innovation achieving dramatic gains in power generation efficiency from coal**
- **Establishment of CO_2 capture and storage technology**

Question

What are you doing to reduce CO_2 emissions from coal use?

Answer 1

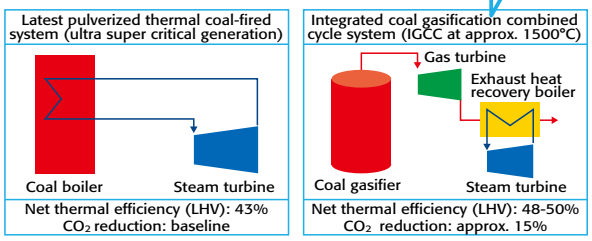
Hideki Gotou Director, Wakamatsu Research Institute, Technology Development Center

We are advancing the EAGLE Project aiming for the pinnacle of clean coal technology.

EAGLE stands for Coal Energy Application for Gas, Liquid, & Electricity. It is the name we have given to our project for "multi-purpose coal gas production technology development." The J-POWER Group is carrying out this project to achieve more efficient utilization of coal and as an important step toward the goal of zero CO_2 emissions. The conventional way of producing electricity from coal is to burn the coal and create steam from the heat, then use that steam to generate electricity. Our research is focused on converting coal to a combustible gas (syngas, consisting mainly of CO and H_2) and using that gas to generate electricity. Besides using the resulting gas to drive a gas turbine, the exhaust heat is used to produce steam for driving a steam turbine. A system using this approach is called an integrated coal gasification combined cycle (IGCC) system. Power generating efficiency is greatly improved, enabling CO_2 emissions to be reduced. Moreover, if we can efficiently capture CO_2 in the coal gas and store it, we will be much closer to our ultimate goal of a zero-emissions electrical plant. Also of note is that the EAGLE coal gas can have multiple uses, as a raw material for manufacturing such products as synthetic fuel and hydrogen.

CO_2 emissions can be reduced by around 15% by more efficient coal use.

>>> Comparison of Coal-Fired Power Generation Systems



EAGLE_Step 1 (test period: FY 2002-FY 2006)

The outstanding performance achieved in 6,000 hours of test operation has given us confidence in this project!

In Step I of the EAGLE Project, we built a pilot plant with capacity of 150 tons of coal per day, at the J-POWER Wakamatsu Research Institute in Kitakyushu, Fukuoka Prefecture, collaborating with the New Energy and Industrial Technology Development Organization (NEDO). Aimed at establishing Japan's own high-performance gasification technology, the pilot project determined the basic performance and verified reliability. Another important aspect of the pilot was obtaining data necessary for designing a large-scale plant. The goal set for the pilot was to demonstrate performance surpassing that of overseas gasification technology. After test operation of around 6,000 hours, we confirmed outstanding basic performance exceeding our goals, further boosting our confidence in the great potential of EAGLE technology.

>>> The EAGLE logo

>>> Outline of the EAGLE pilot facilities

Coal use	150t/day
Gasifier type	Oxygen blown single-chamber two-stage entrained-bed gasifier
Gasification pressure	2.5MPa
Gasification temperature	1,500 to 1,600°C
Gas turbine output	8,000kW

EAGLE pilot plant (Kitakyushu)

The operations room is bristling with anticipation

EAGLE_Step2 (test period: FY 2007- FY 2009)

On to even bigger challenges – Working to meet the great hopes for zero CO_2 emissions, and aiming for higher gasifier performance

With Step I successfully completed, the EAGLE Project is moving on to Step II, as a joint project with NEDO toward practical gasifier implementation. The gasifier is being modified to enable higher-temperature operation, and will be tested to verify its usability with a wide range of coal types. The ability to use various grades of coal will give greater flexibility both in gasifier operation and in coal procurement, easing the way to development of a commercial system.

Step II will also see the world's first attempt to combine gasification with CO_2 capture and storage technology, as a major objective will be to demonstrate the use of CO_2 capture technology with the EAGLE test bed. If successful, the accomplishment is expected to be a major breakthrough in solving the problem of global warming, and to contribute toward establishment of zero CO_2 emissions technology for thermal power stations. This technology is an important development theme also in Cool Earth 50, Japan's project for countering global warming. Much is riding on the successful outcome of Step II.

CO_2 Capture and Storage System

>>>Overview of the CO_2 Capture and Storage System

Gas processing rate	Approx. 1,000 Nm^3/h
Capture method	Chemical absorption
CO_2 capture capacity	Approx. 24 t/day
Captured CO_2 purity	At least 99%

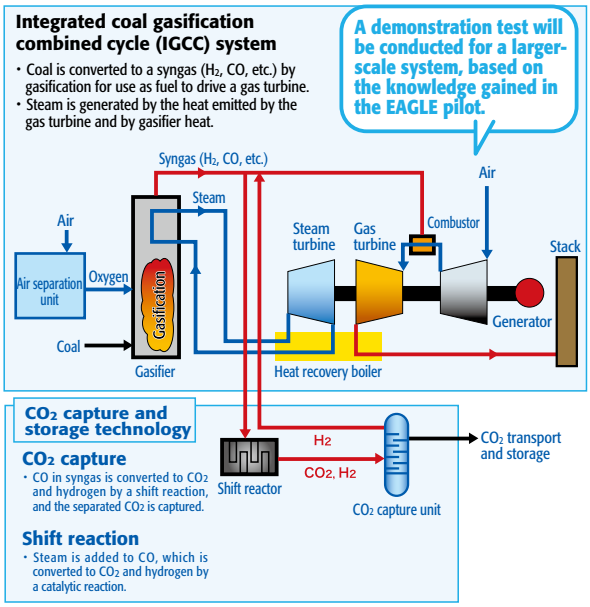
Large-Scale Demonstration of Oxygen-Blown Coal Gasification Technology (conducted jointly with Chugoku Electric Power Co., Inc.)

A large-scale demonstration test, reflecting the results of trials of oxygen-blown coal gasification and CO_2 capture and storage technologies, is expected to start in fiscal 2016 at the Chugoku Electric Power's Osaki Power Station.

The demonstration plant will be built with output in the 170 MW class (processing around 1,100 tons of coal per day). After verifying the reliability, economic efficiency, and operability as an electric power generation system based on oxygen-blown coal gasification, application of the latest CO_2 capture and storage technology will be tested, aimed at realizing revolutionary zero-emission high-efficiency thermal power generation from coal.

This demonstration is also being positioned as one of the projects for innovative zero-emission coal-based power generation of Japan's Ministry of Economy, Trade and Industry (METI), simultaneously meeting both the High-Efficiency Coal Fired Power Generation and CO_2 Capture and Storage (CCS) technological development goals of the METI Cool Earth Innovative Energy Technology Program.

>>>Overview of the Demonstration Test System (Oxygen-blown IGCC)



PERSON | **Establishing CO_2 Capture and Storage Technology** | **Susumu Kage** EAGLE Research & Engineering Group, Wakamatsu Research Institute, Technology Development Center

One of the undertakings in EAGLE Step II is to establish technology for capturing and storing CO_2 produced in the coal gasification process. The technology uses a catalytic reaction to convert CO in syngas to CO_2 and hydrogen (H_2), then separates and captures the CO_2 by means of a chemical absorbing solution. Since there are virtually no examples anywhere of applying this process to coal gas, we are now determining the basic performance of the catalyst and absorbing solution as well as obtaining data on equipment and operation characteristics.

A problem with CO_2 storage and recovery systems is their heavy use of steam and electricity, so that the addition of such equipment to a power generation system greatly reduces efficiency. We are therefore studying how to configure and operate the system so as to minimize this energy use, seen as a crucial step toward future CCS implementation.

Answer2

Nobuhiro Misawa Research Planning Group, Technology Development Center

We are testing CO_2 capture and storage (CCS) technology in a variety of ways.

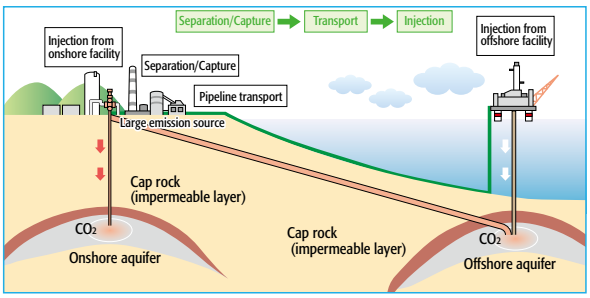
What Is CSS Technology?

One large-scale coal-fired power station with 1,000 MW output today produces around 5 or 6 million tons of CO_2 annually. An effective way to combat global warming would be to reduce the amount of CO_2 discharged from large-scale sources such as coal-fired power stations. Improving the coal use efficiency (thermal efficiency) of coal-fired stations could realize future reductions in CO_2 emissions of at most 30 percent from today's levels. If stronger global warming measures become necessary, however, even further CO_2 reductions are likely to be demanded. For this reason, the J-POWER Group is busy developing CCS technology that will make possible reductions of 90 percent or more in the amount of CO_2 released to the atmosphere by coal-fired power stations.

CCS technology separates and captures CO_2, transports it, and then sequesters it in stable storage deep underground (around 1000m). As such, it entails additional facility installation and energy use. Drawing on our extensive experience in operating and maintaining large numbers of power stations, we are carrying out technology development aimed at deriving a capture method optimally suited to use with power stations. Our researches are also seeking to understand the behavior of CO_2 when stored underground, taking advantage of experience with underground geological formations gained from geothermal power generation.

The CO_2 capture phase of CCS technology is now at the stage of pilot-scale testing. Its practical realization will require solutions to such issues as reducing the costs and energy use, as well as demonstrations using large-scale facilities.

CCS Concept



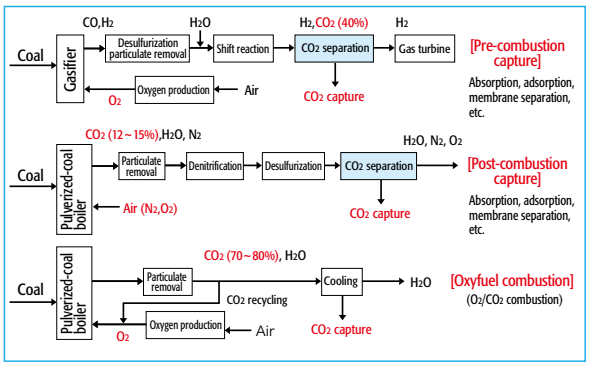
Source: Reference material for March 14, 2006 meeting, Global Environment Committee, Central Environment Council

CO_2 Capture from Coal-Fired Power Generation

There are three basic approaches to separating and capturing CO_2 from coal-fired thermal power generation: (1) pre-combustion capture, (2) post-combustion capture, and (3) oxyfuel combustion. Pre-combustion capture can be used in IGCC and IGFC plants that gasify coal, while post-combustion capture and oxyfuel combustion are suitable mainly for PCF power stations.

We are working on development of technology for all three types of CO_2 separation and capture, aware that PCF power stations, which burn coal to generate energy, are currently widespread, while combination systems using high-efficiency IGCC and IGFC generation with CCS offer great potential for the future.

Technologies for Capturing CO_2 from Coal-Fired Power Generation



Study of an Integrated System for CO_2 Capture and Storage: The Callide Oxyfuel Combustion Project

Oxyfuel combustion supplies the boiler with oxygen instead of air for combustion, with the aim of increasing the concentration of CO_2 in exhaust gas so that less energy is needed for CO_2 capture. The J-POWER Group is one of seven Japanese and Australian companies to take part in the Callide Oxyfuel Combustion Project, conducted at the Callide A power station (PCF, 30 MW) in Queensland with assistance from the Japanese and Australian governments. In order to carry out the world's first demonstration of an integrated system for CO_2 capture and storage applied to an existing power station, power station retrofitting is being implemented from fiscal 2008 to the first half of fiscal 2011, and test operation using oxygen combustion is scheduled to start in the latter half of fiscal 2011 (see also p. 36).