Challenge towards innovative Clean Coal

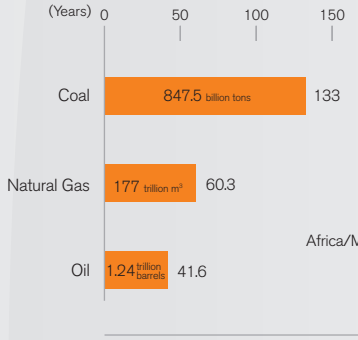
J-POWER is working to make coal resources a cleaner source of energy that can continue to be utilized more efficiently well into the future. To do this, we seek to achieve dramatic improvements in power generation efficiency and zero CO_2 emissions by tackling the challenges of technological innovation and proactively addressing the problem of global warming, all while linking these efforts to the development of new projects.

The Significance of Coal Usage Today and the Problem of Global Warming

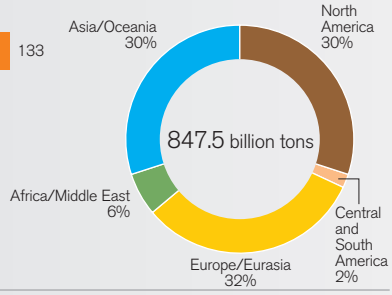
Reducing CO_2 from Coal-fired Thermal Power Generation as a Key to Countering Global Warming

Coal resources are in abundant supply and widely distributed around the world. Among fossil fuels, coal is the most economical and the most readily available resource. Coal is the main fuel source for electric power generation in a number of countries around the world. In fact, coal is the world's largest fuel supply source for electric power, responsible for nearly half of global electricity generation. In China, for example, coal-fired thermal power generation accounts for roughly 90% of total electricity generation, and just over 50% of electricity generation in the United States. Coal will be indispensable to meeting surging demand for energy widely expected going forward. On the other hand, coal-fired thermal power generation is responsible for roughly 30% of global CO_2 emissions. With China, India and other emerging countries projected to sharply increase their coal usage in the coming years, finding ways to reduce CO_2 emissions from coal-fired thermal power globally is becoming an issue of the highest priority.

Proved Reserves

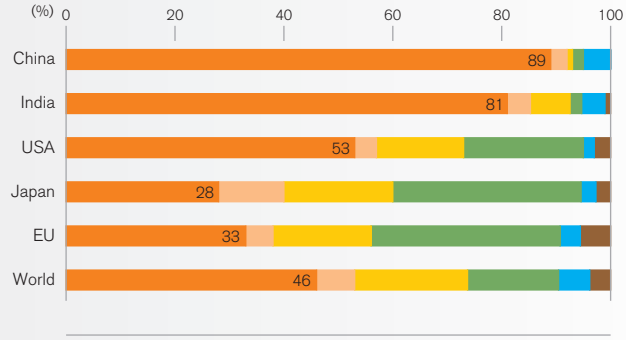


Proportion of Proved Coal Reserves by Region



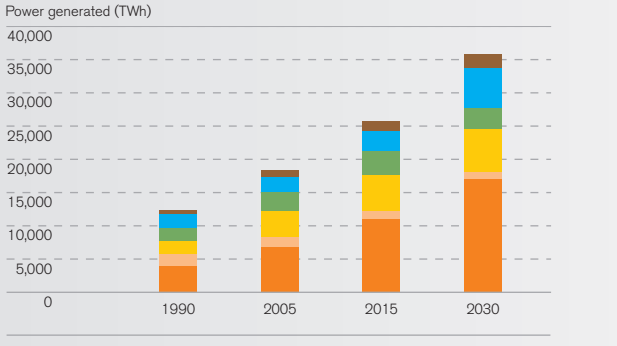
Source: BP Statistical Review of World Energy 2008

Electricity Generation by Fuel (2005)



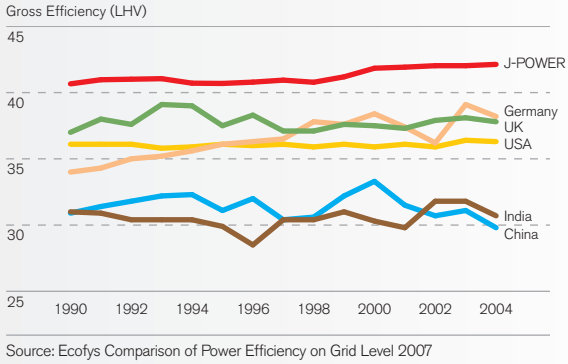
Source: IEA World Energy Outlook 2007

Global Electricity Generation and Outlook by Fuel



Source: IEA World Energy Outlook 2007

Trends of Thermal Efficiency in World's Coal-Fired Thermal Power Generation



Source: Ecofys Comparison of Power Efficiency on Grid Level 2007

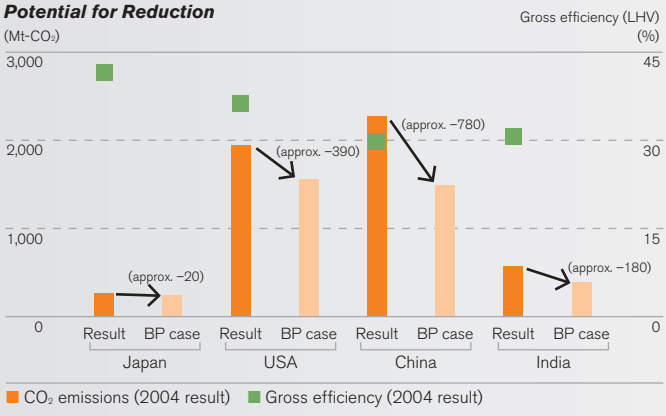
Technologies

1. Coal-Fired Thermal Power Generation by J-POWER
Realizing World-Leading Generating Efficiency and Environmental Performance

J-POWER and other coal-fired power producers in Japan are using a method of generation that raises the pressure and temperature of steam turbines extremely—to the Ultra Super Critical (USC) level. Compared to methods adopted by Europe and other Asian countries, our method attains a greater level of generating efficiency. In particular, as a top operator, we have attained the highest level of generating efficiency in Japan at the Isogo New No. 1 Thermal Power Plant. High-efficiency power generation in itself leads to reduced coal usage, and therefore lower CO_2 emissions. It is estimated that the introduction of Japan's world-leading coal-firing technologies to top CO_2 emitters—namely the United States, China, and India—would enable these countries to cumulatively reduce emissions by approximately 1.3 billion t-CO_2, an amount equivalent to Japan's total emissions and to 5% of global CO_2 emissions. The proliferation of these technologies, therefore, will contribute substantially to addressing global warming and represents an important business opportunity for J-POWER.

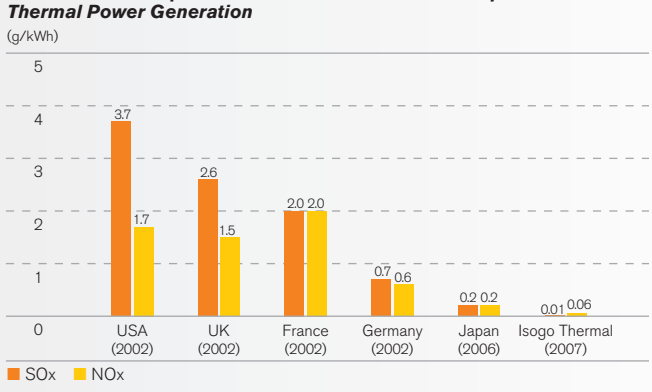
At our thermal power plants, we have enacted various countermeasures to reduce emissions of sulfur oxide (SOx), nitrogen oxide (NOx), dust and other pollutants in exhaust gas, in an effort to prevent air pollution. Thanks to the introduction of the latest environmental technologies, the Isogo No. 1 Thermal Power Plant has achieved relatively low SOx and NOx emissions on par with emissions at gas-fired thermal power plants. Viewing local environmental measures of this kind as another field in which J-POWER can leverage its technological capabilities, we intend to continue to develop business operations in this area.

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



BP case: Calculation assuming application of best practice (highest efficiency from commercial power plant) from Japan
LHV: Lower Heating Value standard
Source: IEA World Energy Outlook 2006, Ecofys Comparison of Power Efficiency on Grid Level

International Comparison of SOx and NOx Emissions per Volume of Thermal Power Generation



Source: The Federation of Electric Power Companies
* Figures for Japan include combined data from 10 EPCOs and J-POWER; figures for Isogo Thermal represent fiscal 2007 results.

Dry-type desulfurization system at Isogo New No. 2 Thermal Power Plant

Developing Operations Using a Dry-Type Flue Gas Desulfurization-Denitrification System (Regenerative Activated Coke Technology: ReACT)

The ReACT dry-type desulfurization–denitrification system continuously regenerates and recycles activated coke and removes such pollutants as SOx, NOx, and soot and dust from flue gas. In addition to using almost no water, another distinctive feature of the process is its high NOx removal capability even at low temperatures. The system is in operation at J-POWER's Takehara Thermal Power Plant Unit 2 and at its Isogo New No. 1 Thermal Power Plant.

J-POWER subsidiary J-POWER EnTech, Inc. provides ReACT engineering services. It has delivered ReACT systems to J-POWER's Isogo New No. 2 Thermal Power Plant and to the Wakayama Steel Works of Sumitomo Metal Industries, Ltd. Going forward, J-POWER EnTech aims to continue efforts to capture opportunities to deliver ReACT systems to power plants, steel plants and other entities both in Japan and abroad.

The activated coke used in the system is sourced from JM Activated Coke, Inc., a joint venture between J-POWER and Mitsui Mining Co., Ltd. that supplies coke to J-POWER and other consumers in and outside of Japan.

2. Realizing Next-Generation Coal-Fired Thermal Power Projects
Oxygen-Blown Coal Gasification as a Key Technology

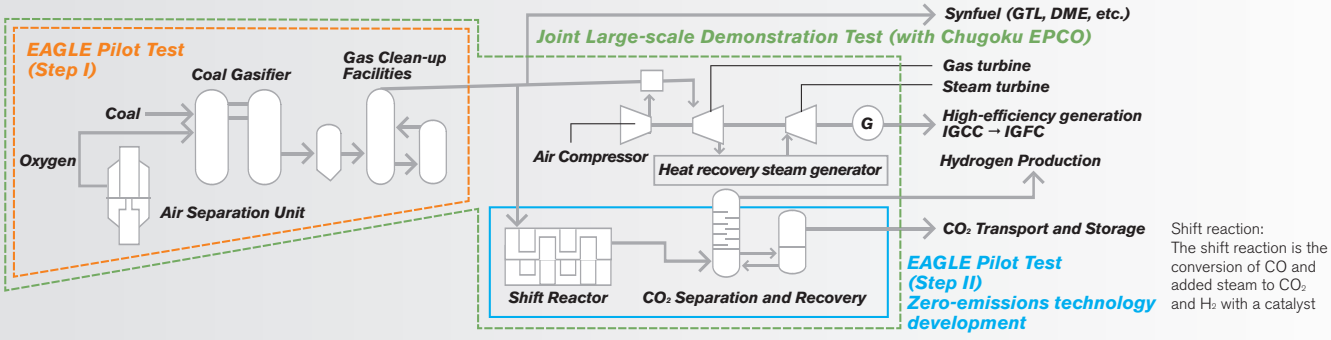
J-POWER aims to achieve the practical application of coal gasification power generating systems (IGCC and IGFC) built on oxygen-blown coal gasification, a technology widely anticipated to become vital to next-generation coal-fired thermal power generation. The establishment and application of Integrated Coal Gasification Combined Cycle (IGCC) and Integrated Coal Gasification Fuel Cell Combined Cycle (IGFC) technologies will lead to a substantial leap in generating efficiency, allowing significant reductions in CO_2 emissions.

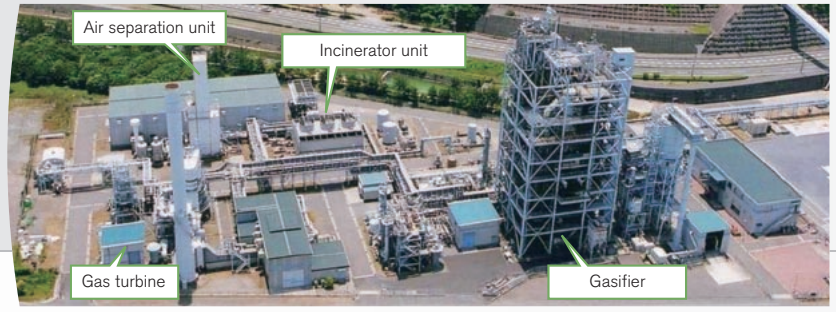
Based on such pioneering technologies, we will work to bring a variety of innovations to our business development. In the medium term, we will apply IGCC systems in constructing new thermal power plants and replacing existing thermal plants. Over the long term, we will enhance our capability to launch new projects based on IGFC technologies.

(1) EAGLE Project (Oxygen-Blown Coal Gasification Technologies) Accomplishments and Outlook

Coal Energy Application for Gas, Liquid & Electricity

Overview of R&D in Clean Coal Technologies at J-POWER





EAGLE pilot-scale testing facilities

CO_2 separation and recovery facility (under construction)

EAGLE—Step I Accomplishments (2002 to 2006)

J-POWER has conducted pilot tests of oxygen-blown coal gasification at its Wakamatsu Research Institute since 2002 with the aim of developing both a gasifier based on this technology and gas clean-up technology. By fiscal 2006, all objectives for the project had been achieved, including confirmation of high-efficiency coal gasification and gas refining performance, providing the necessary trial data that will enable us to enlarge the scale of applications.

In 2007, we successfully accomplished continuous test operation of over 1,000 hours, confirming a high level of facility reliability. This marked significant progress toward the next step of creating demonstration equipment for a coal gasification system centering on oxygen-blown coal gasification technology.

Towards EAGLE—Step II (2007 to 2009)

We are currently implementing testing under step II of the EAGLE Project. The first objective of step II is to develop CO_2 separation and capture technology. The potential for efficient separation and capture of CO_2, which is highly concentrated in coal gas following a shift reaction, is one of the advantages of applying the oxygen-blown method to coal gasification in the EAGLE Project.

The second objective is to expand the number of coal types suitable for gasification. Presently, coal with a low ash melting point, which is unsatisfactory for pulverized coal-firing technology, is well suited for gasification. Extending the scope of usable coal for gasification to include types currently utilized for pulverized coal-firing technology will ensure flexible coal procurement, thereby paving the way toward the development of viable demonstration and commercial facilities.

Features of EAGLE Gasification Technology

- ***High gasification efficiency: Can efficiently transfer the energy stored in coal into coal gas***
- ***Compatibility with multiple types of coal: Applicable even to coal varieties with higher ash melting points***
- ***Suitable for many applications: Oxygen-blown method makes the technology suitable for efficient CO_2 capture, as well as the production of synthetic fuels and hydrogen and other applications***

Overview of EAGLE—Step I Results

Development Objectives

- ***Develop a domestically produced oxygen-blown coal gasifier***
- ***Establish gas clean-up technology***

Results

- ***Achieved all development targets***
- ***Gained technologies for the operation and maintenance of coal gasification facilities***
- ***Confirmed facility reliability through long-term continuous operation***
- ***Identified the gasification qualities of five different coal types***
- ***Acquired data of scale-up gasifier for next stage of project***

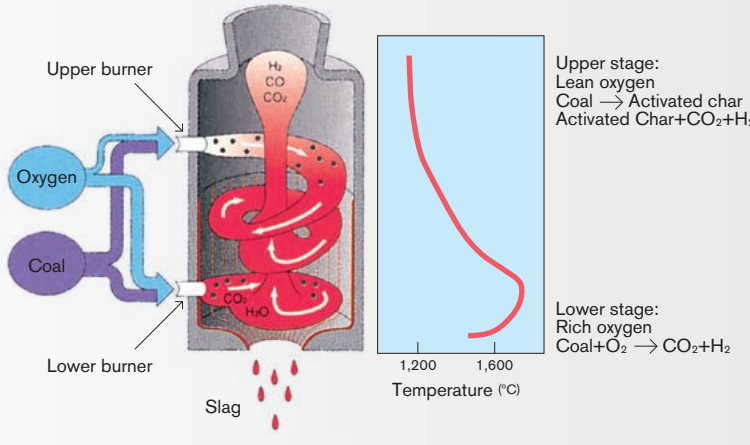
Item		Targets	Results
Carbon conversion rate*1		≧98%	≧99%
Cold gas efficiency*2		≧78%	≧82%
Calorific Value (HHV)		10,000 kJ/m³N	10,100 kJ/m³N
Continuous operation time		1,000 hours	1,015 hours
Adaptable coal types		5 varieties	5 varieties
In product gas	Sulfur	≦1ppm	<1ppm
	Halogens	≦1ppm	<1ppm
	Ammonia	≦1ppm	<1ppm
	Dust	≦1mg/m³N	<1mg/m³N

*1 Proportion of carbon in coal converted to gases such as CO, CO_2 and CH_4.
*2 Proportion of coal HHV converted to syngas HHV. Higher values correspond to higher conversion efficiency.

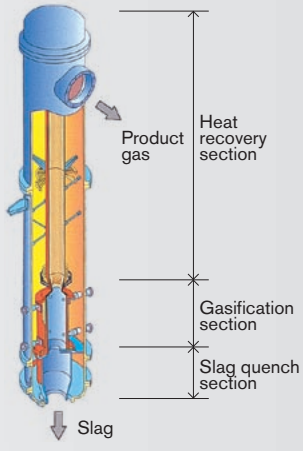
Overview of EAGLE—Step II

Development Objectives	Development Targets
Demonstration of CO_2 separation and capture technology	Raise purity of recovered CO_2 to 99% or higher
Test expansion of useable coal types	Acquire data on gasification characteristics of more than 3 additional coal types
Survey the behavior of trace elements	Understand the behavior of halogens and other trace elements
	Acquire basic environmental assessment data

Conceptual Flow in Gasifier



Structure of the Gasifier



(2) Joint Large-Scale Demonstration Test of Oxygen-Blown Coal Gasification Technology (with Chugoku EPCO): Towards Commercial Application of IGCC

Based on the success of the EAGLE Project, namely our accomplishment in terms of developing oxygen-blown gasification technology and experiments in CO_2 separation and recovery, we are currently implementing a large-scale demonstration test at the Osaki Power Plant (Hiroshima) of The Chugoku Electric Power Co., Inc. in collaboration with Chugoku Electric Power. We aim to commerce the test in fiscal 2016.

This test will involve the construction of a demonstration plant with an output on the scale of 150 MW (coal processing volume of approx. 1,000 tons/day), and will investigate the reliability, economic efficiency, operational properties and other features of power generation based on oxygen-blown coal gasification. We also intend to continue to perform trials for the application of cutting-edge CO_2 separation and recovery technology, in a bid to realize innovative, zero-emissions, high-efficiency coal-fired thermal power generation by combining this technology with Integrated Coal Gasification Combined Cycle (IGCC) technology.

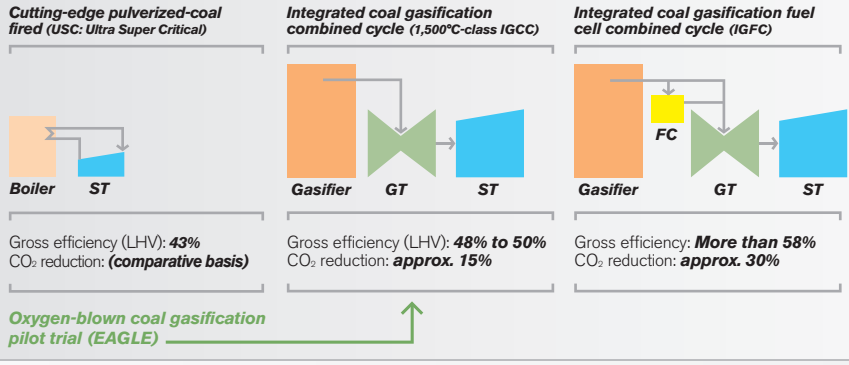
Cool Earth-Energy Innovative Technology Plan

The development of truly innovative technologies, not simply extensions of conventional ones, will be necessary to significantly reduce carbon dioxide levels. Recognizing this, the Japanese government has formulated the Cool Earth-Energy Innovative Technology Plan, which it is now promoting worldwide. The demonstration test involves the development of both "highly efficient coal-fired thermal power generation technology" and "carbon dioxide capture and storage (CCS) technology." Therefore, it is one of the technologies in the plan which is an "innovative, zero-emissions, coal-fired thermal power generation project."

(3) Integrated Coal Gasification Fuel Cell Combined-Cycle (IGFC) Power Generation: The Ultimate in High-Efficiency Power Generation Technology

One of J-POWER's long-term objectives is the realization of Integrated Coal Gasification Fuel Cell Combined Cycle (IGFC) power generation. To this end, we are pursuing R&D in Solid Oxide Fuel Cell (SOFC) technology at our Chigasaki Research Institute, where we are currently testing an atmospheric pressure (150 kW-class) SOFC cogeneration system with the world's largest output capacity. J-POWER has been a pioneer in the development of IGFC technology. From this leading position, we have raised power generating efficiency to around 60% and cut CO_2 emissions by roughly 30% relative to existing pulverized coal-firing technology, resulting in the development of what may be the ultimate coal-fired power technology.

Coal-fired Power Technology for the Next Generation



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

Ultra Super Critical (USC)
USC technology raises the steam pressure and temperature of steam turbines above that of conventional supercritical steam turbines (pressure: 246 kg/cm^2; temperature: 566°C) in order to enhance the efficiency of thermal power plants.

Integrated Coal Gasification Combined Cycle (IGCC) and Integrated Coal Gasification Fuel Cell Combined Cycle (IGFC)
Both technologies are built on coal gasification and offer substantially improved power generating efficiency relative to pulverized-coal fired thermal power. Whereas pulverized-coal fired thermal power utilizes steam turbines only, IGCC power generation is configured around both gas and steam turbines. IGFC power generation adds another element, fuel cells, for a triply integrated power generation configuration.

Solid Oxide Fuel Cell (SOFC)

Atmospheric pressure SOFC cogeneration system (150 kW-class) (Chigasaki Research Institute)

Generating electricity from fuel cells differs from traditional systems that convert heat from the combustion of fuels into electricity, because it transforms chemical energy directly into electrical energy, thus lowering energy losses and delivering high efficiency. The SOFC being developed by J-POWER is made of ion electroconductive ceramics. As they produce heat of between 900°C and 1,000°C during electrochemical reactions, SOFCs provide better generating efficiency than other fuel cells when integrated in combined cycle systems.

3. Carbon Dioxide Capture and Storage (CCS) Technology
Working to Achieve Zero Emissions of CO_2

At present, surveys and plans to conduct trials around CCS, whereby CO_2 from large-scale emission sources is separated and recovered for capture and permanent storage underground or in the ocean, are moving forward most notably in Japan and Europe. Of the three distinct elements comprising CCS—separation and capture, transport and storage—J-POWER has focused most intently on the development of CO_2 separation and capture technologies. This decision reflects our view that aligning "separation and capture" functions with power plant design is the most desirable option, as well as our recognition that CO_2 separation and capture is the most cost-intensive aspect of the entire CCS process.

As part of EAGLE—Step II, J-POWER is conducting pilot testing of CO_2 separation and recovery technology for gases derived from oxygen-blown coal gasification, considered the most promising future technology in this area particularly in terms of efficiency. In parallel, we are actively working to develop similar technologies for combustion exhaust from pulverized-coal fired (PCF) thermal power, currently the most common method of power generation from coal.

CO_2 Separation and Capture at PCF Plants

Facility for demonstrating CO_2 separation and recovery at the Matsushima Thermal Plant, Unit 2

Callide Power Station (Australia)

PCF is currently the most widely used method of power generation in systems fueled by coal, and the separation and capture of CO_2 from combustion exhaust is likely to become common in the future.

At J-POWER's Matsushima Thermal Power Plant, the Group is conducting pilot trials (from 2007 to 2008) in collaboration with Mitsubishi Heavy Industries, Ltd. regarding the chemical absorption method. J-POWER will also take part in a joint demonstration project between Japan and Australia scheduled to take place at the Callide Power Station in Queensland, Australia (from 2010 to 2014), to test an integrated system for the separation, recovery and underground storage of carbon dioxide.

As a leading company in coal-fired thermal power, J-POWER is pursuing these innovative clean coal technologies to convert the challenges posed by global warming into business opportunities.