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Project Status of 250MW Air-blown IGCC Demonstration Plant

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1. Abstract

Clean Coal Power R&D Co. Ltd. (CCP) has been established on June 15, 2001 by the nine regional utility companies of Japan, EPDC (Electric Power Development Company) and CRIEPI (Central Research Institute of Electric Power Industry) (hereafter called as '11 corporations') to conduct the 250MW Air-blown IGCC Demonstration Project. Plant construction will start in 2004 followed by operation tests through 2009. This report presents status of the project and outline of the demonstration plant.

2. Introduction

The primary energy sources for power generation in Japan are, hydroelectric power (20% : including pump-up storage), thermal power (natural gas fired—27%, oil-fired—22%, coal-fired—11%, and geothermal) and nuclear power (20%) as of 1999. The percentage of coal is relatively low, however, it is important for Japan to continue the introduction of coal fired power generation that could use the abundant and economical fuel — coal. As the nature of coal, conventional coal-fired power generation has disadvantage from the emission of carbon dioxide in comparison with that of natural gas-fired and oil-fired power generation. Hence, next generation coal-fired power plants must have the feature of high efficiency and environmental friendliness. Thermal efficiency of conventional coal-fired power plants in Japan have already reached over 42% (net, LHV basis) adopting the ultra supercritical steam conditions, but little further improvement can be expected as far as conventional steam cycle technology is used.

In such circumstances, Integrated Gasification Combined Cycle (IGCC) is considered to play the most important role as the future coal-based power generation technologies due to its high efficiency and environmental compliance. Ministry of Economy, Trade and Industry (METI, formerly 'MITI') and 11 corporations agreed on the necessity of developing coal-fueled IGCC, and 11 corporations have jointly launched IGCC demonstration project.

This project includes plant design, construction and operation. Environmental Impact Assessment (EIA) is decided necessary prior to the beginning of construction just like a commercial plant because of its relatively large unit capacity – 250MW.

3. Establishment of Clean Coal Power R&D

CCP was established on June 15th, 2001. Its role is to conduct the project successfully, that is, in another words, to certify that IGCC is applicable for Japanese commercial power generation use. During the demonstration period CCP is basically non-profitable organization, but obtains patents and accumulates know-how for the future use.

Ten companies are shareholders of CCP and METI doesn't have any share.

CCP has initially 23 employees, most of which are engineers from 11 corporations. The number of engineers will grow up phase by phase and will be its maximum when the plant is under construction.

CCP is located in central Tokyo at present, for the convenience in access to government offices and major companies. Site selection has been our first task. Recently, Nakoso, approximately 200 kilometers north of Tokyo, was chosen for the site and we are now approaching the local government for starting EIA. Approximately a year before the plant construction CCP will be relocated close to the site.

4. Scheme of the Project

Since this is a national project, METI provides CCP with 30% of the project costs as subsidy except for EIA. CCP and 11 corporations made an agreement on the demonstration project, on which CCP should conduct the project while 11 corporations should fund CCP with the project costs other than the governmental subsidy. Figure.1 shows the project scheme.

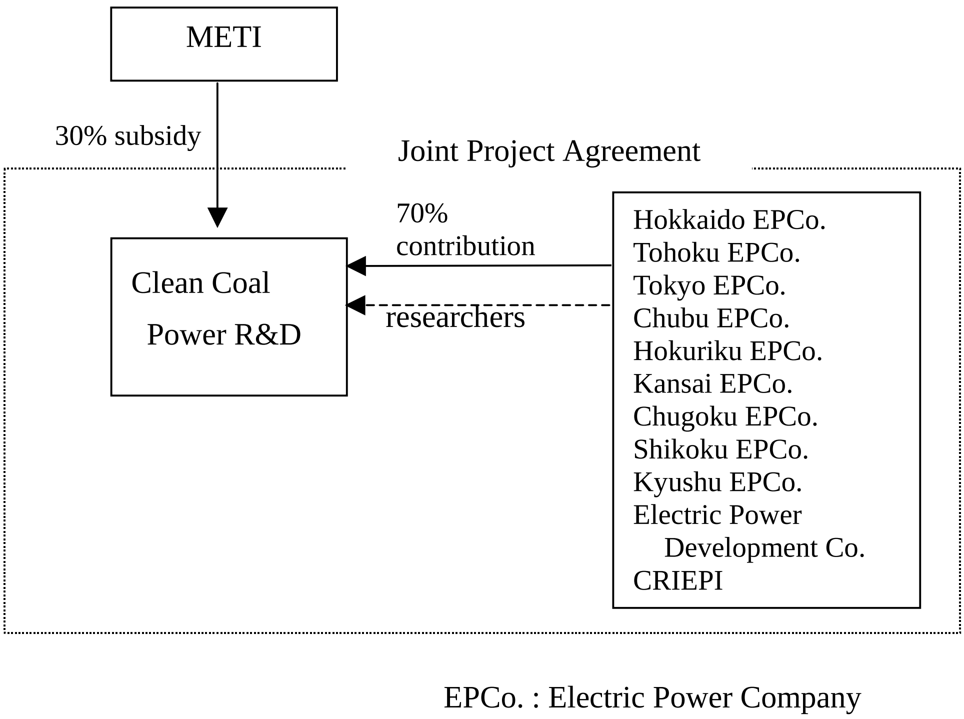

Fig. 1 : Project Scheme

5. Schedule of the project

The project starts in fiscal year 2001 and concludes in 2009. The 9 year project consists of three major phases of period, design, construction and operation test. As each phase takes 3 years, plant construction and operation tests begin in 2004 and around 2007, respectively.

New EIA regulation requires at least three years to finish the EIA, and this is the major reason for start of construction in 2004.

Table 1: Schedule of IGCC Demonstration Plant Project

Fiscal year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Demonstration plant tests	Design of plant			Construction of plant			Operation tests		
Environmental Impact Assessment									

6. Requirements for Japan’s commercial IGCC

Japan, a resource-poor country, is obliged to depend on overseas coals. Moreover, Japan had serious issue of air pollution in the 1960s in the concentrated industrial area. Therefore, we have made a special effort for energy saving and environmental protection. That is the reason why we attempt to develop an original IGCC to meet these historical requirements.

a. High efficiency target

As mentioned before, Japan has a historical policy to introduce high efficiency plants as possible, and conventional coal-fired power plants in Japan have already achieved over 42% (net, LHV basis). It is our common view that commercial IGCCs should have much higher efficiency as possible, especially in consideration of CO_2 decrease.

b. Coal flexibility

Flexibility in coal selection is an important factor to plan coal fired plants in Japan. Since Japan imports coal from all over the world, coal fired plants in Japan have to be designed flexible to a variety of coals. IGCC is expected to be suitable for the coals, which have been unacceptable for conventional coal-fired boilers because of their low ash fusion temperature, etc. This could extend our source of coal and would be a great benefit of IGCC.

c. High reliability of gasifier and gas cleanup

IGCC plants in Europe and the United States usually have natural gas pipelines which could backup power generation in case of gasifier- or gas cleanup outages. That is quite different in Japan. Little natural gas pipeline network is available in Japan except large metropolitan area and presently no coal fired plants have natural gas pipelines nearby.

Therefore, high reliability IGCC is strongly required.

d. High environmental characteristics

Emission regulation for power plants is very stringent in Japan. SOx, NOx, and dust emission from Japanese coal fired plants are regulated in quite low level . IGCC in Japan also should match these environmental standards.

As well as the flue gas emission, waste water and solid are also stringently regulated. Generally, coal ash is discharged in the figure of slag, which occupies half the volume of fly ash from conventional coal-fired plant and causes no leaching of trace element. This is one of the major benefits of IGCC for us because shortage of disposal area is now a serious issue in Japan. However, this will be sacrificed if the carbon conversion from coal to gas is low. High carbon conversion also eliminates complicated waste water treatment and loss of energy.

7. Outline of Demonstration Plant

7.1 Summary

The demonstration plant is the integration of an air-blown gasifier, cold gas cleanup (CGCU) and gas turbine combined cycle. Essentially, the system integrating air-blown, dry-fed gasifier and hot gas cleanup (HGCU) would achieve higher performance than any other options and would be the ultimate feature of IGCC. This HGCU system was once verified to be successful in the Pilot Plant Project (1986-96). However, HGCU is not commercially matured, conventional CGCU will be used in this project.

Power output is rated at 250MW, which was determined considering the scaling up for the commercial plant in the next stage, project costs, and appropriate lineup of gas turbine models. The gasifier consumes approximately 1700 t/day of coal based on design coal and at rated point. We plan to use a gas turbine having around 1200degC-TIT (Turbine Inlet Temperature). Target net efficiency is 42% (LHV basis), which is as high as that of the latest conventional coal-fired units of 700-1000MW class. At the commercial stage, using gas turbines with 1500degC-TIT, we estimate the power output will be 500-600MW and its net efficiency will be over 48% (LHV basis).

Table 2 shows the basic feature, Fig. 1 shows the conceptional drawing and Fig. 2 shows the block flow diagram of the IGCC demonstration plant.

Table 2: Major Specifications of IGCC Demonstration Plant

Capacity	Rated power output	・250 MW(1700ton/day)
Targets of thermal efficiency (LHV basis)	Gross efficiency	・48%
	Net efficiency	・42%
Plant System	Gasifier	・ air-blown, entrained flow gasifier ・dry coal feed
	Gas clean-up	・amine absorption ・ limestone-gypsum method for sulfur recovery
	Gas turbine	・1200degC- class TIT
Flue gas Emission Target	SOx	・8 ppm
	NOx	・5 ppm
	Dust	・4 mg/m^3_N

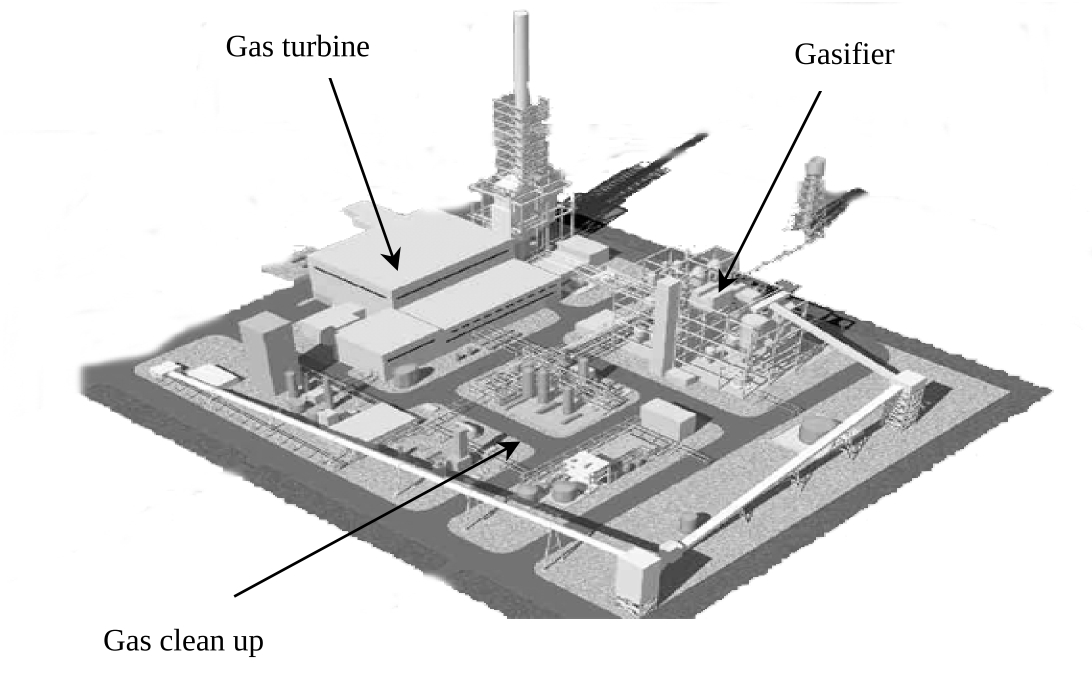

Fig.2: Conceptual Drawing of IGCC Demonstration Plant

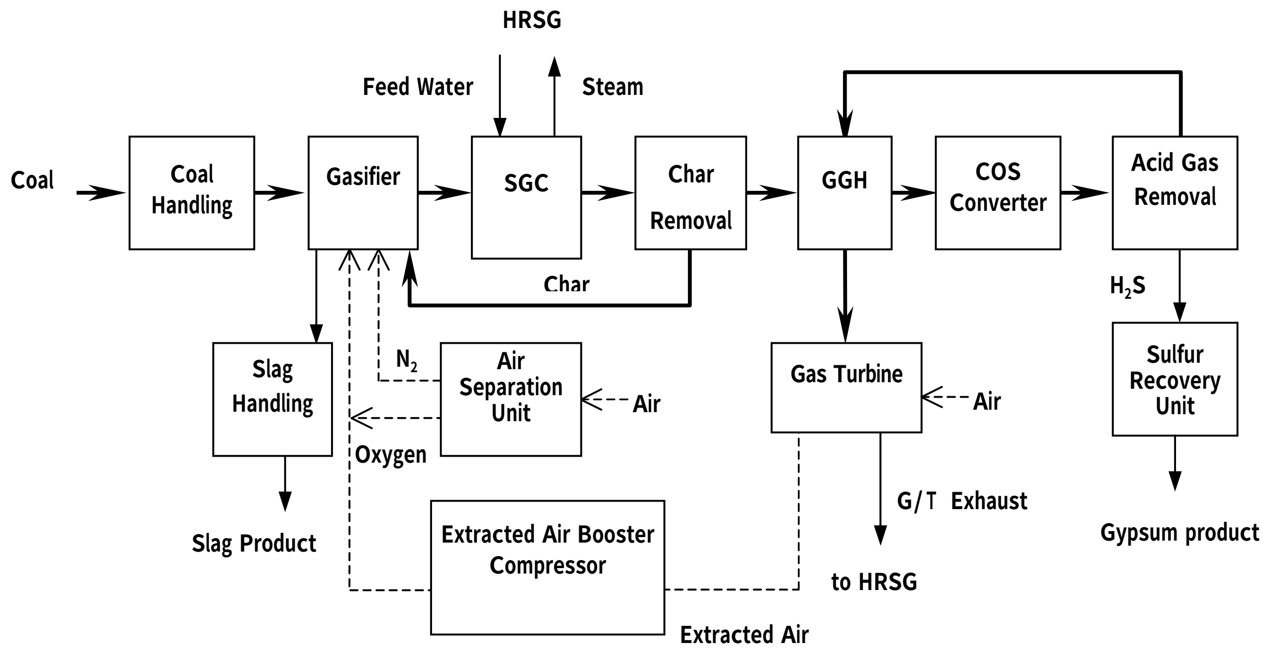

Fig. 3 :IGCC Demonstration Plant Block Flow Diagram

7.2 System characteristics

Unique features, other than use of air-blown gasifier, are as follows:

The system integration is similar to so-called ‘partial integration’ for the oxygen-blown system, that is, oxidizer for the gasifier is partially extracted from the gas turbine compressor and the other part of air is from auxiliary compressor. Air-blown IGCC also has an air separation unit (ASU) and the ASU has its own compressor. However, ASU for air-blown IGCC has the minimum capacity to produce process nitrogen and is quite smaller than those for oxygen blown ones. By-produced oxygen (no need to be so pure) is recovered and used to enrich the oxidizer, that makes the gasifier operation stable. This ‘independent’ ASU design enables to swing the plant load easily, because ASU can be in constant operation regardless of the plant load. It also makes up the drop of net power output even at the high ambient temperature.

In order to meet the stringent NOx emission target, SCR (Selective Catalytic Reducer) is installed in the HRSG (Heat Recovery Steam Generator) to ensure low NOx.

Sulfur will be recovered in the form of gypsum. It is widely used for building materials in Japan and more easily recycled than elemental sulfur. Gypsum from IGCC has higher quality than that from FGDs (Flue Gas Desulfurizer) of conventional plants. This option reduces both SOx and waste solid emission. In order for gypsum recovery, an H_2S furnace and a high performance limestone-gypsum absorber will be installed.

8 Air-blown Entrained Flow IGCC

8.1 Air-blown, entrained flow gasifier

The air-blown, entrained flow gasifier is the key technology of air-blown IGCC. Entrained flow was adopted to have high efficiency and high capacity.

Air-blown IGCC principally aims at reducing the auxiliary power consumed at the ASU and the initial cost of it. Two-stage configuration was introduced to enable smooth molten slag discharge and high carbon conversion at the same time. (Fig.4) That is;

Combustor : the lower chamber, where coal, recycled char and air are fed in, under relatively high air/coal ratio. The temperature inside of it is kept very high and coal ash can be easily separated from the gas as molten slag. Molten slag flows down at the bottom while the gas flows upward into Reductor section in high temperature. The air to the combustor is somewhat enriched with recovered oxygen from ASU to ensure operation flexibility of gasification and sufficient margin of calorific value of syngas to gas turbine combustor.

Reductor : the upper path, where hot gas flows up from the combustor and additional coal is fed into the hot gas stream. In this section gasification takes place by endothermic reaction, for which the hot gas stream from the combustor provides sufficient heat. Volatile matter turns out from the coal, and remaining char also turns into combustible gas. At the top of the reductor the hot gas has been sufficiently cooled down to avoid troubles in the convective heat exchangers. Solid particle containing char is dry and hardly sticky, and plugging or fouling of heating surfaces are minimized to occur.

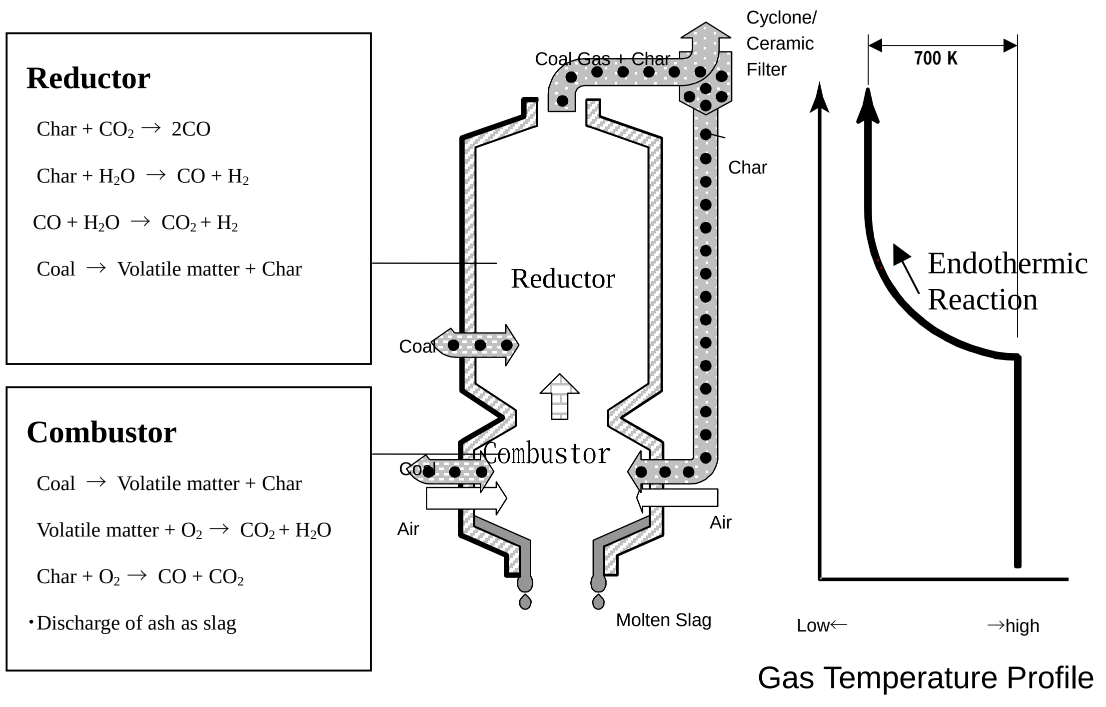

Fig. 4 Concept of two-stage Gasifier

The syngas from the reductor still contains certain amount of char, which is trapped at the cyclones and the ceramic filter units and recycled to the combustor, and turns into either syngas or char.

Thus, carbon conversion of this system from coal to syngas is always over 99.8% while the heat value of the syngas remains high enough required for stable gas turbine combustion, though it contains much nitrogen. As for the slag from the gasifier bottom, no leaching of carbon or trace element has been found. Any other materials, such as flyash or carbon-mixed water, are never discharged.

The original concept was of CRIEPI and Mitsubishi Heavy Industries, Ltd., and they jointly carried out a 2t/d PDU test in 1980's. This system was employed in the Pilot Plant and scaled up to 200t/d. The pilot plant gasifier marked total 4770 hour runs including 789 hour continuous operation in 1995. Reflecting the operating experiences at the pilot plant , various design changes were made in many area of the gasifier. In order to confirm these design changes, 24t/d confirmation test plant was constructed and over 700 hours of test runs were carried out.

Table. 3 shows the results of gasification tests at the pilot plant and 24t/d test plant.

Table. 3 Typical results of gasification tests

Coal	Carbon Conversion Rate(%)	Heat Value of Syngas (MJ/m^3_N)	Gasifier
A (Australia)	99.8	4.9	200t/d P.P.
B (China)	99.9	4.8	24t/d T.P.
C (USA)	99.9	5.1	24t/d T.P.

(note) P.P. : Pilot Plant　　T.P. Test Plant

8.2. History of Air-blown IGCC Development

We will introduce the history of air-blown IGCC.

It has its origin in the Pilot Plant Project starting in 1986. This program was also a joint R&D by 11 corporations (ten utilities and CRIEPI). They established an organization named 'Engineering Research Association for Integrated coal Gasification Combined Cycle Systems' (IGCRA) in FY 1986 to conduct the project. The government funded 90% of the project cost through the New Energy and Industrial Technology Development Organization (NEDO).

The pilot plant had a capacity of 200 t/d, located in Nakoso, approximately 200 kilometers north of Tokyo and exactly the same site where the demonstration plant will be constructed. It was an integration of air-blown, dry-fed gasifier, HGCU, and a 12.5 MW gas turbine. No steam turbines were installed for economic reason. Full integration was employed where oxidizing air for the gasifier is completely the extraction air from the gas turbine.

Toward the end of operation test, 1995, it was confirmed that the air-blown system functioned well enough as a power system, and each components remained quite stable even if the load changed as quick as 10% per minute. Environmental target, oil-fired plant equivalent at the time, was also achieved. Accomplishing their task, IGCRA was dismissed at the end of FY1996.

In order to commercialize the air-blown IGCC technology, it was decided to conduct demonstration test using the plant with semi-commercial capacity to verify reliability, operability, maintainability, safety and economics.

In 1997, 11 corporations carried out feasibility study on the IGCC demonstration plant based on the pilot plant project results. As the result of this study, gas cleanup system had to be changed from HGCU into conventional CGCU to satisfy stringent emission levels within the limited timeframe. Regardless of the efficiency decrease by changing from HGCU to , it turned out that net efficiency 45% (LHV basis) would be still achievable by applying ‘F’ class gas turbine having 1300degC-TIT. With ‘G’ class gas turbines, 1500degC-TIT, over 48% (LHV basis) is expected even with the CGCU system.

FY1999-2000 was the period preparing for the demonstration project, discussing everything including plant scale, budget, organization etc. while trial design studies and preparatory verification tests including the 24t/d test plant were conducted to improve the reliability and durability of the demonstration plant.

9. Conclusion

Aiming at strong progress in ‘Clean Coal Power’, Japanese IGCC Demonstration Project has just started. Newly-founded CCP is responsible for the entire project, design, construction and operation of this 250MW, Air-blown IGCC Demonstration Plant, so that Japanese utilities can construct commercial IGCC plants in 2010’s, which are reliable and have high efficiency, satisfying energy security, economy, and environmental protection.