Dissemination of Advanced Technologies for Fossil Fuel Power Generation, in response to 3E+S

Clean Coal Day 2017
Day2, Keynote 3rd

6th Sep., 2017
Toshihiro Bannai
Director General Environment Department

New Energy Development and Industry Development Organization
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2. Importance of the thermal power plant for the 2030’s electricity power supply in the world and Japan
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1. Outline of NEDO
Outline of NEDO (1/3)

- **NEDO**, an independent administrative agency under METI, promotes R&D as well as the dissemination of industrial, energy and environmental technologies.

### Japanese Government, Ministry of Economy, Trade and Industry (METI)

- Budget
- Coordination with policymaking authorities

### NEDO

- **Budget**: Approx. 1.27 billion US$ (FY2017)
- **Number of personnel**: Approx. 900

### Coordination with Actors

- **Academia**
- **Industry**
- **Public research laboratories**

### Mission

- Solving global energy and environmental problems
Outline of NEDO (2/3)

Technology Seed Development Activities

National Projects (mid- to long-term high risk R&D)

Kyoto Mechanisms

Practical Applications

Research and Development
- Renewables and Energy Efficiency
- Information and Telecommunications
- Life Science
- Nanotechnology and Materials
- New Manufacturing Technology
- Environment Technology

Demonstration
- Renewables and Energy Efficiency
- Environment Technology
- Medical Systems
Outline of NEDO (3/3)

National Projects (1.17 billion US dollars)

Energy and Environmental Field
- New Energy (380.9 million US dollars)
- Energy Conservation (91.8 million US dollars)
- Rechargeable Batteries and Energy System (30 million US dollars)
- Clean Coal Technology (139.1 million US dollars)
- Environment and Resource Conservation (23.6 million US dollars)

Industrial Field
- Electronics, Information, and Telecommunications (111.8 million US dollars)
- Materials and Nanotechnology (113.8 million US dollars)
- Robot Technology (99.1 million US dollars)
- New manufacturing technology (29.1 million US dollars)
- Crossover and Peripheral Field (0.9 million US dollars)

Support for International Expansion (150.9 million US dollars)

Public Solicitation for Proposal Activities (38.2 million US dollars)

Total Budget for 2017FY (1.27 billion US dollars)

- As only an outline of NEDO’s activities is shown above, individual budget amounts do not equal the total.
- Budget amounts are calculated at a rate of 110 yen per US dollar.
NEDO’s lineup of Clean Coal Technology

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Technology for using Coal cleaner
= Clean Coal Technology (CCT)

CCT

Processing, Reforming, Converting

Utilization

Environmental Countermeasures (Global Warming)

Multi-purpose coal utilization technologies

Technologies for high efficiency applications

Carbon countermeasure technologies

Flue gas treatment and gas cleaning technologies

Technologies to effectively use coal ash / slag

Gasification and hydrogenation technology

Combustion Technologies

Gasification and hydrogenation technology

Combustion Technologies

Gasification and hydrogenation technology

Combustion Technologies

TIGAR

IGFC

A-USC

CCUS

CO₂ Capture

De-SOₓ

De-NOₓ

Dust Removal

Environmental Countermeasures

Commercialized
Under development
Developed

EAGLE

Biomass Co-combustion

IGCC

USC

Ash/Slag in cement
2. Importance of the thermal power plant for the 2030’s electricity power supply in the world and Japan
Outlook of Electric Power Supply in the World

Source: IEA World Energy Outlook 2015 (New policies Scenario)
The outlook of electricity power supply and demand from coal and gas source

① Coal Power Plant
Future outlook of the demand of coal power plant is projected to decrease in OECD countries, but it projected to increase in emerging countries located around the Asia and Oceania reason, due to economic growth.

② Gas Power Plant
Future outlook of the demand of Gas power plant is projected to increase all over the world, especially it is projected to expand in East Asia, Africa, Europe and America, because there are many gas-producing countries in those areas.
Japan’s latest policy for New Energy Mix

New Energy and Industrial Technology Development Organization

【Target Level】
- Electricity Demand in 2030 will be consistent with the level of 2013 with energy conservation.
- The dependency of nuclear power generation, which was around 30% share in 2010, will reduce to 20～22% in 2030.
- The dependency of renewable energy such as solar and wind will rise from 22% to 24%, and the one of coal will reduce from 30% to 26%.

Electricity Demand
- Electricity Demand in 2013: 967TWh
  - GDP growth: 1.7%/year
  - Energy conservation: 196TWh (▲17%)
  - Energy Conservation + Renewable Energy = about 40%

(Total Electricity generation)
- 2010: 1,064TWh
- 2013: 939TWh
- 2030 (Fiscal Year): 1,065TWh

Electricity generation
- Renewable Energy: 11% (2030)
- Nuclear: 1% (2030)
- LNG: 43% (2030)
- Coal: 30% (2030)
- Oil: 6% (2030)

(Fiscal Year)
3. Advanced Technology for Fossil Fuel Power Plant
High Efficient power generation technologies roadmap

- **Gas Turbine Fuel Cell Combined Cycle (GTFC)**
  - Efficiency: 63%
  - CO₂ emissions: 280 g/kWh
  - Target: Around 2025

- **Ultra-high Temperature Gas Turbine Combined Cycle**
  - Efficiency: 57%
  - CO₂ emissions: 310 g/kWh
  - Target: Around 2020

- **Advanced Humid Air Gas (AHAT)**
  - Efficiency: 51%
  - CO₂ emissions: 350 g/kWh
  - Target: Around 2017

- **Advanced Ultra Super Critical (A-USC)**
  - Efficiency: 46%
  - CO₂ emissions: 710 g/kWh
  - Target: Around 2016

- **Integrated Coal Gasification Fuel Cell Combined Cycle (IGFC)**
  - Efficiency: 55%
  - CO₂ emissions: 590 g/kWh
  - Target: Around 2025

- **LNG thermal power**
  - Reduction of CO₂ by 20%

- **Coal-fired thermal power**
  - Reduction of CO₂ by 30%

**Power generation efficiency**

- **65%**
- **60%**
- **55%**
- **50%**
- **45%**
- **40%**

**Present**

**Around 2020**

**2030**

*The prospect of power generation efficiencies and discharge rates in the above Figure were estimated based on various assumptions at this moment.*

Even most efficient coal fired thermal power generation discharge about 2 times CO2 compared to LNG-Fired.

Coal fired thermal power generation needs Improvement of the efficiency.

---Comparison of CO2 emission from power generation---

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>CO2 Emissions [g-CO2/kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (Japan)</td>
<td>695</td>
</tr>
<tr>
<td>LNG (Steam)</td>
<td>476</td>
</tr>
<tr>
<td>LNG (GT)</td>
<td>375</td>
</tr>
<tr>
<td>World Ave (coal)</td>
<td>958</td>
</tr>
<tr>
<td>Coal Fired (Japan)</td>
<td>864</td>
</tr>
<tr>
<td>USC</td>
<td>806</td>
</tr>
<tr>
<td>IGCC</td>
<td>660 (target)</td>
</tr>
</tbody>
</table>

# A list of power generating technologies

<table>
<thead>
<tr>
<th>Power-generating technology</th>
<th>Outline and characteristics of technology</th>
<th>Technological establishment (Year)</th>
<th>Transmission end efficiency (% HHV)</th>
<th>CO₂ discharge rate (G-CO₂/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>① USC</strong></td>
<td>- high temperature and pressure steam generated by a boiler.</td>
<td>1995 -</td>
<td>40</td>
<td>820</td>
</tr>
<tr>
<td></td>
<td>- Long experience &amp; reliability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>② A-USC</strong></td>
<td>- higher temperature and pressure steam turbine than USC.</td>
<td>2016</td>
<td>46</td>
<td>710</td>
</tr>
<tr>
<td></td>
<td>- Advanced type of USC with heat resistant materials.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>③ AHAT</strong></td>
<td>- A single gas turbine power generation using humid air.</td>
<td>2017</td>
<td>51</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>- suitable for medium and small turbines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>④ GTCC</strong> (1700 deg. C class)</td>
<td>- combined cycle power generation technology using a gas turbine and a steam turbine.</td>
<td>2020</td>
<td>57</td>
<td>310</td>
</tr>
<tr>
<td><strong>⑤ IGCC</strong> (1700 deg. C class)</td>
<td>- A combined cycle power generation technology through coal gasification and combination of a gas turbine with a steam turbine.</td>
<td>2020</td>
<td>46 - 50</td>
<td>650</td>
</tr>
<tr>
<td><strong>⑥ GTFC</strong></td>
<td>- A triple combined power generation technology combining GTCC with fuel cells.</td>
<td>2025</td>
<td>63</td>
<td>280</td>
</tr>
<tr>
<td><strong>⑦ IGFC</strong></td>
<td>- This is a triple combined power generation technology combining IGCC with fuel cells.</td>
<td>2025</td>
<td>55</td>
<td>590</td>
</tr>
<tr>
<td><strong>⑧ Innovative IGCC</strong> (Steam entrained bed gasification)</td>
<td>- adds steam to gasification furnace on the IGCC system.</td>
<td>2020</td>
<td>57</td>
<td>570</td>
</tr>
<tr>
<td></td>
<td>- reduces oxygen ratio and increases cold gas efficiency.</td>
<td>Steam gasification + dry refinement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2030 Highly-efficient oxygen separation</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td><strong>⑨ Closed IGCC</strong> (CO₂-capturing next-generation IGCC)</td>
<td>- circulates CO₂ contained in exhaust gas as an oxidant throughout a gasification furnace or gas turbine.</td>
<td>2030 or later</td>
<td>42 After CO₂ capture</td>
<td>-</td>
</tr>
</tbody>
</table>
## History of development for IGCC and IGFC in Japan

**New Energy and Industrial Technology Development Organization (NEDO)**

### Method and Development Timeline

<table>
<thead>
<tr>
<th>Method</th>
<th>Coal Feed (t/day)</th>
<th>Power Output (MW)</th>
<th>Year ('80-'20)</th>
<th>Supported by NEDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Blown</td>
<td>2</td>
<td>-</td>
<td>'85</td>
<td>Lab.</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>-</td>
<td>'90</td>
<td>P.P.</td>
</tr>
<tr>
<td></td>
<td>1,700</td>
<td>250</td>
<td>'95</td>
<td>Nakoso</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>'00</td>
<td>D.P.</td>
</tr>
<tr>
<td>Oxygen Blown</td>
<td>1</td>
<td>-</td>
<td>'90</td>
<td>HYCOL</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-</td>
<td>'00</td>
<td>EAGLE</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>-</td>
<td>'10</td>
<td>OCG</td>
</tr>
<tr>
<td></td>
<td>1,180</td>
<td>166</td>
<td>'15</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:**
- **P.P.** : Pilot Plant
- **D.P.** : Demonstration Plant

**Projects:**
- **Lab.** : Nakoso, HYCOL, EAGLE, OCG
- **PP** : Nakoso
- **OCG** : Nakoso

**Notes:**
- Supported by NEDO
Nakoso Air-blown IGCC demonstration plant

Major Specification

Output 250 MW (gross)

Gasifier Air-blown Dry Feed

Gas Clean-Up MDEA (Methyl diethanol amine)

Gas Turbine M701DA GT (1 on 1)

Project Schedule

Operation Started Sep. 2007

Commercial Operation July. 2013

Nakoso 250MW IGCC Demonstration Plant achieved all the following targets.

- Excellent Performance (High Efficiency, Less Environmental impact)
- Higher Reliability (World record of continuous operation, 3,917 hrs
  Cumulative operation hrs. exceeded 38,000 hrs.)
- Fine Operability (Load change rate >3%/min)
- Fuel Flexibility (Verified applicability for low-rank coal)

 Converted to the First Commercial IGCC Plant in Japan.
Team of Japan develops Large IGCC Plants
– Fukushima Revitalization Power 540MW × 2 –

New Energy and Industrial Technology Development Organization

Press Information
August 19, 2015

Conclusion of a Letter of Intent to Develop World’s Most Advanced Coal-Fired Thermal Power Plants in Fukushima Prefecture

Tokyo Electric Power Company, Incorporated (TEPCO), Mitsubishi Heavy Industries, Ltd., Mitsubishi Corporation, Mitsubishi Electric Corporation, Joban Joint Power Co., Ltd., today concluded a letter of intent to promote the development of the world’s most advanced coal-fired thermal power plants in Fukushima. The project is currently being undertaken by TEPCO as part of its contribution to revitalization in the prefecture.

The project was launched with the aim of creating an industrial base and opening up job opportunities in Fukushima as part of moves to support local economic recovery. The project will, at the same time, be a global leader in next-generation clean coal technology through the introduction of the integrated coal gasification combined-cycle (IGCC) in plant operations.

The project aims to construct and operate two 540 MW class IGCC facilities in Fukushima: one at TEPCO’s Hirono Thermal Power Station and the other at Joban Joint Power Company’s Nakoso Thermal Power Station.

Schedule
2014. 5 Environmental Impact Assessment Started
2014. 8 Engineering Work Started
2016. 10 Site Mobilization (Scheduled)
Operation (Scheduled)
2020.9 Nakoso IGCC
2021.9 Hirono IGCC

Major Specification
Output 540 MWgross × 2 Trains
Gasifier Air-blowed Dry Feed
Gas Clean-Up MDEA
Gas Turbine M701F4 GT (1 on 1)
Low carbonization in coal-fired power generation
Osaki CoolGen (OCG) Demonstration Project

IGCC

Air separation unit
Coal
Air

Gasification
Steam
Gasifier
Combustor
Gas turbine
Steam turbine
HRSG (heat recovery steam generator)
Generator
Stack
Compressor

CO₂ Capture Technology

Shift reactor
CO₂, H₂
CO₂, H₂ rich gas

Fuel Cell
Fuel cell

CO₂ transportation and storage processes
Osaki CoolGen (OCG) Demonstration Project

Scaling up of IGCC with the results from EAGLE Project

166MW IGCC plant

Subsidized by METI until Mar. 2016 and NEDO from Apr. 2016
The schedule for OCG Demonstration project

The demonstration test as **1st stage** has conducted since March 2017.

<table>
<thead>
<tr>
<th>Year</th>
<th>09</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGCC optimization feasibility study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1st Stage Oxygen-blowed IGCC | | | | | | | | | | | | | | ↓Now
| 2nd Stage CO₂ Capture IGCC | | | | | | | | | | | | | |
| 3rd Stage CO₂ Capture IGFC | | | | | | | | | | | | | |

- 1st Stage: Design, Construction, Operations testing
- 2nd Stage: FS, Design, Construction, Operations testing
- 3rd Stage: FS, Design, Construction, Operations testing
Low Emission Technology for CO₂

**CO₂ separation and capture cost**

High

Low

**Chemical absorption method**

- Use a solvent, such as amine.
- Separation and capture cost: 4200 yen/t-CO₂

**Solid absorbent method**

- Reduces energy requirement and separates CO₂ by combining amine, etc.

**Physical absorption method**

- CO₂ absorbed into a physical absorption solution under high pressure.
- Separation and capture cost: Approximately 2000 yen level/t-CO₂
- Around 2020

**Membrane separation method**

- Separates by using a membrane which penetrates CO₂ selectively.

**Utilization of CO₂**

- This technology utilizes captured CO₂ to produce valuables such as alternatives to oil and chemical raw material.

**Storage of CO₂**

- To store separated and captured CO₂ in the ground. Practical realization of CCS technology by around 2020.
- The plant for this business is under construction, and the storage will be initiated in 2016.

**Closed IGCC**

- The oxygen fuel technology to the IGCC technology.

* The cost prospect in the Figure was estimated based on various assumptions at present.

Present  Around 2020  Around 2030
## Low Emission Technology for CO2
### A list of CO2 separation and capture technologies

<table>
<thead>
<tr>
<th>CO₂ Separation and capture technologies</th>
<th>Outline of technology</th>
<th>Cost (Yen/t-CO₂)</th>
<th>Technical establishment (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>① Chemical absorption method</td>
<td>- utilization of chemical reaction between CO₂ and liquid.</td>
<td>4,200 yen * In the case of post combustion</td>
<td>Already established</td>
</tr>
<tr>
<td>② Physical absorption method</td>
<td>- dissolved into a liquid for separation and capture. - The absorption capacity depends on the solubility of CO₂ into a liquid.</td>
<td>2,000 yen level</td>
<td>2020</td>
</tr>
<tr>
<td>③ Solid absorbent method</td>
<td>- solid absorbent and absorption materials. (Solid solvent method)</td>
<td>2,000 yen level * Preliminary-calculated</td>
<td>2020</td>
</tr>
<tr>
<td>④ Membrane separation method</td>
<td>- separates a CO₂ from a mixed gas by utilizing the permeation selectivity of the thin membrane of a solid material with separation capacity. - Problem: scale up</td>
<td>1,000 yen level * Preliminary-calculated</td>
<td>2030</td>
</tr>
<tr>
<td>⑤ Oxyfuel combustion method</td>
<td>- separates oxygen from combustion air and burns fuel using this oxygen.</td>
<td>3,000 yen level</td>
<td>2015</td>
</tr>
<tr>
<td>⑥ Closed IGCC (CO₂ capture next-generation IGCC)</td>
<td>- applied technology based on IGCC system. - circulates CO₂ in exhaust gas as an oxidizing agent throughout a gasification furnace and gas turbine.</td>
<td>-</td>
<td>Later than 2030</td>
</tr>
</tbody>
</table>

*1) The method for capturing CO₂ from the exhaust gas after combustion.  
*2) The method for capturing CO₂ from the fuel before combustion  
* The preliminary calculation of the costs in the above table is based on various assumptions and does not determine future separation and capture costs.
Low Emission Technology for NOx/SOx
Comparison NOx/SOx emission by power generation

Emission : OECD Stat Extracts
Electric power generation : IEA ENERGY 2016
Japan : The Federation of Electric Power Companies (FEPC)

Country-by-country comparison through evaluation of SOx, NOx Emission basic unit (g/kWh) (2014-Power Plant)

http://www.fepc.or.jp/library/data/infobase/pdf/06_h.pdf
Low Emission Technology for NOx/SOx Air Quality Control System (AQCS)

New Energy and Industrial Technology Development Organization

Flue Gas De-sulfurizer System (FGD)

Selective Catalytic Reaction System for De-NOx (SCR)

Table:

<table>
<thead>
<tr>
<th></th>
<th>NOx</th>
<th>Dust</th>
<th>SO2</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15~40 ppm-dry</td>
<td>20,000mg/m³N</td>
<td>500~7,000ppm-dry</td>
<td>380°C</td>
</tr>
<tr>
<td></td>
<td>150~200 ppm-dry</td>
<td>30~50mg/m³N</td>
<td>5~10mg/m³N</td>
<td>140°C</td>
</tr>
<tr>
<td></td>
<td>5~500ppm-dry</td>
<td>5~10mg/m³N</td>
<td>50~100°C</td>
<td>100°C</td>
</tr>
</tbody>
</table>

Diagram:

- Boiler
- De-NOx
- GAH
- GGH
- EP
- IDF
- FGD
- GGH
- BUF
- Stack

NH3 Injection Nozzle
Catalytic Layer
Spare Layer
Soot Blower
Flue Gas
Flue Gas
Mist Eliminator
Circulating Pump
Agitator

150~200 ppm-dry
15~40 ppm-dry
20,000mg/m³N
30~50mg/m³N
5~10mg/m³N
5~500ppm-dry
380°C
140°C
100°C
50°C
100°C
4. Dissemination of CCT Technology
Needs to dissemination of CCT Technology–1

By COP21’s Paris agreement (2015), acceleration of further CO2 reduction is required.

By OED’s “Arrangement on guidelines for officially supported Export Credits”, the financing support for Coal Fired Power Plant is limited, but it for High efficiency Plant is maintained.

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### Intended Nationally Determined Contributions (INDC)

<table>
<thead>
<tr>
<th>Country</th>
<th>Reduction target</th>
<th>Reduction target</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>By 2030</td>
<td>60-65% reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005 base balance to GDP</td>
</tr>
<tr>
<td>EU</td>
<td>By 2030</td>
<td>40% reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1990 base</td>
</tr>
<tr>
<td>India</td>
<td>By 2030</td>
<td>33-35% reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005 base balance to GDP</td>
</tr>
<tr>
<td>Japan</td>
<td>By 2030</td>
<td>26% reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2013 base</td>
</tr>
<tr>
<td>Russia</td>
<td>By 2030</td>
<td>70-75% Limiting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1990 base</td>
</tr>
<tr>
<td>USA</td>
<td>By 2030</td>
<td>26-28% reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005 base</td>
</tr>
</tbody>
</table>

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### ANNEX VI SECTOR UNDERSTANDING ON EXPORT CREDITS FOR COAL- FIRED ELECTRICITY GENERATION PROJECTS

<table>
<thead>
<tr>
<th>PLANT UNIT SIZE (gross installed capacity)</th>
<th>Unit &gt; 500 MW</th>
<th>Unit ≥ 300 to 500 MW</th>
<th>Unit &lt; 300 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra-supercritical (i.e., with a steam pressure &gt;240 bar and ≥593°C steam temperature) OR Emissions &lt; 750 g CO2/kWh</td>
<td>12 years (*1)</td>
<td>12 years (*1)</td>
<td>12 years (*1)</td>
</tr>
<tr>
<td>Supercritical (i.e., with a steam pressure &gt;221 bar and &gt;550°C steam temperature) OR Emissions 750 ~ 850 g CO2/kWh</td>
<td>Ineligible</td>
<td>10 years, and only in IDA-eligible countries (*1,2,3)</td>
<td>10 years, and only in IDA-eligible countries (*1,2,3)</td>
</tr>
<tr>
<td>Subcritical (i.e., with a steam pressure &lt; 221 bar) OR Emissions &gt; 850 g CO2/kWh</td>
<td>Ineligible</td>
<td>Ineligible</td>
<td>10 years, and only in IDA-eligible countries (*1,3)</td>
</tr>
</tbody>
</table>

*1 Where eligible for official support, an additional two years repayment term is allowed for project finance transactions consistent

*2 To help address energy poverty, ten year export credit support may be provided in all countries where the National Electrification Rate is reported as 90% or below at the time the relevant completed application for export credit is received

*3 Export credit support may be provided in non-IDA-eligible countries for geographically isolated locations

(TAD/PG(2016)1 ARRANGEMENT ON OFFICIALLY SUPPORTED EXPORT CREDITS)

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**CO₂ Emission from Fuel Combustion**

Needs to dissemination of CCT Technology

- Japan’s average efficiency of the coal power plant is a world highest level, and O&M knowledge can keep it higher level during long term period.
- Dissemination of Japan’s CCT Technology can reduce not only CO2 emission but also environmental emissions (such as NOx, SOx), because Japan’s Air Quality Control System (AQCS) has a world highest level too.

![History of changes in thermal efficiency of coal power plant with comparison of major countries.](image)

(According to the data of ECOFYS)
NEDO’s project to promote dissemination of CCT Technology

New Energy and Industrial Technology Development Organization

In this NEDO project, there are three menus to support the potentiality countries for the CCT Technology:

1. Investigation for preparation of the business environment
2. Technology exchange / Seminar & Work Shop at Partner country
3. Invitation to Japan For technology exchange

[Map showing countries like India, Poland, Ukraine, China, Philippines, Thailand, Indonesia, and Vietnam]
Research for Developing Low Rank Coal firing IGCC Plant in Thailand

Contents

Purpose

This research is to study conceptual design and project scheme of IGCC project by using low rank coal (lignite) produced in Thailand, which contains high moisture, sulfur with the characteristic of low ash melting temperature. Research includes coal sampling, tests and study of potential to reduce greenhouse gas (CO$_2$) emissions and other environmental impacts.

* IGCC : Integrated coal Gasification Combined Cycle

Duration

June, 2015 — March, 2016

Participants

Mitsubishi Hitachi Power Systems, Ltd., Mitsubishi Heavy Industries, Ltd.
Research for Bituminous Coal Firing IGCC in Poland

New Energy and Industrial Technology Development Organization

content

〈Summary〉 This research is to study conceptual design and project scheme of IGCC project by using bituminous coal produced in Poland, which contains high ash content with the characteristic of high ash melting temperature. Research includes coal sampling, tests and study of potential to reduce greenhouse gas (CO$_2$) emissions and other environmental impacts.

〈Investigation period〉 September, 2015 — June, 2016

〈Contractors〉 Mitsubishi Hitachi Power Systems, Ltd., Mitsubishi Heavy Industries, Ltd.
Research for Biomass co-firing in Indonesia

- Feasibility Study (F/S) in Sulawesi island, Indonesia was conducted to achieve both CO2 reduction and increasing of electrification rate in rural communities.
- Circulating Fluidized Bed Boiler (CFB) with biomass co-firing is more suitable for this situation.
- By using the Re-heater in CFB, 13% of CO2 reduction is possible than to conventional system. Moreover, Biomass co-firing can achieve as same level of CO2 emission as SC boiler (@20% Biomass co-firing) or it can achieve as same as USC boiler (@20% Biomass co-firing)

![Google map](image)

**Plant layout (Draft)**

**Result of F/S (CO2 emission)**

- conventional system
- Re-heater in CFB
- Bio Co-firing 20%
- Bio Co-firing 30%
- USC
Demonstration of TIGAR (Twin IHI Gasifier) project is going at PT Kujang Indonesia.

**Purpose**

① Check the maintenance durability in long operation (Total 4,000 hr operation) using Indonesia lignite.

② Confirmation of TIGAR performance and reliability, and reflect in commercial plant engineering.

③ Demonstration of TIGAR gasification technology for future clients.

**50t/d plant spec**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal feed rate</td>
<td>50 t/d (as received, 43% moisture)</td>
</tr>
<tr>
<td>Syngas output</td>
<td>1,800 m³N/h-dry</td>
</tr>
<tr>
<td>Steam generation</td>
<td>4.5 t/h (2.0MPaG, 513deg.C)</td>
</tr>
<tr>
<td>Site area</td>
<td>100m × 80m</td>
</tr>
</tbody>
</table>
Characteristics of TIGAR

- Components of TIGAR are based on mature Fluidized Bed technology
- The low grade material (lignite, biomass) can be gasified, and applied to chemical raw material, fuel

- Atmospheric pressure
- Low temperature

<table>
<thead>
<tr>
<th>Applicable Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal (lignite)</td>
</tr>
<tr>
<td>Bark</td>
</tr>
<tr>
<td>Bagasse</td>
</tr>
<tr>
<td>Wood</td>
</tr>
<tr>
<td>Palm Waste</td>
</tr>
</tbody>
</table>

Unreacted char is burned with air

High temperature bed materials are circulated

Steam gasification

Steam

Air

Combustor (heat emission)

Gasifier (heat absorption)

Circulation
Conclusion

• NEDO promotes R&D as well as the dissemination of industrial, Clean Coal Technology (CCT) is important technical domain.
• Japan’s position on coal fired power generation is to promote the development of technologies to reduce GHG emissions (e.g., IGCC) by improving the power generation efficiency.
• The air-blown IGCC technology was established in 2013 after the completion of the demonstration operation in Nakoso. It has been already commercialized since June 2013.
• The demonstration project, “Osaki CoolGen Project”, for the oxygen-blown IGCC/IGFC combined with CO2 capture is currently in progress. The demonstration test has been conducted to verify the performance, reliability and economic efficiency since March 2017.

➢ NEDO intends to make continued efforts to lead the development of the high efficiency coal gasification and the CO₂ capture technologies.
➢ NEDO is also making efforts to disseminate the high-efficiency coal-fired power generation technology to developing countries.
Thank you for your attention.