Overview of NEDO’s CCT Development

2 June. 2014

Shinji Kakuno

Environment Department
New Energy and Industrial Technology Development Organization (NEDO)
Japan
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

Funding

Academia

Industry

Public research laboratories

Mission

- Solving global energy and environmental problems
- Enhancement of Japan’s industrial competitiveness
1. NEDO Policy on CCT Development

2. Coal Gasification Technology

3. Dissemination of High-efficiency CCT
1. NEDO Policy on CCT Development

Current situation:
- Coal accounts for one fourth of global primary energy consumption and its consumption is expected to increase. However, CO$_2$ emission from coal is larger than other fossil fuels.
- As a result of continued R&D and effective O&M, Japan has achieved the highest efficiency levels of coal-fired thermal power generation in the world. On the other hand, there are many low-efficiency coal thermal power stations around the world.
- In Japan, coal has been re-evaluated as an important base-load power source in terms of stability and cost effectiveness since the Great East Japan Earthquake and will be utilized while reducing environmental load by effective use of high efficiency coal fired thermal power plant.

Policy:
- NEDO promotes R&D on high-efficiency clean coal technology (CCT) that contribute to mitigate CO$_2$ emission form coal fired thermal power plant including CO$_2$ capture and storage technology.
- NEDO aims to utilize these Japanese technologies to promote CCT overseas particularly in developing countries, in order to stabilize energy supply and demand and contribute to the establishment of a low-carbon society.

Priority activities:
1. Improvement of Coal-fired Power Generation Efficiency and reducing CO2 Emission
2. Development of CO2 Capture Technology to realize Zero-emission Coal-fired Power Plant
3. Dissemination of High-efficiency Clean Coal Technology
1.1 Global Trend of the Coal Demand

Global primary energy demand by source

Global power generation by source

1.2. Importance of Clean Coal Technology

Japan's Power Generation by Source

- Others
- Nuclear
- Gas
- Oil
- Coal

Power Generation, 100 GWh

1.3 “The 4th Strategic Energy Plan of Japan”

Position and Policy Direction of Coal

(1) Position
Though coal has a problem – it emits a large amount of greenhouse gas – it is now being re-evaluated as an important base-load power supply because it involves the lowest geopolitical risk and has the lowest price per unit of heat energy among fossil fuels. It is an energy source that we should use while reducing the environmental load through the utilization of highly efficient coal thermal power generation technology, etc.

(2) Policy Direction
In addition to promoting the replacement of aging thermal power plants and introducing available leading-edge technology through the construction of new facilities and the expansion of existing ones, GOJ further promotes the development of technologies to drastically reduce greenhouse gas emissions per unit of generated power (e.g., IGCC) by largely improving the power generation efficiency. It is necessary to use coal while reducing the global environmental load by promoting the introduction of such high-efficiency technologies not only in Japan but also globally.

Source: Strategic Energy Plan (April, 2014)
Chapter 2 Basic policy regarding measures concerning energy supply and demand
Section 2. Position of each energy source and policy timeframe
NEDO regards gasification technology as a key technology, and has carried out gasification technology development utilizing coal.
1. NEDO Policy on CCT Development

2. Coal Gasification Technologies

3. Dissemination of High-efficiency CCT
2.1. Efficiency Improvement in Coal-fired Power Generation

In order to improve power generation efficiency, NEDO has placed an emphasis on the development of IGCC and IGFC which utilize gasification as a core technology.
2.2. IGCC/FC Technology

**IGCC**

- Air separation unit
- Coal
- Gasifier
- Oxygen
- Steam turbine
- HRSG (heat recovery steam generator)

**Gas clean-up facilities**

- Syngas (CO, H₂)
- Combustor
- Air

**CO₂ Capture Technology**

- Shift reactor
- CO₂ Capture Technology
- CO₂, H₂ (H₂ rich gas)
- Fuel Cell
- Fuel cell
- CO₂ transportation and storage processes
### 2.3. Coal Gasification Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Place</th>
<th>Technology</th>
<th>Stage</th>
<th>Power</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen-blown entrained flow gasification</td>
<td>EAGLE Project</td>
<td>Fukuoka</td>
<td>IGCC + CO2 Capture</td>
<td>Pilot</td>
<td>8 MW</td>
</tr>
<tr>
<td>Air-blown entrained flow Gasification</td>
<td>Nakoso IGCC Plant</td>
<td>Fukushima</td>
<td>IGCC</td>
<td>Demonstration Commercial</td>
<td>250 MW</td>
</tr>
<tr>
<td>Oxygen-blown entrained flow gasification</td>
<td>Osaki Cool Gen Project</td>
<td>Hiroshima</td>
<td>IGCC/FC + CO2 Capture</td>
<td>Development</td>
<td>170 MW (IGCC)</td>
</tr>
</tbody>
</table>
2.4 Coal Energy Application for Gas, Liquid & Electricity (EAGLE)

- Air separation facilities
- Gas purifier (150 tons/day)
- Gas turbine house (8 MW)
- CO₂ Separation facilities
- Physical adsorption
- Chemical adsorption
- Gasifier (150 tons/day)

EAGLE Pilot Plant (150 tons/day)
## 2.5 Results of the EAGLE Project

<table>
<thead>
<tr>
<th>Stage</th>
<th>Contents/Target</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage-1 (2002-2007)</td>
<td>Cold gas efficiency</td>
<td>82%</td>
</tr>
<tr>
<td></td>
<td>Continuous Operation</td>
<td>&gt;1,000 hours</td>
</tr>
<tr>
<td></td>
<td>Diversification of Coal Type</td>
<td>5 type of coal (unique)</td>
</tr>
<tr>
<td></td>
<td>Scale-up Data Collection</td>
<td>Design data obtained for scale-up</td>
</tr>
<tr>
<td>Stage-2 (2008-2010)</td>
<td>Coal with High Ash Fusion Temperature</td>
<td>+3 coals (unique)</td>
</tr>
<tr>
<td></td>
<td>CO2 Capture (chemical absorption)</td>
<td>Approx. 30% of energy saving (2points efficiency improvement)</td>
</tr>
<tr>
<td></td>
<td>Trace Elements Behavior</td>
<td>Design data obtained for scale-up</td>
</tr>
<tr>
<td>Stage-3 (2010-2013)</td>
<td>CO2 Capture (physical absorption)</td>
<td>Approx. 10% of energy saving than chemical absorption (Future application for higher gas turbine temperature)</td>
</tr>
</tbody>
</table>
2.6 Nakoso IGCC Commercial Plant (Nakoso Unit 10) - First IGCC Commercial Plant in Japan
## 2.7 Nakoso IGCC Project

### Status

- Pilot plant (200t/d)
- Demonstration plant (1700t/d)
- Commercial plant (1700t/d)

### Timeline

- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

### Achievement

<table>
<thead>
<tr>
<th>Demonstration test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Term continuous Operation</td>
<td>2238hr</td>
</tr>
<tr>
<td>Net Thermal Efficiency</td>
<td>42.9% (LHV basis)</td>
</tr>
<tr>
<td>Carbon Conversion Rate</td>
<td>&gt;99.9%</td>
</tr>
<tr>
<td>Coals</td>
<td>Chinese (B), Russian (B), USA (2SB), Indonesian (B,2SB), Colombian (B), Canadian (B)</td>
</tr>
</tbody>
</table>
2.8 Osaki Cool Gen (OCG) Project

Rendering of OCG facilities

- New Business Area
- IGCC Plant Area

- Syn Gas Treatment Equipment
- Gal Gasification
- Old Water Treatment System
- No 1-1 Plant
- ASU
- Water Treatment System
- Gas Combined Cycle

Osaki Cool Gen
2.9 Schedule for Osaki Cool Gen (OCG) Demonstration project

| Stage | Year | 09  | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  |
|-------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| IGCC optimization feasibility study |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 1st Stage |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Oxygen-blown IGCC |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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
Schedule:

**September 10\(^{th}\), Wed.  ** 10.00-17.00hrs.
International Symposium on the Coal Gasification Technology at Hotel Okura Tokyo

**September 11\(^{th}\), Thu.  ** 10.00-17.00hrs.(TBC)
Site visit to Nakoso IGCC Power Station, Fukushima, Japan

Organizer:
NEDO with the support of the Ministry of Economy, Trade and Industry of the Japanese Government (TBC)
1. NEDO Policy on CCT Development

2. Coal Gasification Technologies

3. Dissemination of High-efficiency CCT
As Japan has achieved the world’s highest efficiency levels for coal-fired power generation technology, feasibility studies for project formation are currently being conducted on high-efficiency CCT, such as USC and IGCC in order to disseminate the technology worldwide and reduce global CO$_2$ emissions.

Feasibility Studies utilizing following Clean Coal Technologies:
- USC, A-SUB, USC + CCS
- IGCC, IGCC + CCS
- Coal gasification
- Upgrading or drying of low rank coal
- Operation know-how

International comparison of fossil fuel power generation efficiency (ECOFYS) (2013)
3.1. Japanese High-efficiency Clean Coal Technology

Beside the highest level of the thermal efficiency utilizing USC technology,
✓ Japanese coal-fired power plant has impressive track record of thermal efficiency
✓ Japanese utilities and manufacturers have long history of utilizing USC technology and lots of O&M experiences

Gross thermal efficiency (%, HHV)

- Designed thermal efficiency
- Maintaining high efficiency through the appropriate operation and maintenance
- Efficiency degradation

Coal-fired power plant in Japan
Coal-fired power plant in developing countries

Years in operation

Long history of utilizing USC technology

About 20 years experience

* According to METI FS research 2010 & 2011.
3.2. NEDO Project Formation Research on High-efficiency CCT

32 feasibility projects in 19 countries around the world.

- 2011-2012: High-efficiency coal power plant (USC) in Poland
- 2011, 2013: High efficiency coal power plant (SC) and CCS in Bulgaria
- 2012: HECA IGCC project (additional FS) in USA
- 2012: Basic Research on High-efficiency CCT in South East Europe Area (Hungary, Romania, Serbia)
- 2012: High-efficiency coal power plant (USC) in Bosnia and Herzegovina
- 2013: Gasification project in Hungary

(Europe / U.S.)
3.3. F/S for New Coal-fired Power Plant Project in Poland

- The Chugoku Electric Power Co., Inc., one of Japanese utility companies, conducted a feasibility study of Tauron Wytwarzanie’s new coal fired power plant project from June 2011 to March 2013, as a part of a research program for “Developing Projects Using High-efficiency Coal Utilization Systems” sponsored by NEDO.

- In the project site, there are aged power plants to be replaced in near future.

- Realization of this Project will contribute to improve plant thermal efficiency and to reduce CO2 emission.

**Proposed project outline in FS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New plant</strong></td>
<td>1 unit of 1,000MW class</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Polish domestic hard coal</td>
</tr>
<tr>
<td><strong>Steam condition</strong></td>
<td>&lt;USC&gt; 600/620 deg C, 25MPa</td>
</tr>
<tr>
<td><strong>Plant thermal efficiency</strong></td>
<td>45.1%</td>
</tr>
<tr>
<td><strong>Ref : Existing plants</strong></td>
<td>2 units of 125MW class (45 years aged)</td>
</tr>
<tr>
<td></td>
<td>4 units of 225MW class (40 years aged)</td>
</tr>
</tbody>
</table>
Thank you for attention