Feasibility Studies with the Aim of Developing a Bilateral Offset Credit Mechanism  FY2011

Studies for Project Development and Organization

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Program organization research of Ultra Super Critical (USC) coal-fired thermal power plant construction project in the Republic of India

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Mizuho Corporate Bank, Ltd.
I. Introduction

Background :

○ This report summarizes the results of the feasibility study of introducing an ultra super critical (USC) coal-fired thermal power plant rated at 2,000 MW (two 1,000 MW generators) to the Republic of India.

○ The purposes are to support the design of a bilateral offset credit mechanism (BOCM) to be introduced by the Japanese government and to provide information to peoples connected with overseas governments and a variety of stakeholders who are interested in the system.

The outline of this research report :

○ “Chapter II: Survey of the Indian Power Market and Measures against Climate Change” organizes basic information necessary to the promotion of this project.

○ “Chapter III: Basic Design of Power Plant” describes how we designed an USC coal-fired thermal power plant expected by this project and what we investigated to develop system specifications necessary to the project and to draw up a project implementation plan.

○ “Chapter IV: Review of the MRV Method” describes the MRV method employed in this project and summarizes issues in the estimation of green gas reduction and its methods.

○ “Chapter V: Consideration toward the Design of a Bilateral Offset Credit Mechanism” shows issues in the system design identified through this investigation and organizes arguing points.
II. Survey of the Indian Power Market and Measures against Climate Change

1. Current state and future prospect of power generation plans
   - Currently, most of electric power companies employ subcritical coal-fired thermal power plants, and only small part of them introduces super critical (SC) technology.
   - Currently, only one company plans to employ the ultra super critical (USC) cycle shown in this investigation, but does not announce when it starts.
   - Many companies are interested in USC technology but recognize that it is less advantageous than subcritical and SC technologies from the viewpoints of the initial cost.

2. Financing plans
   - Most of the electric power companies assume a basic finance model whose debt/equity = 70 – 80/30 – 20.
   - Some have dealings with overseas banks but many companies raise funds from domestic financial institutions.
   - The opinion “Importance should be given to (1) Reduction in initial cost, (2) Low-interest loans, and (3) Long repayment period” dominates the state power market.

3. Possibility of introducing Japanese technology and of joint ventures
   - The appliance procurement market is dominated by BHEL and L&T (domestic companies), which are followed by Chinese companies.
   - India gives importance to the cost reduction of power as a measure for demand far beyond supply rather than a rise in energy efficiency.
   - Many Indian companies give priority to initial costs rather than life-cycle expenses, so they require foreign companies to work out a scheme for reducing the initial cost.
II. Survey of the Indian Power Market and Measures against Climate Change (continued)

4. Impression on CDM

- It is well known that India has several coal-fired thermal power generation projects that aim to be listed in the CDM Registry.
- They have common opinions shown below;
  - The registration process takes too long time.
  - It is difficult to prove additionality.
- These are hurdles they shall jump over. In addition, they encounter the following problems:
  - Communication with CDM Executive Board is not enough.
  - The specified baseline is too conservative.
  - Procedures are complicated.

5. Impression on BOCM

- A certain company says that it has no idea as far as no BOCM agreement is made between Japanese and Indian governments, while many companies have a good impression on BOCM because it is more flexible than CDM.
- In addition, companies which have already been working on CDM deepen their understanding of BOCM through a description from Japan and put many good questions and opinions about system design, which are shown below.
  - How do you specify credit prices? (It should be higher than CER.)
  - Can Indian companies receive income given by selling the credit at an early stage?
  - The credit issuance period should be longer.
  - The registration process should be shorter.
- Some companies understand that ACM0013 is put on hold and credits issued from India project registered after 2012 cannot be used in the third phase of EU-ETS.
- That is to say, the Indian electric power companies know that BOCM promoted by Japan is advantageous to them.
- Accordingly, in order for the Japanese side to design BOCM in detail and to make an agreement with the Indian side, it is important to prepare a campaign for showing advantages to the Indian companies, such as giving a continuous and polite description, buying the credit shown above at a high price, and providing profits in advance.
### III. Basic Design of Power Plant

#### Comparing Thermal Power Generation Cycles

- **Super critical (SC) cycle:** Thermal power generator having a steam cycle rated at a main steam pressure of not less than 22 MPa, a main steam temperature of 566 degC, and a reheat steam temperature of up to 593 degC.

- **Ultra super critical (USC) cycle:** Thermal power generator having a steam cycle rated at a main steam pressure of not less than 24.1 MPa, a main steam temperature of not less than 593 degC, and a reheat steam temperature of not less than 593 degC.

- **Advanced ultra super critical (A-USC) cycle:** Thermal power generator having a steam cycle rated at a main steam pressure of 35 MPa, a main steam temperature of 700 degC, and a reheat steam temperature of 720 degC.

- **Integrated coal gasification combined cycle (IGCC):** Thermal power generator consisting of a coal gasification furnace and gas turbine. The subcritical cycle applies to the steam cycle because exhaust heat from the gas turbine is used as a heat source.

#### Results of comparing the various cycles

<table>
<thead>
<tr>
<th></th>
<th>SC cycle</th>
<th>USC cycle</th>
<th>A-USC cycle</th>
<th>IGCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam pressure</td>
<td>&gt; 22MPa</td>
<td>&gt; 24.1MPa</td>
<td>35MPa</td>
<td>—</td>
</tr>
<tr>
<td>Steam temperature</td>
<td>&lt; 566°C/593°C</td>
<td>&gt; 593°C/593°C</td>
<td>700°C/720°C/720°C</td>
<td>—</td>
</tr>
<tr>
<td>Net thermal efficiency (HHV)</td>
<td>40%</td>
<td>42%</td>
<td>46%</td>
<td>46%</td>
</tr>
<tr>
<td>CO₂ emissions per unit energy</td>
<td>815g-CO₂/kWh</td>
<td>776-CO₂/kWh</td>
<td>709-CO₂/kWh</td>
<td>709-CO₂/kWh</td>
</tr>
<tr>
<td>Maturity of technology</td>
<td>Commercial stage</td>
<td>Commercial stage</td>
<td>Developing stage</td>
<td>Demonstrating stage</td>
</tr>
<tr>
<td>Construction cost</td>
<td>&lt; JPY270k/kW</td>
<td>JPY272k/kW</td>
<td>—</td>
<td>JPY290k/kW (target)</td>
</tr>
<tr>
<td>Power generation cost</td>
<td>JPY 5.9/kWh</td>
<td>JPY 5.9/kWh</td>
<td>Same as USC (target)</td>
<td>Same as USC (target)</td>
</tr>
</tbody>
</table>
III. Basic Design of Power Plant

(continued)

Comparison of the net thermal efficiencies under Japanese Circumstances

The left side figure shows the net thermal efficiency of each technology under Japanese circumstances (low cooling water temperature and high coal property, etc.).

Since the 1980s, the net thermal efficiency has increased year by year.

Comparing the estimated CO2 emissions per unit energy indicates that the A-USC cycle and IGCC have the almost same CO2 emission as oil-fired thermal power generation though they use coal as a fuel (right hand figure).

Comparison of CO2 emissions on a cycle basis under Japanese Circumstances

Note: The CO2 emission factors of coal and oil are 379.28 g-CO2/1,000 kcal and 296.8 g-CO2/1,000 kcal respectively, and the HHV efficiency of oil-fired thermal power generation is 36%.

Source: We have created this table according to various documents and excerpted the construction and power generation costs from No. 11 IEEJ Seminar delivered by Agency for Natural Resources and Energy, METI in February 2008.
**IV. Review of MRV methodologies**

○ **Identification of baseline monitoring methodologies**
  - Considering economic attraction and technical issues, the baseline scenarios at the moment is introduction of the subcritical coal fired power generation.
  - However, since it is assumed that the period of the power generation project is long and that technology introduction is likely to be accelerated in the years ahead, a review of the baseline scenarios may be required in the future.
  - Also, a review of the necessity for a system for regularly reviewing the baseline with the host country’s governments may be required.
  - Accordingly, this survey also evaluates possible reduction resulting from the baseline scenario of the supercritical coal fired generation for future review.

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<table>
<thead>
<tr>
<th>Proposed baseline</th>
<th>Description</th>
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</table>
| 1) subcritical coal fired generation | • Subcritical technologies will be introduced as power plants capable of generating the output equal to envisioned scale.  
• This option not only complies with all relevant laws and regulations, but also gives the highest cost competitiveness with matured existing technologies and years of experience in operation. |
| 2) SC coal fired power plant | • Supercritical (SC) coal fired power plant will be introduced as power plants capable of generating the output equal to the envisioned scale.  
• At last, the introduction of SC coal fired power plants has begun.  
• It has higher initial construction cost than the subcritical plant and limited or no experience in operation using introduced technique.  
• Due to such a risk, the SC may result in a greater barrier to the introduction than the subcritical. |
| 3) USC coal fired power plant | • Ultra super critical (USC) coal fired power plant will be introduced as power plants capable of generating the output equal to the envisioned scale.  
• Very limited experience in USC coal fired power plants.  
• For this, they result in greater barrier to the introduction than the subcritical plants. |
V. Discussion about bilateral offset credit mechanism design

Points in the design of the BOCM conceivable through this survey are described below.

<table>
<thead>
<tr>
<th>System framework</th>
<th>Treatment of reduction activities including other country’s technologies and products</th>
<th>How the technologies are deployed by the multinational consortium including Japan should be discussed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment of reduction activities by other country’s technologies and products</td>
<td>How the following options are treated would become the major issues to be examined in the future.</td>
<td></td>
</tr>
<tr>
<td>Treatment of credits</td>
<td>Allotment of credits by partner country and Japanese governments</td>
<td>Almost no discussion is made as to how credits issued by the partner country government and Japanese government are allotted.</td>
</tr>
<tr>
<td>Treatment of credits</td>
<td>Crediting period</td>
<td>A reasonable period must be set for the crediting period when the bilateral agreement is reached.</td>
</tr>
<tr>
<td>Treatment of credits</td>
<td>Credit price</td>
<td>Envisioned options are as follows:</td>
</tr>
<tr>
<td>Treatment of credits</td>
<td>Advance of credit income</td>
<td>If the amount of credit income is fixed and is used to lower the initial investment, it will help purchase relatively expensive high-performance products.</td>
</tr>
</tbody>
</table>
V. Discussion about bilateral offset credit mechanism design

ex.) Credit price advance scheme (overall image)

- This scheme will help purchase relatively expensive and high-performance products.
  - At the initial investment phase, certain amount credit income is paid for a certain period based on the expected reduction amount (for example, 90% of expected amount).
  - After the commencement of the project, the rest income will be paid based on the difference between the actual reduction amount and estimated one.
  - However, the issuance of credit is done after the finalization performance. As a result, the excess issue will be able to avoid.
- Since the risk of excessively issuing credits may not be zero, the risk should be considered separately.
- In order to provide flexibility to project implementing bodies, it is important to give the option of selecting the rate of the initial definitive amount (fixed amount) of the estimated reduction and the definitive amount according to the actual amount (variable amount) or allow pricing accordingly.

At the time of initial investment, credit income for the 90 percent of the expected reduction amount by the project is paid.

Income will be paid excluding the income already paid.

When actual reduction amount doesn’t reach the expected amount, there are no additional income. And there are no penalty, too. (No-lose target)

As an institution, it is considered that the debt would also carry over to following years.

*The certain income is paid before the start of the project. However, the issuance of credits is done after the finalization performance. As a result, the excess issue will be able to avoid
Points in the design of the BOCM conceivable through this survey are described below.

<table>
<thead>
<tr>
<th>Upgrading of external environment</th>
<th>• Upgrading of Japanese company’s export environment through involvement with partner country’s policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Support to partner country’s policies through the export of Japanese technologies</td>
<td>• It is desirable for Japan that a system is designed for the Indian law and/or policy, which provides incentives for introducing highly-efficient technologies at the time of selection of the technologies.</td>
</tr>
<tr>
<td></td>
<td>• It is also important to encourage the government to provide preferential treatment through the involvement of Japanese companies.</td>
</tr>
<tr>
<td></td>
<td>• Japanese technologies can appeal to developing country’s government for benefits as technologies that will assist in implementing partner country’s policies.</td>
</tr>
</tbody>
</table>

Acknowledgement

We would like to give deep acknowledgements to great cooperation received from the people connected to the Ministry of Economy, Trade and Industry, New Energy and Industrial Technology Development Organization, and New Delhi Office of NEDO. We also thank the people connected to the Indian government and many stakeholders including electric power companies for lots of their support by spending time on our investigation and providing important information.

We look forward to the results of this investigation contributing to the in-depth design of a BOCM, to talks between the two governments, and to measures against climate change.