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

Studies for Project Development and Organization

Study for the Possibility of Application of Ultra Super Critical Steam Conditions for Coal Fired Power Plant in Vietnam

New Energy and Industrial Technology Development Organization (NEDO) Mitsubishi Research Institute Inc.
Final Report

Study for the Possibility of Application of Ultra Super Critical Steam Conditions for Coal Fired Power Plant in Vietnam

March 2012
1. Objectives of the Pre-Study

Objectives of this Pre-Study on the introduction of the USC coal-fired power plant to the existing planned site.

- Investigate the economic & financial analysis and procurement of coal for the USC plant.
- Study the applicability of the Bilateral Offset Credit Mechanism (BOCM) to Vietnam.

Ultimate Goal

- Achieve implementation of USC to the coal-fired power plant in Vietnam
- Establish Bilateral Offset Credit Mechanism between Vietnam and Japan
2. Selected sites for site survey

Legend: Site name (Fuel)
Unit, Capacity, Planned COD (Commencement of Operation Date):
[PDP7 (the data available in 2010)]

Studied last year

Vung Ang (Import Coal)
- 3-#1 600MW after 2026
- 3-#2 600MW after 2027
- 3-#3 600MW after 2027
- 3-#4 600MW after 2028

Binh Dinh (Import Coal)
- 2-#1 1,000MW 2029 (2018)
- 2-#2 1,000MW 2029 (2021)
- 3-#1 1,000MW – (2018)
- 3-#2 1,000MW – (2021)

Kien Luong (Import Coal)
- 3-#1 1,000MW 2027 (2016)
- 3-#2 1,000MW 2028 (2017)

Vinh Tan (Import Coal)
- 4-#1 600MW 2017
- 4-#2 600MW 2018

Studying This year

Hanoi
Haiphong
Hue
Da Nang
Ho Chi Minh
Binh Dinh
3. USC Technology

Effects of the Steam Conditions

Gross Thermal Efficiency (LHV Base)

- **Sub Critical**: 16.6MPa, 538/538°C
  - Current 41.0%
  - Estimated +3.5% to 44.5%

- **Super Critical**: 24.1MPa, 538/566°C
  - Current 42.5%
  - Estimated +2.0% to 44.5%

- **Ultra Super Critical**: 24.5MPa, 600/600°C
  - Estimated 44.5%

Estimated under the condition of Vietnam
Coal type: Sub-bituminous, 4,700 kcal/kg (LHV)
4. Installation Record of USC in Asia

**Korea (2008~)**
- **Operation:**
  - Total 2 Units (★)
  - Total 1,600MW
- **Construction:**
  - Total 6 Units (★)
  - Total 6,000MW

**Japan (1993~)**
- **Operation:**
  - Total 23 Units (★)
  - Total 18,360MW
- **Construction:**
  - Total 2 Units (★)
  - Total 1,600MW

**China (2006~)**
- **Operation:**
  - Total 37 Units (★★)
  - Total 37,000MW
- **Construction:**
  - Total 52 Units (★★)
  - Total 52,000MW

**Taiwan**
- **Operation:** None
- **Construction:**
  - Total 2 Units (★)
  - Total 1,600MW
- **Planning & Bidding:**
  - Total 6 Units
  - Total 4,800MW

**Indonesia**
- **Operation:** None
- **Construction:**
  - Total 2 Units (★)
  - Total 2,000MW
- **Planning & Bidding:**
  - 1 Site
  - Total 2,000MW

- Origin of technology introduced to USC power plants which operating now is developed by Japanese manufactures.
- Japanese manufactures has about 20 years development history before commencement of operation of first USC power plant in Japan.
- Japan has much longer track record than other countries.
- Most of USC power plants in Asian countries are introduced Japanese USC technology.
5. Emission Reduction Potential

**Estimated model : Vinh Tan 4**

- **Capacity**: 600 MW × 2
- **Coal Condition**: 4,700 kcal/kg (LHV)
- **Gross Efficiency**: 44.5 % (LHV)
- **Output**: 7,884 GWh/year (PLF: 75%)
- **Emission Factor**: 0.811 t-CO₂/MWh

**Emissions Reduction**
\[
\text{Emissions Reduction} = \text{Baseline Emissions} - \text{Project Emissions} = \text{Electricity Generation} \times \text{Baseline Emission Factor} - \text{Fuel Consumption} \times \text{Net Calorific Value} \times \text{Emission Factor of Fuel}
\]

<table>
<thead>
<tr>
<th>Options (ex.)</th>
<th>Baseline</th>
<th>Sample Group</th>
<th>Emission Factor</th>
<th>Estimated Emission Reduction (2 Units)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline Option 1</strong></td>
<td>X or Y</td>
<td>15%</td>
<td>2 PPs (2007-2009)</td>
<td>1.109 t-CO₂/MWh</td>
</tr>
<tr>
<td>Ave. Emission Factor in Top X% performers of coal fired TPPs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseline Option 2</strong></td>
<td></td>
<td>3 years</td>
<td>4 PPs (2009-2011)</td>
<td>1.172 t-CO₂/MWh</td>
</tr>
<tr>
<td>Ave. Emission Factor in recently-build coal fired TPPs (within Y years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Scenario Analysis for Vinh Tan4

Tariff Comparison (US $/kWh; IRR = 9.80% Constant)

<table>
<thead>
<tr>
<th>Plant Cost (kW)</th>
<th>Sub Base Case</th>
<th>SC Base Case</th>
<th>USC OPT1</th>
<th>USC OPT2</th>
<th>USC Base Case1</th>
<th>USC Base Case2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US$ 1,050</td>
<td>US$ 1,250</td>
<td>US$ 1,400</td>
<td>US$ 1,400</td>
<td>US$ 1,400</td>
<td>US$ 1,483</td>
</tr>
<tr>
<td>Efficiency (LHV)</td>
<td>41.0 %</td>
<td>42.5 %</td>
<td>44.5 %</td>
<td>44.5 %</td>
<td>44.5 %</td>
<td>44.5 %</td>
</tr>
<tr>
<td>Finance</td>
<td>BC</td>
<td>BC</td>
<td>BC</td>
<td>Yen Loan</td>
<td>Yen Loan</td>
<td>Yen Loan</td>
</tr>
<tr>
<td>CO2 Credit</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>US$ 45.1 Mil/Year</td>
<td>US$ 45.1 Mil/Year</td>
</tr>
<tr>
<td>Marine Work &amp; Other Civil Cost</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>Including</td>
</tr>
</tbody>
</table>

▲US $ 0.18/kWh (Fuel Cost Saving; 42.5% ⇒ 44.5%)
▲US $ 0.25/kWh (CO2 Credit)
▲US $ 1.27/kWh (Yen Loan)
+US $ 0.07/kWh (Marine Work & Other Civil Cost)

- USC is equivalent to SC without Yen Loan and CO2 Credit and if the coal price increases in the future, USC becomes more feasible than SC.
- If either of Yen Loan or CO2 Credit is applicable, USC becomes more feasible than SC.

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## 7. Comprehensive Comparison of Project Sites

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Vinh Tan 4</th>
<th>Vung Ang 3</th>
<th>Binh Dinh 2 &amp; 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viability on PDP 7th (Planned COD)</td>
<td>4-#1 600MW (2017)</td>
<td>3-#1 600MW (after 2026)</td>
<td>2-#1 1,000MW (2029)</td>
</tr>
<tr>
<td></td>
<td>4-#2 600MW (2018)</td>
<td>3-#2 600MW (after 2027)</td>
<td>2-#2 1,000MW (2029)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-#3 600MW (after 2027)</td>
<td>3-#1 1,000MW (–)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-#4 600MW (after 2028)</td>
<td>3-#2 1,000MW (–)</td>
</tr>
<tr>
<td>Land Form</td>
<td>Rock Layers (about 40 meters deep from the ground)</td>
<td>Sand dune (about 30 meters high)</td>
<td>Sand dune (about 5 meters high)</td>
</tr>
<tr>
<td>Marine Work &amp; Other Civil *</td>
<td>Construction of port facilities and land levelization would be completed.</td>
<td>New port facility is necessary to construct. Wider area dredging required.</td>
<td>New port facility is necessary to construct. Dredging required.</td>
</tr>
<tr>
<td>Transmission Line</td>
<td>Under construction</td>
<td>Necessary to construct</td>
<td>Necessary to construct</td>
</tr>
<tr>
<td>Access Road</td>
<td>Very close to National Route #1</td>
<td>Very close to National Route #1</td>
<td>Necessary to construct access road about 20 km</td>
</tr>
<tr>
<td>Environmental &amp; Social Condition **</td>
<td>Involuntary Resettlement 80 households. Some resettlement areas have already planned and positive reaction of residential people to relocate new living area.</td>
<td>Involuntary Resettlement 72 households, 19 graves, 2 schools</td>
<td>Involuntary Resettlement 300 households, 1 primary school, 2 kindergartens, 2 temples and about 700 graves</td>
</tr>
</tbody>
</table>

Result: **Most Feasible** | **Feasible** | **Feasible**

* Cost allocation of port, jetty, unloading facility and other civil
** Information provided by local consultants
8. Conclusion

1. USC is Japanese prudent technology and its advantages of higher thermal efficiency and less fuel consumption will bring benefit to power sector in Vietnam.

2. USC Power Plant is economically feasible in all the three sites (Vinh Tan 4, Vung Ang 3, and Binh Dinh 2 & 3).

3. USC is equivalent to SC without Yen Loan and CO2 Credit and If the coal price increases in the future, USC becomes more feasible than SC.

4. If either of Yen Loan or CO2 Credit is applicable, USC becomes more feasible than SC.

5. It is feasible to introduce USC technology to each selected site of Vinh Tan 4, Vung Ang 3 and Binh Dinh 2 & 3.

6. Vinh Tan 4 is most feasible in terms of the comparison of site conditions.

7. Several million tons of CO2 emission reduction are expected by introducing USC power plant to the each selected site.

8. Additional revenue of CO2 credits will make each USC power plants more attractive once Bilateral Offset Credit Mechanism is established.

Conclusion

- USC technology is economically competitive with SC.
- Vinh Tan 4 is the most feasible site among the three selected sites.