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

Studies for Project Exploration and Planning

Vietnam Utilization and Mitigation of VAM/CMM Emissions at underground coal mines by the lean methane treatment system

New Energy and Industrial Technology Development Organization (NEDO)
Kawasaki Heavy Industries, Ltd.
Mitsui and Co., Ltd.
Overview:

◆ Study Contents:
  ➢ Assesses the opportunity of introducing a lean methane treatment system (“System” hereinfater) in underground coal mines in Vietnam.
  ➢ Assesses projects CMM (Coal Mined Methane) /VAM (Ventilated Air Methane) amount in Khe Cham Mines, and
  ➢ Makes feasibility study and replicable opportunity of System in Vietnam.

◆ Technology (Refer to the below flow diagram):
The System consists of a catalytic combustion gas turbine generator set and VAM oxidizer, which is unique design developed by Kawasaki Heavy Industries, Japan.
  ➢ **Catalytic gas turbine generator set:**
    to generate 850kW electricity by 2% concentration methane as fuel in the form of gas turbine intake air
  ➢ **VAM oxidizer:**
    to destruct VAM without NOx emissions by utilize use of gas turbine generator’s exhaust gas.
Findings (1) : Energy in general

◆ Coal-fired electricity hike:
  ➢ 50% of total electricity in 2025 from coal-fired electricity while total output becoming 6.6 times.

![Graph 1: Electricity Plan per primary energy resources](Sources: Coal Note)

◆ Underground coal mine supply increase:
  ➢ Coal supply from anthracite underground mines from 24 million tons in 2010 to 37 millions in 2025. To achieve this, deeper coal resource expected to be mined, resulting in more CH₄ emissions.
  ➢ Deeper coal mines are expected in future, resulting Coal Mined Methane (CMM) to be drained due to coal mine safe operation.

![Graph 2: Vietnam Coal Production Plan per mining method](Sources: Coal Note)
Findings (2) : Methane gas emissions

◆ **CH₄ emissions increased from coal mines:**
  - These emissions from current coal production profile i.e. 69% from open pit mine and 41% from underground mines.
  - As described in Findings (1) more coal will be mined from deeper underground with more CH₄ contained, resulting in 76% of coal production in 2025 to be from underground mines.

◆ **Gassy coal mines:**
  - The expected coal production in 2015 from gassy coal mines is 10 million tons of coal, which would liberate 99 million m³ of methane.
  - Methane will be liberated either in Coal Mined Methane (CMM) extraction or in Ventilated Air Methane (VAM), while more CMM extraction is expected due to mine safe operation.
  - Vinacomin starts the first pilot CMM in Khe Cham Mine in 2012, while plans several CMM extraction in other mines.

◆ **Projected CMM and VAM Amount in Khe Cham Mine:**

<table>
<thead>
<tr>
<th></th>
<th>Khe Cham I</th>
<th></th>
<th>Khe Cham II</th>
<th></th>
<th>Khe Cham III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CMM m³ CMM/h</td>
<td>VAM m³ VAM/h</td>
<td>2% Mixed m³ Mix/h</td>
<td>CMM m³ CMM/h</td>
<td>VAM m³ VAM/h</td>
</tr>
<tr>
<td>2016 (eg)</td>
<td>618</td>
<td>9,610</td>
<td>10,228</td>
<td>618</td>
<td>9,610</td>
</tr>
</tbody>
</table>

◆ **Khe Cham III as Model Project candidate:**
  - Study assesses feasibility the System based on expected CMM and VAM amount at Khe Cham III.
Findings (3) : Methodology

- ACM0008 based:
  - Methodology: based on ACM0008 with simplified version.
  - Baseline scenario: CMM extracted and emitted due to safe operation (methane concentration ratio is below 2%) + VAM emitted (methane concentration ratio is below 1%)
  - Project activities: a catalytic combustion gas turbine generator set and VAM oxidizer
  - Additionality: deemed due to non-common practice as well as representation of a-first-of-its-kind.
Findings (4) : Technical and Economic Feasibility

◆ Technical Feasibility with three cases:

<table>
<thead>
<tr>
<th>Case</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(CMM treated)</td>
<td>(All)</td>
<td>(Required for GT)</td>
<td>(Required for GT)</td>
</tr>
<tr>
<td>(Treated @ YAM oxidizer)</td>
<td>(Best CMM incl)</td>
<td>(Best CMM not incl)</td>
<td>(No oxidizer)</td>
</tr>
<tr>
<td>Gross output</td>
<td>850kW</td>
<td>850kW</td>
<td>850kW</td>
</tr>
<tr>
<td>Auxiliary electricity</td>
<td>90kW</td>
<td>45kW</td>
<td>30kW</td>
</tr>
<tr>
<td>Net electricity output</td>
<td>760kW</td>
<td>805kW</td>
<td>820kW</td>
</tr>
<tr>
<td>Net electricity/yr.</td>
<td>6,458kWh/yr</td>
<td>6,840kWh/yr</td>
<td>6,968kWh/yr</td>
</tr>
<tr>
<td>Emission Reductions/yr.</td>
<td>80,592tCO₂e/yr</td>
<td>54,409tCO₂e/yr</td>
<td>52,712tCO₂e/yr</td>
</tr>
<tr>
<td>Tariff (saved)</td>
<td>VND 1,245/kWh</td>
<td>(¥4.5/kWh)</td>
<td></td>
</tr>
</tbody>
</table>

◆ Economic Feasibility in case of Case-3:

- @ ERs Price of ¥1,200/tCO²e
  - Payback period 8.0 years
  - IRR 12.9%

◆ Replicability:

- Replicable opportunity: 18set of Systems to be installed in case of drainage efficiency 70%, contributing 954,000tCO²e Emissions Reductions in Vietnam.