The Achievement of Environmental Impact Controls
And
The Study on the IGCC Project
in Mae Moh Coal-Fired Power Plant

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Engineer from Mae Moh Power Plant

Electricity Generating Authority of Thailand, THAILAND
Contents

- Overview of Mae Moh Power Plant
- Power Plant Emission Control (SO₂, NO₂, TSP)
  - Process
  - Management measures
- Study of The IGCC Project 500 MW at Mae Moh
  [MHI + IEEJ + JCOAL + METI]
Overview Mae Moh Power Plant

Satellite Image Above Mae Moh Power Plant and Mining Area

Mae Moh mining process

Source: Mae Moh Mine, EGAT

<table>
<thead>
<tr>
<th>Unit</th>
<th>Construction (Year)</th>
<th>Operating (Year)</th>
<th>Generating Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1981</td>
<td>1984</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td>1981</td>
<td>1984</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>1982</td>
<td>1985</td>
<td>150</td>
</tr>
<tr>
<td>7</td>
<td>1982</td>
<td>1985</td>
<td>150</td>
</tr>
<tr>
<td>8</td>
<td>1986</td>
<td>1989</td>
<td>300</td>
</tr>
<tr>
<td>9</td>
<td>1987</td>
<td>1990</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>1989</td>
<td>1991</td>
<td>300</td>
</tr>
<tr>
<td>11</td>
<td>1989</td>
<td>1992</td>
<td>300</td>
</tr>
<tr>
<td>12</td>
<td>1991</td>
<td>1995</td>
<td>300</td>
</tr>
<tr>
<td>13</td>
<td>1991</td>
<td>1995</td>
<td>300</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>2,400</td>
</tr>
</tbody>
</table>

Remark: Unit 1-3 (3*75MW) were decommissioned since 1st October 2003

Electricity Generating Authority of Thailand
Overview Mae Moh Power Plant

EGAT Generation Plan Y2012

- **Installed Capacity**: 32,200 MW
- **Fuel Breakdown**:
  - Coal, 20.7%
  - Gas, 64.7%
  - Diesel, 0.05%
  - Fuel Oil, 0.06%
  - Hydro, 12.4%
  - Renewable, 1.4%
  - Other, 0.1%

- **Energy Generation and Purchase**: 166,457 GWh
- **Peak Demand**: 25,233 MW
- **Total Lignite Consumption**: 11.38 Million tons
- **Total Net Energy Generation**: 11,565 GWh
- **Availability Factor**: 93.14%

Coal Energy Generation Plan

- **Y2012 (8 months)**
- **Total Lignite Consumption**: 11.38 Million tons
- **Total Net Energy Generation**: 11,565 GWh
- **Availability Factor**: 93.14%

Source: System Control Operation Division, EGAT
Source: Mae Moh Production Division, EGAT
Overview Mae Moh Power Plant

- The existing units using domestic lignite at Mae Moh (Open Pit Mining: Area of 30 square kilometers)

- Consumption:
  - Lignite 45,000 ton/day (16 million ton/year)
  - Water 133,000 m$^3$/day (50 million m$^3$/year)
  - Limestone 3,600 ton/day (1.3 million ton/year)

- By Products and Emission:
  - Ash 4.4 million ton/year
  - Gypsum 2.4 million ton/year
  - $\text{SO}_2$, $\text{NO}_2$, TSP
  - Waste water 9.1 million m$^3$/year

PROXIMATE ANALYSIS

<table>
<thead>
<tr>
<th></th>
<th>% BY WT.</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOISTURE</td>
<td></td>
<td>30 - 32</td>
</tr>
<tr>
<td>ASH</td>
<td></td>
<td>20 - 26</td>
</tr>
<tr>
<td>VOLATILE MATTER</td>
<td></td>
<td>22 - 32</td>
</tr>
<tr>
<td>FIXED CARBON</td>
<td></td>
<td>15 - 23</td>
</tr>
<tr>
<td>AVG. SULPHUR</td>
<td></td>
<td>2.4 - 3.5</td>
</tr>
<tr>
<td>LHV</td>
<td>Kcal/Kg</td>
<td>2,450</td>
</tr>
<tr>
<td>HHV</td>
<td>Kcal/Kg</td>
<td>2,750</td>
</tr>
<tr>
<td>SULPHUR/LOW.HEAT</td>
<td></td>
<td>11.2 mg/Kcal</td>
</tr>
<tr>
<td>SULPHURDIOXIDE CONCENTRATION</td>
<td></td>
<td>4,536 ppm.</td>
</tr>
</tbody>
</table>

Source: Mae Moh Production Division, EGAT
PART I: EMISSION CONTROL
Air pollution occurred in the past

During 1992, in early October
- Weather(season) : rainy => winter
- High pressure atmosphere => the air around the plant to engross in the phenomenon

Ground level ambient SO$_2$ concentration was observed.

Environmental impact => people living in several villages located downwind from the power plant sought medical attention for symptoms which included stinging nose and throat and shortness of breath. The plants and animals have been affected.

 Afterwards, EGAT realize to eliminate the problem completely.

Pollution Control Department (PCD)
Ministry of Natural Resources and Environment, Thailand
Y1998 Issued New Standard: Mae Moh Power Plant Emission
- SO$_2$ Emission <780 µg/Nm$^3$ in one hour.
  And Total of all units <11 ton/hr.
- SO$_2$ Concentration <320 ppm.
FLUE GAS DESULFURIZATION SYSTEM (FGD)

: FGD Mae Moh Power Plant

: Actual SO₂ Emission @Stack Point Y2001 - Y2011 (Monthly)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Efficiency (%)</th>
<th>Commissioning (Year)</th>
<th>Construction Cost (Million Baht)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-5</td>
<td>97</td>
<td>2000</td>
<td>2,321</td>
</tr>
<tr>
<td>6-7</td>
<td>97</td>
<td>1999</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>95</td>
<td>1997</td>
<td>2,624</td>
</tr>
<tr>
<td>9</td>
<td>95</td>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>95</td>
<td>1998</td>
<td></td>
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<tr>
<td>11</td>
<td>95</td>
<td>1998</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>92</td>
<td>1995</td>
<td>2,160</td>
</tr>
<tr>
<td>13</td>
<td>92</td>
<td>1995</td>
<td></td>
</tr>
</tbody>
</table>

Total: 7,105

Source: Mae Moh Production Division, EGAT

Electricity Generating Authority of Thailand
SO\textsubscript{2} Emission control

Mae Moh Power Plant

Source: Mae Moh Production Division, EGAT
**SO₂ Emission Control Procedures**

**Normal controls at power plant:**

SO₂ Emission @stack sum of all units

- Mar-Oct < 4.8 ton/hr.
- Nov-Feb < 2.0 ton/hr. (06:00-12:00 am) < 3.0 ton/hr. (other times)

SO₂ concentrate at stations monitoring:

“Solution is Decrease Load to control”

**Emergency Case: FGD Outage (unavailable)**

- Reduce lignite consumption
- 30 mins. later if FGD still unavailable
  => use only diesel fuel. And then if FGD still unavailable within 2 hrs. must shutdown plant.
- Nov-Feb 06:00-11:00 am
  => Trip plant immediately

**Sources:** Mae Moh Production Division, EGAT
NO$_2$ Emission control

Successful NO$_x$ Removal!

No$_x$ Emission: The factors
- Oxidation with Nitrogen in fuel
- Oxygen/Nitrogen Ratio control

Sources: Mae Moh Production Division, EGAT

Electricity Generating Authority of Thailand
TSP Emission control

All Units : ESP Efficiency
more than design value (99.5-99.75%)

Successful TSP Removal!

Electro Static Precipitator (ESP)

Collecting Plate + Emitting Coil

Stack Particulates Emission (mg/Nm³)

Source: Mae Moh Production Division, EGAT
Continuous Emission Monitoring

11 stations + 1 point@Stack for each unit

- Mae Moh District Office
- Baan Sop Paad
- Pratu Pha Camp
- Baan Ta See
- Baan Sadej
- Baan Hua Fai
- Main Station
- Baan Sop Paad

Government Pollution Control Department Monitoring Station

- Baan Sop Moh
- Baan Mae Jang
- Rattanagisint
- Huai King

EGAT

Ambient Air Quality Monitoring Station

Electricity Generating Authority of Thailand
The pollution problems in the past as a key to improve the manufacturing process. More environmentally conscious.

We search for devices which high performance technology to capture particles that pollute the environment around Mae Moh Power Plant.

Process & Continuous Measuring Controls are very important.

ISO 14001 Certification: 1st time Y2001 (Cont. until now)

“Therefore, The Mae Moh Power Plant which is the largest coal-fired power plant in Thailand can control pollution emitted than the law requires.”
PART II: STUDY OF THE IGCC PROJECT
Study of The IGCC Project at Mae Moh

- **May 2011**: EGAT and IEEJ => coordinated =>
  To Applying Clean Coal Technology by study for Coal Gasification and Generation at Mae Moh
- **Jul. 2011**: Feasibility Study ➔ Start!
- **Aug. 2012**: Summary Report of the Study to EGAT
Study of The IGCC Project at Mae Moh

MHI Air-Blown IGCC System

1. Highly Efficient Gasifier (Air-Blown)

2. Highly Efficient Gas turbine (High Temperature)

3. Small ASU for N2 Production (for Coal Transportation and Inerting)

4. System Integration capability is MHI’s key factor of strength.

Electricity Generating Authority of Thailand
Study of The IGCC Project at Mae Moh

Variety of Coal Experience

Experience of various coals including Lignite MHI Gasifier successfully gasified, will enable Mae Moh Lignite gasification.

Electricity Generating Authority of Thailand
Study of The IGCC Project at Mae Moh

Features of MHI Air-Blown IGCC

- CO2 is extremely reduced by high efficiency.
- The Air-Blown IGCC is MHI’s original technology.

![Diagram showing efficiency and CO2 emission comparison between MHI Air-Blown IGCC and other conventional methods.](image)

- Net Plant Efficiency: $\eta$ (%) LHV
- CO2 Emission (%)

Assumption: Same gas turbine applied
Study of The IGCC Project at Mae Moh

Present Status of 250MW IGCC Demonstration Project (Nakoso)

- Ministry of Economy, Trade and Industry (METI)
  - 30% Subsidy
  - Joint Project Agreement

- Clean Coal Power R&D Co., Ltd.
  - 70% Contribution
  - Researchers

- MHI
  - Single Point Responsibility (EPC Turn-Key Contract)

Project is going on Schedule.
Operation started Sep. 2007
100% Load
2,000hrs. Continuous Operation finished
Coal Change / Load Swing / Efficiency Improvement, etc.
5,000hrs. Durability Test finished => Subsidy from METI ended

All of the demonstration targets have been achieved.

Electricity Generating Authority of Thailand
Study of The IGCC Project at Mae Moh

Typical Major Specification of 500MW Plant -Typical Plot Plan-

- Net Efficiency (LHV %)
  - Demo. Plant: 701DA G/T (38.2%)
  - 500MW Plant: 701F G/T (48.2%)

- Gross Output
  - 550 MW

- Output
  - Gross: 550 MW
  - Net: 500 MW

- Gasifier Oxidizer
  - Air

- Coal Feed
  - Dry

- Acid Gas Clean-up
  - Wet MDEA

- Gas Turbine
  - M701F × 1 (1 on 1)

- Net Efficiency (LHV)
  - Approx. 48 % (w/o CO2 Capture)

Note: Plant performance like output and efficiency depends on site conditions including coal properties. Emission performance like S0x, NOx and PM can be discussed, depending on the regional regulation.
## Study of The IGCC Project at Mae Moh

### Typical Major Specification of 500MW Plant - Utilities & Emissions -

<table>
<thead>
<tr>
<th>Items</th>
<th>Utilities</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal consumption</td>
<td>285.4 metric-ton/hour</td>
<td>As received basis</td>
</tr>
<tr>
<td>Oxygen consumption</td>
<td>40.3 metric-ton/hour</td>
<td>O2 purity: 95vol%</td>
</tr>
<tr>
<td>Slag discharge</td>
<td>38.5 metric-ton/hour</td>
<td>Dry basis</td>
</tr>
<tr>
<td>Elemental Sulfur production</td>
<td>5.0 metric-ton/hour</td>
<td>Elemental “S”</td>
</tr>
<tr>
<td>Cooling Water consumption</td>
<td>11,800 m³/hour</td>
<td></td>
</tr>
<tr>
<td>Demineralized water</td>
<td>34 metric-ton/hour</td>
<td>(max.)</td>
</tr>
<tr>
<td></td>
<td>17 metric-ton/hour</td>
<td>(ave.)</td>
</tr>
<tr>
<td>Industrial water</td>
<td>1,260 metric-ton/hour</td>
<td>(max.)</td>
</tr>
<tr>
<td></td>
<td>1,250 metric-ton/hour</td>
<td>(ave.)</td>
</tr>
</tbody>
</table>

### Emissions

<table>
<thead>
<tr>
<th>Items</th>
<th>Emissions</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust Gas Flow Rate</td>
<td>2,013,000 m³N/hour</td>
<td>dry basis</td>
</tr>
<tr>
<td>SOx</td>
<td>9.6 ppmV</td>
<td>@15%O2-dry</td>
</tr>
<tr>
<td>NOx</td>
<td>6.0 ppmV</td>
<td>@15%O2-dry</td>
</tr>
<tr>
<td>Dust</td>
<td>4.8 mg/m³N</td>
<td>@15%O2-dry</td>
</tr>
</tbody>
</table>

= 23 ppmV @7%O2-dry
= 14 ppmV @7%O2-dry

Electricity Generating Authority of Thailand
We are very interested in IGCC technology. Executive Committee was appointed to feasibility study this technology.

Although, in foreign countries such as USA, this technology has occurred for a long time. But that is a new technology for the electric power industry in Thailand. So it should be study the advantages - and disadvantages in more details.

Present status of IGCC, demonstration project(Nakoso) only 250 MW.

“Therefore, The chief executive of EGAT remain under consideration to apply IGCC for Replacement Project (600 MW) at Mae Moh Power Plant.”
Mae Moh Power Plant
“Energy and Environmental awareness always”

Thank you for your kind attention!