CASE STUDY FOR RETROFIT OF TURBINE INLET COOLING IN BATAM, INDONESIA

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Introduction

- About Medco Power
- About TAS
- Turbine inlet cooling – the impact
- Indonesia project execution
- Operating results
- Conclusions
About Medco Power

- Independent power developer based in Jakarta
- Subsidiary of Medco Energi Internasional
- Recent projects:
  - PT Dalle Energi Batam – 2 X RB211
  - PT Mitra Energi Batam – 2 X RB211
  - 340 MW Sarulla Geothermal Power Project in Indonesia
About TAS
Turbine Inlet Chilling the Impact

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Temperature Degradation

Combined Cycle Simple Cycle

~14 % Incremental Capacity?
Capturing High Value Markets

- Large daily demand peak AND price peak benefit TIC
- Generation mix will determine the value of off-peak power
- Weather profile contributes to power demand & price peak
Incremental Energy & Efficiency

Representative Plant Performance Curve

7FA CC evap cooled vs. Full TES
Chilling vs. Other Options (Metric)

The limit of fogging and evaporative technologies

Target turbine inlet

7°C

32°C

Common design dry bulb

Adiabatic Cooling

Mechanical Chilling

Relative Humidity (%)
Wet Bulb Temperature (°C)
Specific Enthalpy (kJ/kg dry air)
Specific Entropy (kJ/kg dry air).

Psychrometric Chart
Barometric Pressure 1.01325 bar

Dry Bulb Temperature (°C)
Humidity

°C
°C

°C
## Economics of inlet chilling

<table>
<thead>
<tr>
<th></th>
<th>209FA</th>
<th>209FA Chilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost (installed)</td>
<td>$315M ($492/KW)</td>
<td>$336M ($465/KW)</td>
</tr>
<tr>
<td>Base MW (35°C)</td>
<td>658</td>
<td>740</td>
</tr>
<tr>
<td>Heat Rate (BTU/KWH)</td>
<td>6,385</td>
<td>6,425 (+0.6%)</td>
</tr>
<tr>
<td>Non-Fuel O&amp;M</td>
<td>$4/MWH</td>
<td>$0.8/MWH (chiller)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$3.64/MWH (both)</td>
</tr>
<tr>
<td>Fuel Cost</td>
<td>$34.8/MWH</td>
<td>$35.0/MWH</td>
</tr>
<tr>
<td>Total Generation Costs</td>
<td>$38.8/MWH</td>
<td>$38.6/MWH (-0.5%)</td>
</tr>
</tbody>
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Assumptions:
1. Non-fuel O&M: GT parts, labor, maintenance, repairs, water treatment
2. US$ 5/MMBTU Gas

### Improvement in Generation Economics
PT Dalle Energy Batam

- System installed in parallel with new unit installation as a retrofit – not in base design
- Owner is PT Dalle Energy Batam
- Located in Batam
- Performance guarantees critical
- Integration with site activities
Project Execution

- System design
- Manufacturing
- Shipping
- Installation
- Startup and commissioning
- Actual Results
Note that there are typically no high RH incidents at high dry bulb temperatures!
Batam Summary

- Site conditions:
  - 32°C dry bulb & 27°C wet bulb
- Cooling to 13°C
- 20% incremental power - +9MW Net
- 1-2% heat rate improvement
- Incremental personnel: 0
- No impact on GT maintenance intervals or costs
- Chiller non-fuel O&M costs: US$0.50/MWH
RB211 Air Flow

Exhaust Gas Conditions

- Exhaust Gas Temperature (DegC)
- Exhaust Mass Flow (kg/sec)
- Ambient Temperature (DegC)

- Exhaust Temperature
- Exhaust Mass Flow
RB211 6761 Power & Heat Rate

Power and Heat Rate

Power Output (kWe)

Heat Rate (kJ/kWe.Hr)

Ambient Temperature (DegC)

5.5 MW – gross per GT
Batam Site Prior to Chiller
Delivering the Solution

- Site visits to confirm conditions and dimensions saved much time and effort
- Knowledgeable owner required
- Quality local supply of external structures and piping available – no issues
- Minimizing site interference is critical
Project Execution (cont.)

- Experienced shipping personnel necessary, but with this, process went well
- Local contractors had a learning curve on chilled water systems
- Modular solution critical to the overall solution
- Solutions provided required for startup and commissioning
Chiller Package On Site
Retrofit in Place Prior to Connection
Filterhouse Complete
Actual Measured Results

- Total project costs – on budget
- Heat Rate – 1-2% less than base plant
- +9 MW NET for 2 X RB211 at 32°C
Summary

- Turbine inlet cooling is accepted worldwide
- For power producers that need more power – great value proposition
- The humidity in Asia is not a problem
- Simple cycle plants running well for long periods
- Combined cycle plants benefit also as proven by installation on advanced GT’s