Combined Heat and Power (CHP)

COGENERATION at PETRONAS’ Gas Processing Plant

By: Fairos Roslan, Head of Business Development, PGB

Date: 5 June 2012

Venue: Room 403/404, KL Convention Center
Objective

- To share a case study example of Combined Heat and Power (CHP) on PETRONAS Gas Berhad (PGB)’s Cogeneration Plant installation project at Gas Processing Plant (GPP) A and B Complex, in Terengganu, Malaysia
INTRODUCTION TO PETRONAS GAS BERHAD (PGB)

BACKGROUND
- Current process operation and utilities at GPP A and GPP B

PGB’S PROPOSAL FOR COGENERATION SYSTEM
- Process operation and utilities with cogeneration system

JUSTIFICATION FOR COGENERATION SYSTEM
- Improved reliability of sales gas supply to the country
- Sales gas saving to the country
- Energy efficiency
- Attractive economics

CONCLUSION
Corporate Profile of PETRONAS GAS BERHAD (PGB)

- Private Limited Company
  - 23 May 1983

- Public Limited Company
  - 28 March 1995

- Listed on KLSE Main Board
  - 4 September 1995

- PETRONAS owns 60.63% equity
Business Division of PETRONAS GAS BERHAD (PGB)

- **Plant Operations Division (POD)**
  - Separating natural gas into Sales Gas, Ethane, Propane, Butane & Stabilised Condensate

- **Transmission Operations Division (TOD)**
  - Transporting and distributing of Sales Gas, Ethane, Propane & Butane via pipelines

- **Centralised Utility Facilities (CUF)**
  - Producer of industrial utilities i.e. Power, Steam, Nitrogen, Oxygen, cooling water, etc

- **Re-Gasification Terminal Division (RGTD)**
  - Operation of the LNG Regasification Facilities and Jetty

- **Headquarters (Enablers)**
  - HSE, Finance, HRM, Commercial, Project Team, etc.
PETRONAS GAS BERHAD (PGB) plays a major role in adding value to Natural Gas.
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Current Process Operation and Utilities setup at the Gas Processing Plant (GPP)-A

GPP A

Feed Gas
- Pretreatment
- Acid Gas Removal
- Dehydration

• Low Temperature Separation Unit
• Product Recovery Unit

Customers

Product
- Sales gas (C1)
- Ethane (C2)
- Propane (C3)
- Butane (C4)
- Condensate (C5+)

Sales Gas for Internal Gas Consumption (IGC)

Electricity
- Maximum demand: 21 MW
- Annual consumption: 178 Mil kWh

Other utilities
- E.g., Instrument Air, Nitrogen, Cooling Water

Steam system
- 390 degC, 39.5 bar
- Demand: 279 t/hr

Fuel Gas System
- 28 degC, 4.5 bar
- Gas Turbines, Furnace, Fired boilers

Notes:
* TNB: Tenaga Nasional Berhad i.e. national electricity grid/supplier

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPP 1</td>
<td>4.5</td>
</tr>
<tr>
<td>GPP 2</td>
<td>5.5</td>
</tr>
<tr>
<td>GPP 3</td>
<td>5.5</td>
</tr>
<tr>
<td>GPP 4</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td><strong>21</strong></td>
</tr>
</tbody>
</table>

Notes:
HRSG: Heat Recovery Steam Generator
IGC: Internal Gas Combustion

From TNB*
21 MW
Current Process Operation and Utilities setup at the Gas Processing Plant (GPP)-B

Feed Gas
- Pretreatment
- Acid Gas Removal
- Dehydration

Electricity
- Maximum demand: 22 MW
- Annual consumption: 186 Mil kWh

Other utilities
- E.g., Instrument Air, Nitrogen, Cooling Water

Steam system
- 410 degC, 44 bar
- Demand: 173 t/hr

Fuel Gas System
- 28 degC, 4.5 bar
- Gas Turbines, Furnace, Fired boilers

Product
- Sales gas (C1)
- Ethane (C2)
- Propane (C3)
- Butane (C4)
- Condensate (C5+)

Sales Gas for Internal Gas Consumption (IGC)

Location
<table>
<thead>
<tr>
<th>Maximum Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPP 5 &amp; 6</td>
</tr>
<tr>
<td>22</td>
</tr>
</tbody>
</table>

Notes:
* TNB: Tenaga Nasional Berhad i.e. national electricity grid/supplier

Notes:
HRSG: Heat Recovery Steam Generator
# Summary of GPP utilities

<table>
<thead>
<tr>
<th>UTILITY</th>
<th>SUPPLY CONDITION</th>
<th>DESCRIPTION</th>
<th>CURRENT DEMAND</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GPP A</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>11 kV</td>
<td>Maximum Demand</td>
<td>21,000 kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual Electricity Consumption</td>
<td>178 million kWh</td>
</tr>
<tr>
<td>HP Steam</td>
<td>Pressure: 39.5 bar (abs) Temperature: 390 DegC</td>
<td>Total HP Steam Demand</td>
<td>279 T/hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam generation from Fired Boilers</td>
<td>78 T/hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam generation from Waste Heat Boilers</td>
<td>201 T/hr</td>
</tr>
<tr>
<td>Fuel Gas</td>
<td>Pressure: 4.5 barg Temperature: 28 degC</td>
<td>Total Consumption</td>
<td>36.6 mmscfd</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consumption at gas turbines, furnace and other users</td>
<td>27.22 mmscfd</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consumption at steam system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supp. Firing at HRSG: 4.23 mmscfd Fired boiler: 5.15 mmscfd</td>
<td></td>
</tr>
<tr>
<td><strong>GPP B</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>132 kV / 33 kV / 6.6kV</td>
<td>Maximum Demand</td>
<td>22,000 kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual Electricity Consumption</td>
<td>186 million kWh</td>
</tr>
<tr>
<td>HP Steam</td>
<td>Pressure: 44 bar (abs) Temperature: 410 DegC</td>
<td>Total HP Steam Demand</td>
<td>173 T/hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam generation from Fired Boilers</td>
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<td>Fuel Gas</td>
<td>Pressure: 4.5 barg Temperature: 28 degC</td>
<td>Total Consumption</td>
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<td></td>
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<td>Fired boiler: 4.41 mmscfd</td>
</tr>
</tbody>
</table>
Presentation outline

• INTRODUCTION TO PETRONAS GAS BERHAD (PGB)

• BACKGROUND
  • Current process operation and utilities at GPP A and GPP B

• PGB’S PROPOSAL FOR COGENERATION SYSTEM
  • Process operation and utilities with cogeneration system

• JUSTIFICATION FOR COGENERATION SYSTEM
  • Improved reliability of sales gas supply to the country
  • Sales gas saving to the country
  • Energy efficiency
  • Attractive economics

• CONCLUSION
GPP-A installation of new COGEN unit will enable us to shutdown 2 fired-boilers while satisfying the steam demand.

**Feed Gas**
- Pretreatment
- Acid Gas Removal
- Dehydration

**Cogeneration unit**
- Generation Capacity: 12,300 kW x 2 units
- HRSG capacity: 25 t/hr x 2 units

**Low temperature separation unit**
- Product Recovery Unit

**Sales Gas for Internal Gas Consumption (IGC)**
- • Sales gas (C1)
- • Ethane (C2)
- • Propane (C3)
- • Butane (C4)
- • Condensate (C5+)

**Customers**

**Electricity**
- Maximum demand: 21 MW
- Annual consumption: 178 Mil kWh

**Other utilities**
- E.g., Instrument Air, Nitrogen, Cooling Water

**Steam system**
- E.g., Gas Turbines, Furnace, Fired boilers
- 390 degC, 39.5 bar
- Demand: 279 t/hr
- Gas Turbines, Furnace, Fired boilers

**Fuel Gas System**
- 28 degC, 4.5 bar
- (Supp.firing) 4.23 mmscfd
- 2.64 mmscfd
- 5.66 mmscfd

**Electricity from COGEN**
- 21 MW

**Steam from COGEN**
- 38 t/hr

**HRSG**
- 40 t/hr
- 78 t/hr

**Fired Boiler**
- 201 t/hr

**GPP A**

**From TNB**
- 0.5 MW
GPP-B installation of new COGEN unit will enable us to totally shutdown the operation of fired-boilers

**Cogeneration unit**
Generation Capacity: 12,300 kW x 2 units
HRSG capacity: 25 t/hr x 2 units

**Electricity**
Maximum demand: 22 MW
Annual consumption: 186 Mil kWh

**Other utilities**
E.g., Instrument Air, Nitrogen, Cooling Water

**Steam system**
410 degC, 44 bar
Demand: 173 t/hr

**Fuel Gas System**
28 degC, 4.5 bar
Gas Turbines, Furnace, Fired boilers

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- Sales gas (C1)
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**Sales Gas for Internal Gas Consumption (IGC)**

**Feed Gas**
Pretreatment
Acid Gas Removal
Dehydration

**Low temperature separation unit Product Recovery Unit**

**Customers**

**Electricity**
From TNB
0.5 MW

**Cogeneration unit**
Generation Capacity: 12,300 kW x 2 units
HRSG capacity: 25 t/hr x 2 units

**Steam from COGEN**
40 t/hr

**Steam system**

**Fired Boiler**

**HRSG**

**Fuel Gas System**

**Sales Gas for Internal Gas Consumption (IGC)**

**Customers**

**Electricity**
From TNB
0.5 MW

**Cogeneration unit**
Generation Capacity: 12,300 kW x 2 units
HRSG capacity: 25 t/hr x 2 units

**Steam system**
Steam from COGEN
40 t/hr

**Fuel Gas System**

**Sales Gas for Internal Gas Consumption (IGC)**

**Customers**
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<td></td>
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<td>-nil-</td>
<td>6.15 mmscfd</td>
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  • Sales gas saving to the country
  • Energy efficiency
  • Attractive economics

• CONCLUSION
Sales Gas supply reliability to the country will improve from 93.8% to 99.9%

- **Offshore Feed Gas Supply Reliability**
  - 2010: 78.5%

- **Gas Processing Plant Reliability**
  - 2010: 99.6%

- **Gas Transmission Pipeline Reliability**
  - 2010: 99.9%

- **Power Supply to GPP Reliability**
  - 2010: 96 - 97%

**Sales Gas Supply Reliability**

- **2010**: 93.8%
- **2014**: 99.9%

**On-going development by PETRONAS**

- Development of new gas field
- Development of marginal fields.
- Re-gasification facilities by 2012
- Plant Revamp and Rejuvenation in 2013 - 2014
- Sustenance of performance
- Installation of cogeneration plant at GPP

**Sales Gas supply reliability to the country**

- **2010**: 93.8%
- **2014**: 99.9%

---

(1) Source data: POD Production Planning department
(3) Calculated based on GPP
(4) High reliability of power supply to GPP due to parallel operation with TNB. Cogen reliability is at 97.6% as per PGB project proposal
Sales Gas savings to the country is 3.93 mmcf/d

Total savings to the country: 3.93 mmcf/d

3.93 mmcf/d = 19 MW electricity can be generated

3.93 mmcf/d = RM 59.5 million/year @ Gas price = RM 38.00/mmbtu
Power generation efficiency comparison between TNB and PGB Cogeneration for GPP-A

**INPUT**

- **Fuel Input**
  - 4.31 mmscf/d
  - (45.9 x 10^6 kcal/hr)

- **Power Generation by TNB**
  - Efficiency: 39.4%*

- **Electricity generated**
  - 21.0 MW
  - (18.1 x 10^6 kcal/hr)

**OUTPUT**

- **Electricity generated**
  - 21.0 MW
  - (18.1 x 10^6 kcal/hr)

**GPP A Cogen**

- **Fuel Input**
  - 5.66 mmscf/d
  - (60.3 x 10^6 kcal/hr)

- **Efficiency**
  - 69%

- **Electricity generated**
  - 21.0 MW
  - (18.1 x 10^6 kcal/hr)

- **38 T/hr HP Steam generated**
  - (23.5 x 10^6 kcal/hr)

* Overall TNB Net thermal efficiency was taken from TNB 2010 Annual Report
Power generation efficiency comparison between TNB and PGB Cogeneration for GPP-B

**INPUT**

- **Fuel Input**
  - 4.51 mmscfd
  - \((48.0 \times 10^6 \text{ kcal/hr})\)

**TNB**

- **Efficiency** 39.4%*
- **Electricity generated**
  - 22.0 MW
  - \((18.9 \times 10^6 \text{ kcal/hr})\)

**Output**

- **Electricity generated**
  - 22.0 MW
  - \((18.9 \times 10^6 \text{ kcal/hr})\)

**GPP B Cogen**

- **Fuel Input**
  - 6.15 mmscfd
  - \((62.0 \times 10^6 \text{ kcal/hr})\)

- **Efficiency** 71%
- **Electricity generated**
  - 22.0 MW
  - \((18.9 \times 10^6 \text{ kcal/hr})\)

- **HP Steam generated**
  - 40 T/hr
  - \((25.1 \times 10^6 \text{ kcal/hr})\)

* Overall TNB Net thermal efficiency was taken from TNB 2010 Annual Report
New Cogeneration plant is economically feasible

Economics results for 20 years (from Year 2011-2032)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROI</td>
<td>17.8 %</td>
</tr>
<tr>
<td>NPV@ 10%</td>
<td>RM 71.9 million</td>
</tr>
<tr>
<td>Payback period</td>
<td>6.5 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROI</td>
<td>26.7%</td>
</tr>
<tr>
<td>NPV@ 10%</td>
<td>RM 147.6 million</td>
</tr>
<tr>
<td>Payback period</td>
<td>3.5 years</td>
</tr>
</tbody>
</table>
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  - Energy efficiency
  - Attractive economics

- CONCLUSION
This COGENERATION Project will benefit the country in the aspect of...

• **Transfer of operational risk from TNB to PGB** for the security of supply for sales gas to the country

• **Improved reliability of sales gas supply** to the nation from 93.8% to 99.9%, above world class reliability standard.

• **Net reduction of sales gas volume** available to the nation by 3.93 mmscfd

• **Improved overall thermal efficiency** from 39.4% to 69% at GPP A and 71% at GPP B.

• **Economically feasible** with Internal Rate of Return (IRR) of 17.8% and 26.7% at GPP A and GPP B respectively.
Thank You
BACKUP SLIDES
Upstream reliability = Actual supplied volume

\[
\text{Plant capacity} \\
\frac{2321}{2512} = 92.4\% \\
\frac{1972}{2512} = 78.5\% \\
\frac{2437}{2512} = 97.0\% \\
\frac{2470}{2512} = 98.3\%
\]

* Calculated based on KPBI yr 2014
* Figures are calculated based on actual data

### Power supply reliability to GPP (based on 4 years data)

<table>
<thead>
<tr>
<th>Year</th>
<th>GPP A Outage (hr)</th>
<th>GPP B Outage (hr)</th>
<th>GPP A Reliability (%)</th>
<th>GPP B Reliability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1.2</td>
<td>0</td>
<td>99.99</td>
<td>100</td>
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<tr>
<td>2009</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2008</td>
<td>48.25</td>
<td>0</td>
<td>99.45</td>
<td>100</td>
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<tr>
<td>2007</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Power generation thermal efficiency (extracted from TNB 2010 Annual Report, pg 121)
<table>
<thead>
<tr>
<th>NO</th>
<th>DESCRIPTION</th>
<th>INFO / VALUE ASSUMPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maximum Demand During Peak Period</td>
<td>GPP A: 21 MW, GPP B: 22 MW</td>
</tr>
<tr>
<td>2</td>
<td>Total power consumption</td>
<td>GPP A: 178 Mil kWh, GPP B: 186 kWh</td>
</tr>
<tr>
<td>3</td>
<td>Natural Gas Price</td>
<td>RM 10.70/mmbtu according to GPTA until 2014. By the year 2015 onwards, RM 38/mmbtu as per PEMANDU guideline</td>
</tr>
<tr>
<td>4</td>
<td>Total CAPEX Cost</td>
<td>RM 142.6 mil (per GPP)</td>
</tr>
<tr>
<td>5</td>
<td>Project Life</td>
<td>20 Years. Commercial Operation Date (COD) -July 2013</td>
</tr>
<tr>
<td>6</td>
<td>Debt : Equity Ratio</td>
<td>100 % Equity</td>
</tr>
<tr>
<td>7</td>
<td>Depreciation</td>
<td>Straight line over 20 years</td>
</tr>
<tr>
<td>8</td>
<td>Capital Allowance</td>
<td>1st Yr: 34%, 2nd-5th Yr: 14%, 6th Yr: 10%</td>
</tr>
<tr>
<td>9</td>
<td>Reinvestment Allowance</td>
<td>60 %</td>
</tr>
<tr>
<td>10</td>
<td>Corporate Income Tax</td>
<td>25 %</td>
</tr>
<tr>
<td>11</td>
<td>TNB Electric Tariff Charge</td>
<td>GPP A: E2 Rate, GPP B: E3 Rate</td>
</tr>
<tr>
<td>12</td>
<td>TNB Electricity Annual Increment</td>
<td>3.0% (Based on historical data)</td>
</tr>
<tr>
<td>13</td>
<td>Non Firm Stand-by From TNB</td>
<td>GPP A: 9 MW, GPP B: 10 MW</td>
</tr>
</tbody>
</table>
## Economic assumptions (2/2)

<table>
<thead>
<tr>
<th>NO</th>
<th>DESCRIPTION</th>
<th>INFO /VALUE ASSUMPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Discount Rate</td>
<td>10%</td>
</tr>
<tr>
<td>15</td>
<td>Exchange Rate</td>
<td>1 USD = RM 3.03 as publish by Bank Negara Malaysia on the 22\textsuperscript{nd} Feb 2011</td>
</tr>
<tr>
<td>16</td>
<td>GT ,Generator &amp; HRSG Maint</td>
<td>RM 2.3 Million /yr</td>
</tr>
<tr>
<td>17</td>
<td>Annual Increment of Gas Turbines &amp; Generator Maintenance Cost</td>
<td>3 % ( Based on average US-CPI index)</td>
</tr>
<tr>
<td>18</td>
<td>GTG and HRSG Reliability</td>
<td>96%</td>
</tr>
</tbody>
</table>
Existing GPP-A Steam System Overview
(GPP Generates 78 t/hr of steam from fired-boilers)
GPP-A Steam System Overview – Post COGEN project i.e. able to shutdown 4/6 fired-boilers
Existing GPP-B Steam System Overview (GPP Generates 63 t/hr of steam from fired-boilers)
GPP-B Steam System Overview – Post COGEN project i.e. able to shutdown ALL fired-boilers

With COGEN in the future, GPP B are able to switch to AGRU motor pumps, thus, reducing the total steam demand from 173 t/hr to 138 t/hr.