Methane to Markets
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Overview of Jincheng 120 MW Coal Mine Methane Cogeneration Power Project in PRC
Sustainable Green Electricity From Coal Gas in China

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Road Map for the Presentation

- Introduction
- Technical Challenges and Selection
- Product Capabilities
- Commercial Opportunity
Road Map

• Introduction
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Project Timeline

- **Phase 1 - First 30 packages**
  - CAT Introduction: November 2002
  - US TDA $0.5M Funds Approved: January 2005
  - CAT Awarded Contract: March 2006
  - Grand Signing Ceremony in BJ: March 2007
  - Phase 1 Commissioning: May 2007
  - Project Handover: June 2007

- **Phase 2 - Second 30 packages**
  - Custom Visit CBM EPG Site: March 2004
  - ADB Project Loan Approved: March 2005
  - Announcement of CAT Successful Bid: November 2005
  - Tender Open: December 2005
  - CAT Successful Bid: April 2006
  - Tender Open: March 2006
  - CAT Selected: April 2006
Project Scope

- 120 MW of 24/7 Continuous Electric Power and Steam Generation
  - Divided into 4 Bank of 30 MW Each
  - 60X CAT 1.8 MW G3520C CMM Gas Engines
  - 16.5 Tons/hr of Superheated Steam Generation at 2.5 MPa and 400°C
  - 4X 3 MW Steam Turbines and/or 10 MW of Hot Water for Winter Heating
  - 10.5 kV, 50 Hz Operation
  - Standard Grid Parallel with Emergency Island Mode
  - Full Load System Thermal Efficiency of 80%
3 MW Steam Turbine

HRSG

5X G3520C

G3520C
Power Project Benefits

• Commercial
  – Improve project viability, cash flow on account of Carbon credit

• Social - Economic and Environmental
  – Electric Power for Township
  – Energy Efficiency Program – Cogeneration
  – Removal of Hazardous Gas – Mine Safety
  – Reduction of Greenhouse Gas – Environmental (CDM Program in Place)
Vital Statistics

• Power Generation - Export to Utility
  – 840,000 MW-hr/yr

• Heat Recovery
  – 233,600 GJ

• Carbon Credit
  – 4.5 MMTCE to the World Bank’s Prototype Carbon Fund
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Low Energy Fuels

Low Energy Fuel Heat Range

- Coal Seam
- Landfill
- Digester
- Wood Chip
- Manufactured

Heat Value (MJ/Nm³)
## Typical Fuel Properties

<table>
<thead>
<tr>
<th>Component</th>
<th>Symbol</th>
<th>Units</th>
<th>Pipeline Natural Gas</th>
<th>CBM</th>
<th>CMM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>CH$_4$</td>
<td>vol %</td>
<td>92.3</td>
<td>85.9</td>
<td>40.0</td>
</tr>
<tr>
<td>Ethane</td>
<td>C$_2$H$_6$</td>
<td>vol %</td>
<td>2.5</td>
<td>3.8</td>
<td>---</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>H$_2$S</td>
<td>vol %</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O$_2$</td>
<td>vol %</td>
<td>---</td>
<td>2.1</td>
<td>12.6</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N$_2$</td>
<td>vol %</td>
<td>3.5</td>
<td>8.2</td>
<td>46.8</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>vol %</td>
<td>1.8</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Lower Heating Value</td>
<td>LHV</td>
<td>MJ/Nm$^3$</td>
<td>33.2</td>
<td>32.5</td>
<td>13.4</td>
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<tr>
<td>Caterpillar Methane Number</td>
<td>MN</td>
<td></td>
<td>80</td>
<td>86</td>
<td>100</td>
</tr>
</tbody>
</table>

* Represents one particular site
Key Technical Challenges

- Fuel Quality and Fuel Handling
  - Gas Conditioning
  - Combustion Stability
  - Emissions
  - Life
Gas Conditioning

• < 80% Relative Humidity at Minimum Gas Operating Temperatures Required
• Gas to be Filtered for Particulates < 2 microns
• Pressures to be Boosted Up from Near Atmospheric to 700 mbar
Fuel Management and Handling

- Fuel Quality Swing Considerations
  - Predetermined Fuel Composition Information
    - Ensures Engine Safety, Reliability, Performance and Life

- Contaminant Control
  - Minimized Contaminants
    - Ensures Longevity
    - Reduces Downtime
    - Lowers O&M and Repair Costs
Selection Criteria

- Gas Pressure Requirement for Prime Mover
- Availability of Gas – Resource Assessment
- Generation Voltage
- Utility Connection Point Voltage
- Ability to Tolerate Fuel Swings
- Capital Costs
Selection Criteria

Gas pressure requirement

- Why is it important?
  - Well pressure is in the order of 50-100 mbar
  - Compression equipment needed to boost the pressure
  - Volumes required are high due to the low LHV
- High speed Engines 1 – 2 MW require 300-1000 mbar (16 HP/ MW Compressor power)
- Medium Speed Engines 3 – 6 MW range need 2 – 3 bar (50 HP/ MW Compressor power)
- Turbines (6 MW and above) need around 25 bar (130 HP/ MW Compressor power)
- Higher pressure calls for more elaborate compression equipment
  - More power needed just to boost compression
  - Wasted Energy consumption affects overall efficiencies
  - More safety concerns
Selection Criteria

Availability of Gas

- Depends on the type and characteristics of the mine
- Limited by the extractability and process of mining
- Wide fluctuations in volume is a real possibility
Selection Criteria

- Ability to tolerate fuel swings
  - Depends on the type of gas available in the region
  - Calls for a faster response of the Engine
  - Calls for better air fuel ratio control
Gas Generator Set selected

- From all the arguments the following emerge
  - Require Engines operating with lower gas pressures
  - Due to volume variation multiple units required
  - Flexibility to have Low Voltage & High Voltage Generation
  - Ability to response quickly to fuel swings
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Engine Technology Development

- Basic Requirements
  - Safety
  - Reliability
  - Efficiency
  - Low Emissions
  - Product Support

Voice of the Customer!
Product Support

• Fast Repair and Reduced Downtime
  – Critical for Plant Economics
  – Cannot be Compensated with Higher Efficiency

• Worldwide Logistics
  – Parts Supply within 24 hours

• Service Contracts
  – Extended Service Agreements
  – Fleet Management
Road Map

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Project Finance (USD 240M)

• Bank Loans (74%)
  – Asian Development Bank
  – Japan Bank for International Cooperation
  – Industrial Commercial Bank of China

• Equity Capital (26%)
  – Coal Mining Group
  – Provincial Government
  – Municipal Government

• Grants
  – USTDA Grant on project management (USD 450K)
Equipment Partnership

• Customer and End User
  – Coal Mining Group
• Equipment Suppliers
  – Caterpillar (Gas Generator Sets, Switch Gear, Gas Train)
  – Shanghai Electric Company (Balance of Plant)
Project Cash Flow

- Power Purchase Agreement (PPA)
  - Established with Provincial Utility Company

- Fuel Purchase Agreement (FPA)
  - Established between sister companies under the same Mining Group

- Carbon Credit Trading
  - Carbon credits (4.5 million tones CO$_2$ equivalent) from the World Bank’s Prototype Carbon Fund
  - Estimated carbon credit trading between $5-10 USD/ton
QUESTIONS?
Thank You

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