Sustainable Energy Development
Coal Mine Methane in China

Overview of a 120 MW Coal Mine Methane Cogeneration Power Project in PRC

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Road Map for the Presentation

• Introduction
• Selection Criteria and Product Capability
• Project Challenges
• Commercial Opportunity
• Summary
Road Map for the Presentation

• Introduction
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Power house

HV Substation

Power house

Water Treatment

DCS Building

Compression Station
120MW CMM Project

P.R. China

Shanxi

Beijing

Project Site
HISTORICAL MOMENT
MAY 18, 2006
GRAND SIGNING CEREMONY
GREAT HALL OF THE PEOPLE
TIANANMEN SQUARE
Project Timeline (Pre Contract)

- **November 2002**: CAT Introduction
- **March 2004**: Custom Visit CBM EPG Site
- **US TDA $0.5M Funds Approved**: Jan 2005
- **Customer Visit CAT in the U.S.**: April 2005
- **Announcement of CAT Successful Bid**: March 2006
- **November 2005**: Tender Open
- **March 2006**: Tender Open
- **April 2006**: CAT Awarded Contract
- **May 2006**: Grand Signing Ceremony in BJ
- **ADB Project Loan Approved**: March 2005
Project Timeline (Post Contract)

- **Sep 2006**: Delivery of 1st batch of 30 G3520C Genset + Auxiliary
- **Feb 2007**: Delivery of 2nd batch of 30 G3520C Genset + Auxiliary
- **Jun/Aug 2007**: Test/Commissioning of 120MW power plant
- **Sep-Oct 2007**: All wiring check & Test
- **#4 & #3 Power house construction & equipment installation**
- **#2 & #1 Power house construction and equipment & installation**

**Phase 1 - First 30 packages**
**Phase 2 - Second 30 packages**
Project Timeline (Post Contract)

Sep 2006
- Deliver 1st batch of 30 G3520C Genset + Auxiliary

Feb 2007
- Deliver 2nd batch of 30 G3520C Genset + Auxiliary

Jun/Aug 2007
- All wiring check & Test

Sep-Oct 2007
- Test/Commissioning of 120MW power plant

#4 & #3 Power house construction and equipment & installation

#2 & #1 Power house construction and equipment installation
120 MW Coal Mine Methane Cogeneration Power Plant
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
  - Full Load System Thermal Efficiency of 80%

- **Equipment Suppliers**
  - Caterpillar (Gas Generator Sets, Switch Gear, Gas Train)
  - Shanghai Electric Company (Balance of Plant)
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# 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>CH₄</td>
<td>vol %</td>
<td>92.3</td>
<td>85.9</td>
<td>40.0</td>
</tr>
<tr>
<td>Ethane</td>
<td>C₂H₆</td>
<td>vol %</td>
<td>2.5</td>
<td>3.8</td>
<td>---</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>H₂S</td>
<td>vol %</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O₂</td>
<td>vol %</td>
<td>---</td>
<td>2.1</td>
<td>12.6</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N₂</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/Nm³</td>
<td>33.2</td>
<td>32.5</td>
<td>13.4</td>
</tr>
<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
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
Selection Criteria

- Utility Connection Point Voltage
  - Depends on the size of the power plant and load in the region
  - Depends upon the availability of the transmission line nearby
  - Depends on the location of the unit

- Higher the connection point voltage the better the Stability
- Local plant load usually integrated with the Utility
Gas Generator Set selected

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

• Basic Requirements
  – Safety
  – Reliability
  – Efficiency
  – Low Emissions
  – Product Support

Voice of the Customer!
Efficiency Improvements

- Leaner combustion with high energy spark initiation
- Cross-Flow cylinder head for improved engine breathing
- Increased power density for more efficient fuel utilization
- Integrated control of timing, speed, and combustion
- Patented air/fuel and emission controls
- Optimized valve events for efficiency improvement
Engine Emission Enhancement

- **Power Density Impact**
  - New Gas Engines Have Higher Power Density Than Comparable Diesel Engines at Continuous Ratings

- **Efficiency Impact**
  - 7 Points More Efficient

- **Emissions Impact**
  - 75% Reduction in NO\textsubscript{X}
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
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Key Project Challenges

#1 - Phase 1 - G3520C Generator Set & Aux. – Five months after Contract

Action:-

• Strong Support from Caterpillar. Top priority for Sustainable Development Project
• Key project managers – Factory, Regional & local level
• Daily/weekly meeting on progress
• Advance Logistic arrangement
• Working closely with customer and importation company.
#2 - Learning Experience

- First in the country - Large scale coal mine methane power plant development
  - Design Concept
  - Contracting
  - Project management
#3 – Complexity in Project Management

- 9 Bid Packages
- Need experience project manager to organize and pull the work together
- Critical Path analysis
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Power Project Benefits

• Commercial
  – Largest CMM Power Plant in the World

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

• Corporate Governance
  – Improve Bilateral Trade between USA and China
Vital Statistics

• Power Generated and Sold to Utility
  – 840,000 MW-hr/yr

• Heat Recovery in Winter
  – 233,600 GJ

• Carbon Credit
  – 4.5 MMTCE to the World Bank’s Prototype Carbon Fund
Project Finance (USD240M)

• 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)
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Sustainable Green Electricity from Coal Gas in China

- **Safety** Concerns – A Local Priority
  - Effective Drainage

- **Security** Concerns – A National Priority
  - Energy Price’s Volatility

- **Environmental** Concerns – A Global Priority
  - Increasing Global Warming awareness worldwide
James Connaugton
Chief Council of Environment Quality
White House

Visited

Jincheng 120mW Power Plant in

August 2007
Thank You