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WHERE THE WORLD TURNS FOR POWER

Methane to Markets
Feb 22-23, New Delhi

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

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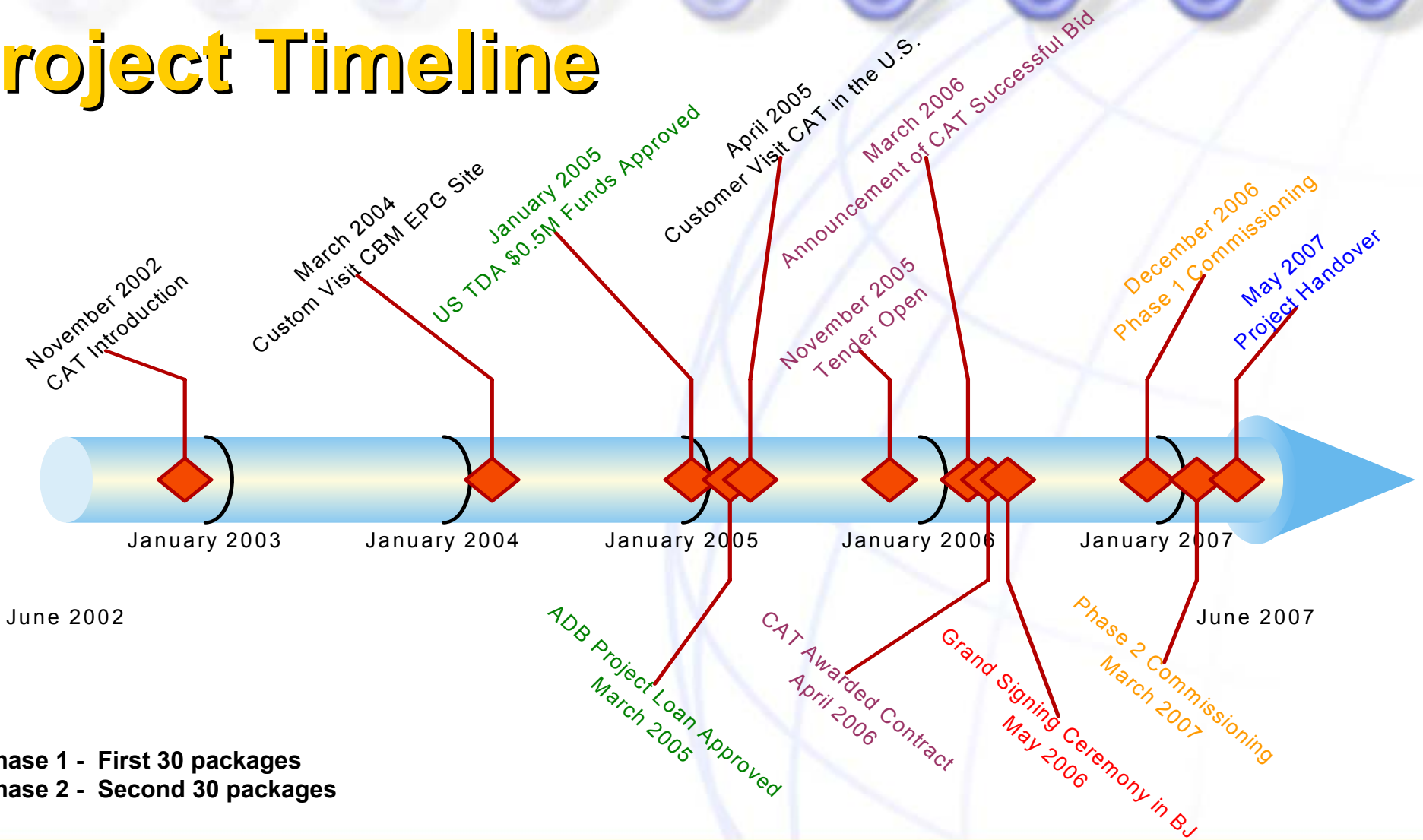
Project Timeline



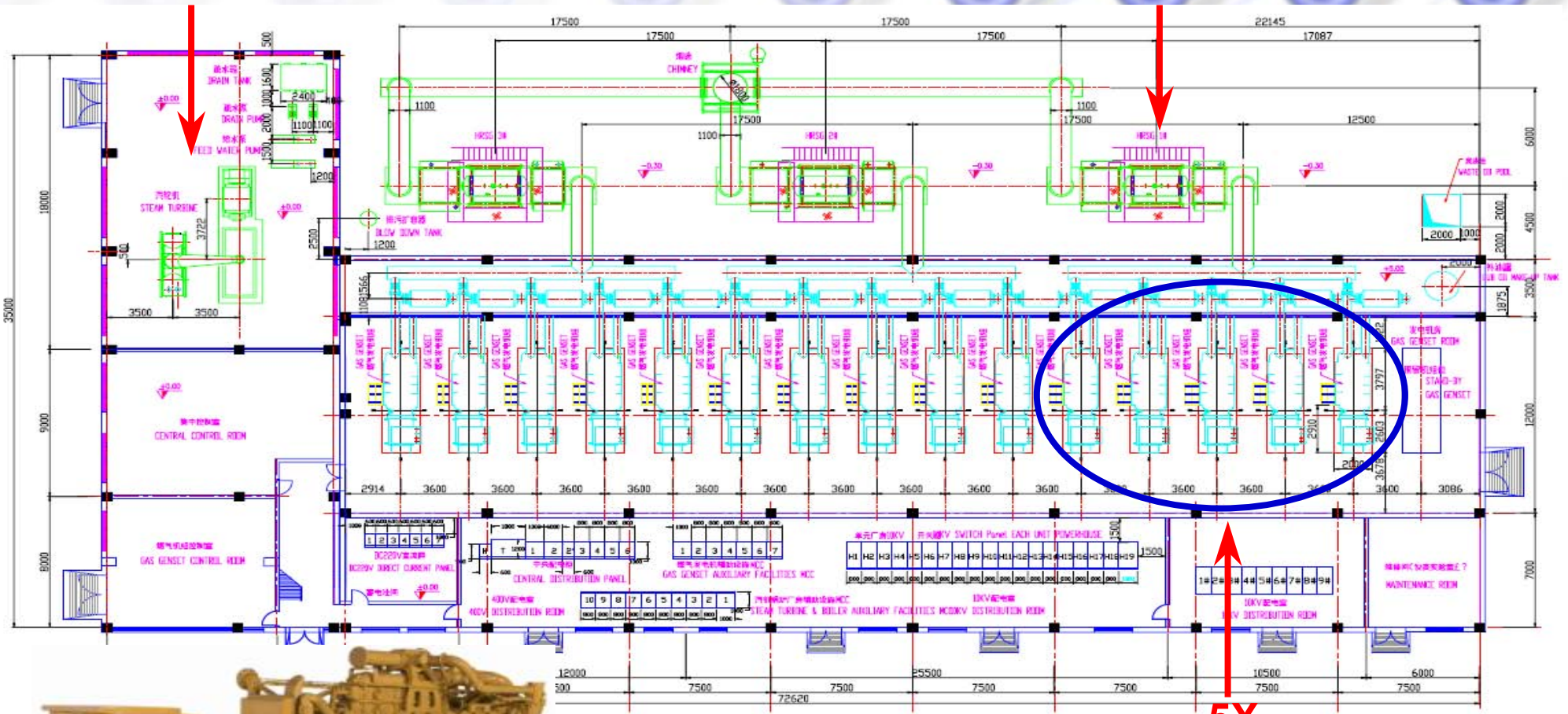
Phase 1 - First 30 packages
Phase 2 - Second 30 packages

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%

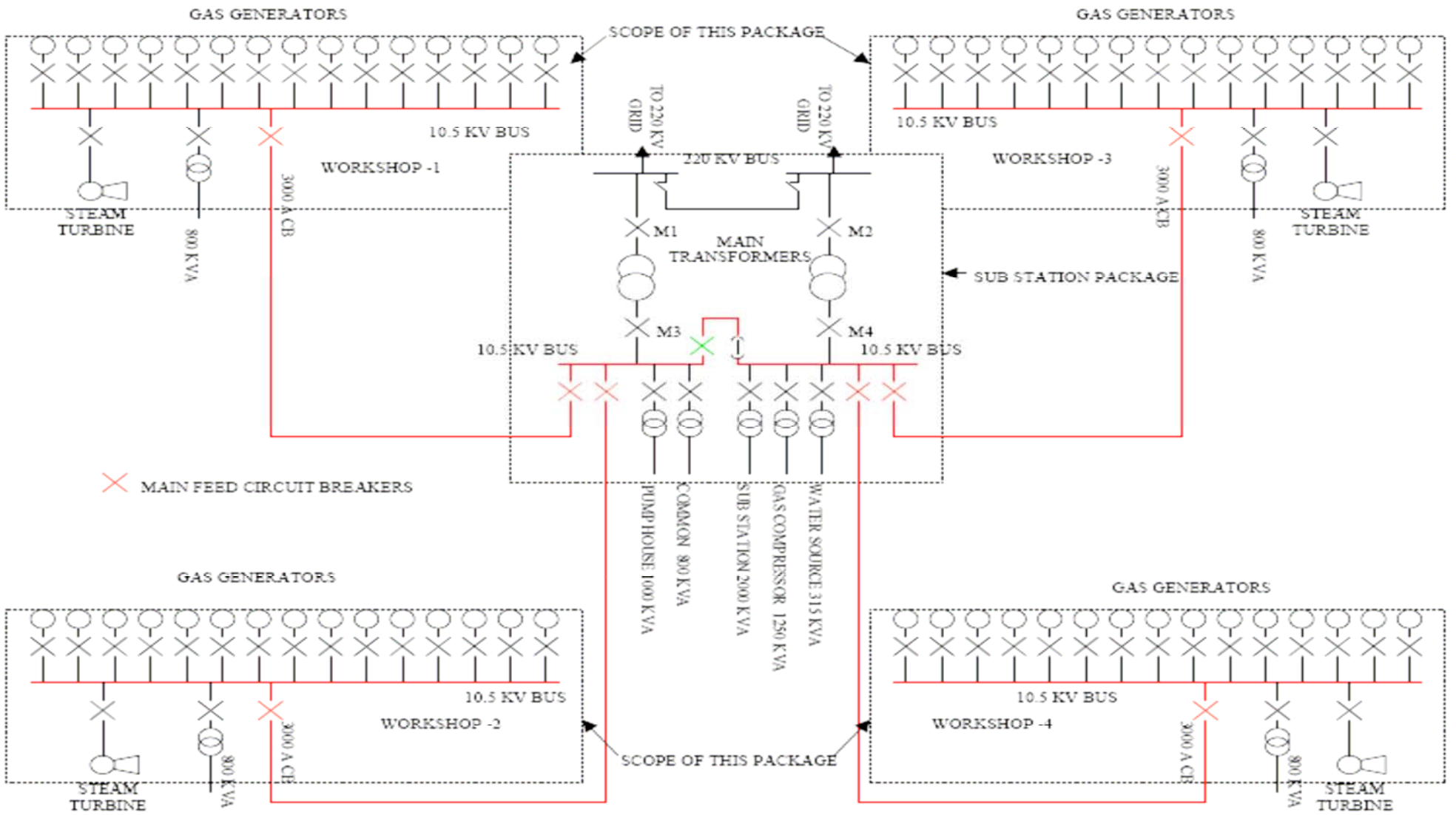
3 MW Steam Turbine

HRSG



G3520C

5X
G3520C


GAS GENERATORS
SCOPE OF THIS PACKAGE
GAS GENERATORS
10.5 KV BUS
WORKSHOP -1
3000 A CB
STEAM TURBINE
800 KVA
TO 220 KV GRID
TO 220 KV GRID
220 KV BUS
M1
M2
MAIN TRANSFORMERS
M3
M4
10.5 KV BUS
10.5 KV BUS
10.5 KV BUS
WORKSHOP -3
3000 A CB
800 KVA
STEAM TURBINE
SUB STATION PACKAGE
MAIN FEED CIRCUIT BREAKERS
PUMP HOUSE 1000 KVA
COMMON 800 KVA
SUB STATION 2000 KVA
GAS COMPRESSOR 1250 KVA
WATER SOURCE 315 KVA
GAS GENERATORS
GAS GENERATORS
10.5 KV BUS
WORKSHOP -2
3000 A CB
800 KVA
STEAM TURBINE
SCOPE OF THIS PACKAGE
10.5 KV BUS
WORKSHOP -4
3000 A CB
800 KVA
STEAM TURBINE

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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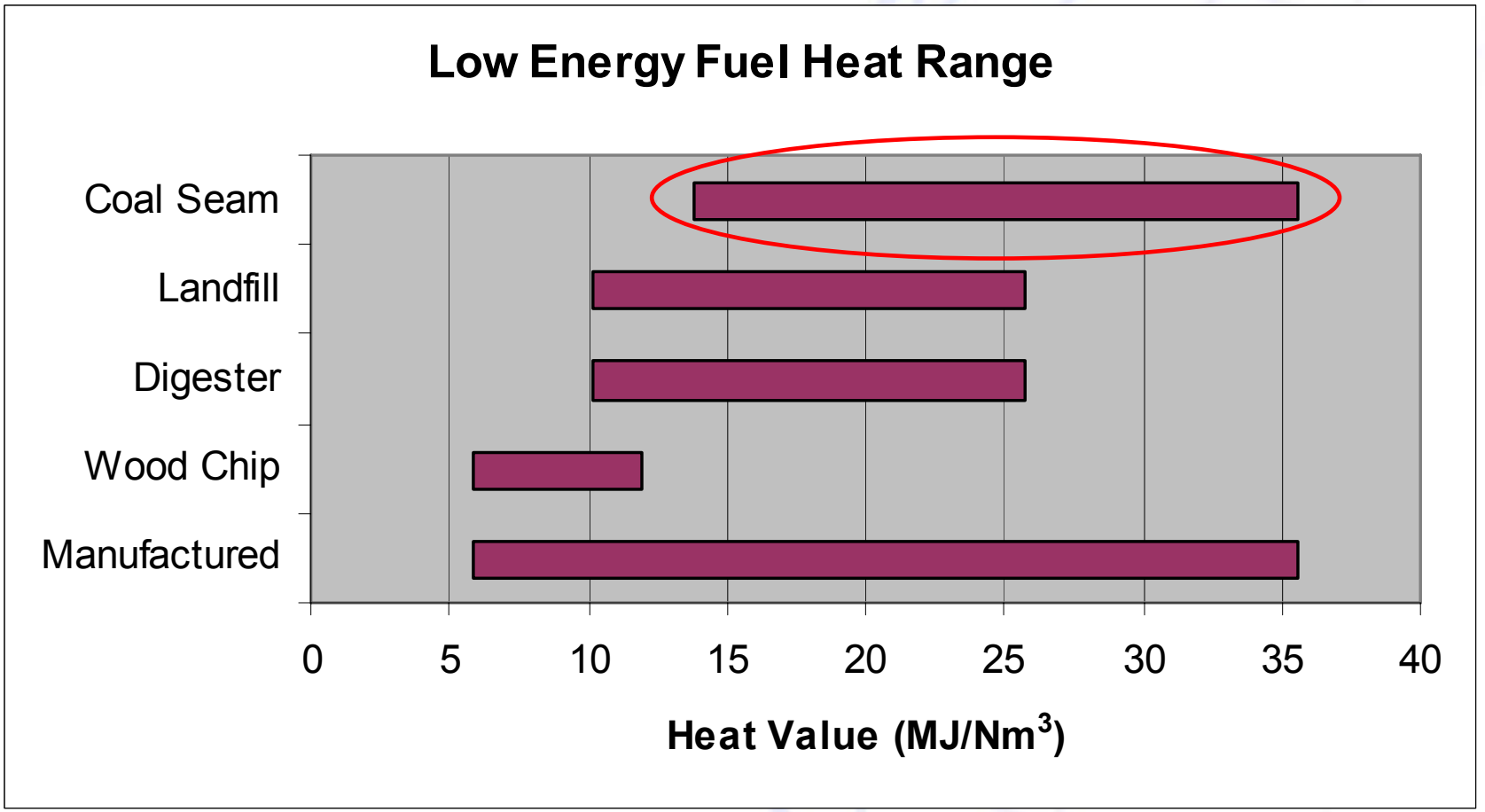
Low Energy Fuels



Typical Fuel Properties

Component	Symbol	Units	Pipeline Natural Gas	CBM	CMM*
Methane	CH_4	vol %	92.3	85.9	**40.0**
Ethane	C_2H_6	vol %	2.5	3.8	---
Hydrogen Sulfide	H_2S	vol %	---	---	---
Oxygen	O_2	vol %	---	2.1	12.6
Nitrogen	N_2	vol %	3.5	8.2	46.8
Others	---	vol %	1.8	0.0	0.6
Lower Heating Value	LHV	MJ/Nm^3	33.2	32.5	**13.4**
Caterpillar Methane Number	MN	---	80	86	100

*** 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

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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)

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_2equivalent) from the World Bank's Prototype Carbon Fund
  - Estimated carbon credit trading between $5-10 USD/ton

QUESTIONS?

Thank You

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