The Clean Coal Advantage

clean coal Project

Expert Meeting on Financing CCS Projects
London, England
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Presentation Overview

• Background
• The Opportunity
• The Engineering
• The Project as Proposed
History Lesson

Fall 2005:

• Canada tables GHG regulations
• Canada requests proposals for GHG initiatives
• SaskPower engaged in option studies (internally and with others)
2006 - January

• SaskPower Assembles Clean Coal Team to prepare Commercial Proposal to be evaluated against other supply options

• Coal Exploration rigs into the field (-30C)
2006 - February

- Engineering Resources and Manufacturers Engaged
- EOR Operators Contacted
- Project Office Opened
2006 - September

- Oxyfuel Technology Selected
2006 - November

- Coal Negotiations Completed
- Site Selected
2007 - April

- Technical Proposal to SaskPower
- Project Guidelines for EIA Received
- Application for Water License Submitted
Presentation Overview

• Background
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• The Project as Proposed
World’s largest, full-scale, in-field MMV (Measurement, Monitor and Verification) study with EOR
Weyburn Pool Production History

Barrel/Day (thousands)


Waterflood
Infill
Hz Drilling

$500 Million annual revenue
Overall COAL to OIL Process

1 Tonne Coal Produces 0.8 MWh + 2 to 10 barrels Oil
Net Emissions Impact

Near Zero emissions electricity plus:

1 Barrel Weyburn Crude: Equivalent to 1.0 GHG unit

- Offsets

1.3 to 1.4 GHG equivalents
Middle East Oil

or

1.9 GHG equivalents
Alberta Oil Sands
Presentation Overview

• Background
• The Opportunity
• The Engineering
• The Project as Proposed
• 70 system design bases
• 32 process diagrams
• 23 Project Standards
• Single line diagrams, layout and arrangement drawings
• Full thermodynamic model (Gate cycle)
• Oxyfuel furnace CFD model (in production)
• (Roughly 100,000 engineering man-hours)
Engineered Deliverables

• Detailed plant design (two sites) for amine and oxyfuel with cost/performance comparison
• Detailed Oxyfuel design:
  – Full and part load
  – Air fired start up
  – Range of fuel characteristics
  – Range of ambient conditions
  – Work with available water resources
• Project Integrated Construction Schedule
• Hazop Analyses
• Structured Risk Analyses
SaskPower Oxyfuel Process
SaskPower Oxyfuel Process
SaskPower Oxyfuel Process

Operability, Reliability and Availability

Steam

Electricity

COAL

Syn AIR

O2

N2

AIR SEPARATION UNIT

FURNACE

FILTER

FGD

Limestone

Small Stream: CO2, Argon,

CaSO4.H2O (Gypsum)

Waste Storage

ASH, Water, Trace Hg

Trace Materials from Coal

PERMANENT GEOLOGICAL STORAGE

COMPRESSOR

95+% CO2
Presentation Overview

• Background
• The Opportunity
• The Engineering

• The Project as Proposed
Heat Rejection
Compression Building
Clean Coal Project – Technical Proposal: In-Service Date & Capacity Factor

- Air Fired Operation Date
  ➢ March 1, 2012

- Oxyfuel In-Service Date
  ➢ September 1, 2012

- Forecast Capacity Factor
  ➢ 85%
Clean Coal Project – Technical Proposal: Operating Costs

- $26 million per year O&M cost
  - $18 million fixed cost
  - $3.80 variable cost/MWh
  - Life cycle capital costs also estimated

- Coal Requirements
  - 2.3 Mt per year

- Fuel Pricing
  - Fuel Supply has established coal price
  - Dragline pricing received
Clean Coal Project – Technical Proposal: CO₂ & Electrical Production

- Forecast Annual CO₂ For Sale
  - 3.15 million Mt per year - net
- Annual Electrical Production
  - 2.2 million MWh - net
## Atmospheric Emissions Performance Comparison

<table>
<thead>
<tr>
<th></th>
<th>2006 Compliance¹</th>
<th>Conventional Unit (Approved 1988)</th>
<th>Clean Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂, kg/MWh</td>
<td>2.9</td>
<td>2.86</td>
<td>~ 0</td>
</tr>
<tr>
<td>NOₓ, kg/MWh</td>
<td>0.69</td>
<td>2.86</td>
<td>0.02</td>
</tr>
<tr>
<td>Particulate Matter, kg/MWh</td>
<td>0.095</td>
<td>0.49</td>
<td>~ 0</td>
</tr>
<tr>
<td>Mercury, kg/TWh</td>
<td>15.0</td>
<td>-</td>
<td>~ 0</td>
</tr>
<tr>
<td>CO₂, kg/MWh</td>
<td>1000 (unregulated)</td>
<td>1044.0</td>
<td>44.0</td>
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</table>

¹. These compliant guidelines reflect the current guidelines issued as New Source Emission Guidelines of the Canadian Environment Protection Act (CEPA) for SOₓ, NOₓ and PM, and the Canadian Council of Ministers of The Environment (CCME) Canada Wide Standard for Mercury.
Environmental Issues

• Project is an addition to an existing site
• Site was approved as a two unit site in 1988
  – One unit built – on line in 1992
  – Second unit approved as IGCC in early 1990’s – not built
• EIS being updated now to cover the proposed clean coal unit at this site
  – Need to update EIS to current standards
Corporate Risk

Risk Management
GHG Regulations

• Canada issued a “Regulatory Framework for Air Emissions” in April 2007
  – Will cover all air emissions, including CO2
  – Reductions in GHG intensity – 18% by 2010, 26% by 2015
  – $15/tonne beginning in 2010
  – $20/tonne in 2013

• Detailed regulations for a specific industry to be developed this year and issued spring of 2008
  – Several instruments being proposed
  – Still difficult to develop detailed plans
Clean Coal Project - Risks
Technology

Issues

- (Safety – managed through HAZOP)
- Oxyfuel Process
  - Flue Gas Cooling
  - Furnace Heat Transfer
  - Burner Performance
- CO₂ Compression & Clean Up
- Air Separation Unit
- Process Integration
- Waste Water Management
- ..more....
## Conceptual Risk Assessment
(Values are for demonstration only)

<table>
<thead>
<tr>
<th>Issue</th>
<th>Expected Loss</th>
<th>Maximum Exposure</th>
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</thead>
<tbody>
<tr>
<td>Clean Coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction Labour</td>
<td>$ 55,000,000</td>
<td>$ 550,000,000</td>
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<tr>
<td>CO2 Sale Price</td>
<td>$ 96,000,000</td>
<td>$ 480,000,000</td>
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<tr>
<td>Electricity Sale Price</td>
<td>$ 48,000,000</td>
<td>$ 240,000,000</td>
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<tr>
<td>Change in Interest Rates</td>
<td>$ 20,000,000</td>
<td>$ 200,000,000</td>
</tr>
<tr>
<td>Long Term OM&amp;A Costs</td>
<td>$ 32,000,000</td>
<td>$ 160,000,000</td>
</tr>
<tr>
<td>Technical Risks - Oxyfuel</td>
<td>$ 34,375,000</td>
<td>$ 137,500,000</td>
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<tr>
<td>Material Price Risk</td>
<td>$ 25,000,000</td>
<td>$ 160,000,000</td>
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<tr>
<td>GHG Regulations</td>
<td>$ 310,375,000</td>
<td>$ 550,000,000</td>
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<table>
<thead>
<tr>
<th>Compliant Coal</th>
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<tbody>
<tr>
<td>Expected Loss</td>
<td>$ 38,465,250</td>
<td>$ 384,652,505</td>
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<tr>
<td>Maximum Exposure</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Expected Loss</td>
<td>$ 48,000,000</td>
<td>$ 240,000,000</td>
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<tr>
<td>Maximum Exposure</td>
<td>$ 13,987,364</td>
<td>$ 139,873,638</td>
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<tr>
<td>Expected Loss</td>
<td>$ 16,000,000</td>
<td>$ 80,000,000</td>
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<tr>
<td>Maximum Exposure</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Expected Loss</td>
<td>$ 17,484,205</td>
<td>$ 69,936,815</td>
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<tr>
<td>Maximum Exposure</td>
<td>$ 240,000,000</td>
<td>$ 960,000,000</td>
</tr>
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GHG Exposure for Compliant Coal may offset the project execution risks around “First Of” Clean Coal.
Shand #2 CO₂ Cogen Plant - 2007 Supply/Build Prices

Cost of Electricity (vs. N. Gas)

Current Supply/Build Pricing

2005 Supply/Build Pricing

CO₂ Sell Price

No-Go

Go

0%
50%
100%
150%
200%

0%
50%
100%
150%
200%

0% 50% 100% 150% 200%
QUESTIONS?