Presentation to

KSU Intersession Course/Workshop
Energy, Environmental Impacts and Sustainability

Overview of Coal-Fueled Power Plants
Agenda

- What Is Coal?
- Electricity from Coal
- Why Coal?
- Future of Coal
Coal Plant – Jeffrey Energy Center
US Coal Regions

Unit Trains

Sources: University of Wyoming at smtc.uwyo.edu/coal/ images/coaltrain3.jpg
Electric Generation from Coal

- Conventional Combustion
  - Pulverized Coal
  - Circulating Fluidized Bed
  - Others
- Gasification
  - Integrated Gasification Combined Cycle (IGCC)
US Generation by Fuel - 2003

Sources: US DOE EIA, Energy Information Administration, Form EIA-906, "Power Plant Report."
# Representative Emissions and Water Usage

<table>
<thead>
<tr>
<th>Description</th>
<th>NO$_X$, lb/MBtu</th>
<th>SO$_2$, lb/MBtu</th>
<th>PM, lb/MBtu</th>
<th>Water Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal – Combustion</td>
<td>0.07</td>
<td>0.090</td>
<td>0.018</td>
<td>Higher</td>
</tr>
<tr>
<td>Coal – IGCC</td>
<td>0.05</td>
<td>0.012</td>
<td>0.014</td>
<td>Base</td>
</tr>
<tr>
<td>NGCC</td>
<td>0.06</td>
<td>Trace</td>
<td>0.012</td>
<td>Base</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.10</td>
<td>Trace</td>
<td>0.018</td>
<td>Higher</td>
</tr>
<tr>
<td>Wind</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Solar</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
## Representative Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Direct Capital Cost, $/kW</th>
<th>Busbar Cost, ¢/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal – Combustion</td>
<td>1,200 - 1,400</td>
<td>5.0</td>
</tr>
<tr>
<td>Coal – IGCC</td>
<td>1,400 – 1,825</td>
<td>5.5</td>
</tr>
<tr>
<td>NGCC</td>
<td>450 – 700</td>
<td>7.5*</td>
</tr>
<tr>
<td>Biomass</td>
<td>2,000 - 2,750</td>
<td>8.0*</td>
</tr>
<tr>
<td>Wind</td>
<td>1,300 - 1,500</td>
<td>6.0</td>
</tr>
<tr>
<td>Solar</td>
<td>4,000 – 5,000</td>
<td>11.5</td>
</tr>
</tbody>
</table>

* Highly fuel cost dependent
Typical Annual Demand Profile

Year 1

Available Capacity

Demand (MW)

Hour

0 1000 2000 3000 4000 5000 6000 7000 8000
Typical Load Duration Curve

- Existing Peaking
- New Peaking
- Existing combined cycle
- Existing coal
- Existing coal
- New coal capacity

Load (MW) vs. Plant Hours

0% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90% 95% 100%

0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

Existing hydro

Confidential information. © Copyright Black & Veatch Corporation 2005. All rights reserved.
The Future of Coal – Large Capacity Additions

Figure 5. Electricity generation by fuel, 1980-2030 (billion kilowatthours)

Sources: US DOE EIA, “Annual Energy Outlook 2006 (Early Release)”
The Future of Coal - Emissions

Permittable Emissions Limits

- $\text{SO}_x$
- $\text{CO}_2$
- Mercury

Tighter limits increase capital and operating costs of conventional technologies.

Tighter limits provide opportunities for newer technologies, namely IGCC.
Future of Coal - IGCC Process Schematic

- Air Separation Unit
- Raw Syngas Cooling
- Gasifier
- Particulate Removal
- Acid Gas Removal
- Ash
- Sulfur Byproduct
- Cleaned Syngas
- Additional processing for chemicals production (hydrogen, methanol, gasoline, diesel, etc.)
- Combustion Turbine
- Heat Recovery Steam Generator
- Steam Turbine
- Generators
- Electricity
- Air
- Oxygen
- Feedstock
- Aggregate Byproduct for Construction
- Slag
- Steam
The Future of Coal - IGCC

Benefits

- Low Emissions and High Efficiency
- Low Emissions From High Sulfur Coal
- Lower Cost Mercury Removal
- Lower Water Use
- Lower Cost CO₂ Removal
- Expect Less Resistance to Permitting

Challenges

- Higher Project Cost
- Uncertainty in Cost and Schedule
- Commissioning Duration
- Availability
- Financing
Summary

- Coal Is a Sensible Choice for Current and Future Power Projects
- Conventional Coal Is Currently More Proven and Lower Capital Cost
- IGCC Has Advantages in Performance and Emissions Reduction Capabilities, Including CO\(_2\) and Hg
- IGCC Expected to Face Some Obstacles to Market Acceptance in Short Term
- IGCC Expected to Become Increasingly Popular Choice Over the Next 5 to 15 Years
Questions

Contact Information:

Sam Scupham
Black & Veatch

ScuphamSK@bv.com
913.458.7959