Indiana Center for Coal Technology Research
Advisory Panel Meeting

IUPUI Campus Center
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Recovering Coal Fines for Use in Stoker Boilers
Presenter: William J. Harrington

Project Director
- Power Generation
  - Power Project & Business Development

FUELSTREAMERS GROUP

3050 Post Oak Boulevard, Ste 500
Houston, TX 77056, USA

Office: +1-713-579-7870
Fax: +1-888-835-6364
Email: w.harrington@fuelstreamers.com
1. Two Biodiesel Plants
2. Largest Exporter of Ethanol in North America
3. Solid Fuel/Power Generation Background
   • Clean Coal Technologies
   • Waste Coal Deposits
   • Creating Innovative Solutions to Meet Regulatory Compliance
POWER GENERATION

Wholesale Electricity – Low by Historic Standards

Fuel accounts for 70 - 80% of Operating Costs

Probable that 30% of Coal Units Retired in 5 – 10 years without Solutions
WHY COAL?

COMPARISON OF FUEL PRICING

$ per mmBTU

Fuel Oil $ 21.95
Natural Gas $ 4.78
Coal $ 2.01
Wood $ 8.33

Source: EIA
WHY COAL?

45% Electrical Generation in US

90% in Indiana

Manufacturing Base
WHY COAL?

Cost of Electricity
Fuel = 70 - 80%

Hypothetical Household Electrical Bill - $300 per Month

- Fuel Oil $3,276
- Natural Gas $713
- Wood $1,243
<table>
<thead>
<tr>
<th></th>
<th>Quadrillion BTU</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Production</td>
<td>74.934</td>
<td>77.7%</td>
</tr>
<tr>
<td>(By Coal)</td>
<td>(33.645)</td>
<td>(34.9%)</td>
</tr>
<tr>
<td>Net Imports</td>
<td>21.572</td>
<td>22.3%</td>
</tr>
</tbody>
</table>

US EIA / Monthly Energy Review March 2011
Waste Coal Deposits

- More than 1 Billion Tons in US
- Cleaning up Tillable Land
- Mitigating Potential Water Table Contamination
- Displaces Need to Mine Equivalent BTU’s in Other Fuels
WHY COAL?

STOKER BOILERS

Price of Stoker Fuel: $50 - $100 / ton

Synthetic Stoker Coal
WHY COAL?

WASTE COAL

Problems

1. High Sulfur
2. High Moisture
3. Low BTU
4. Compliance Issues
WHY COAL?

WASTE COAL

1. Front End – Pre-Combustion
   Improve Plant Performance

2. Back End – Pollution Control Equipment
   Parasitic Load
### WHY COAL?

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Air-fired plant</th>
<th>IGCC plant with CCSb</th>
<th>Oxy-fuel plant with CCS</th>
<th>Air-fired plant</th>
<th>Oxy-fuel plant with CCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam conditions (psi/F/F)</td>
<td>3,600/1,100/1,100</td>
<td>NA</td>
<td>3,600/1,100/1,100</td>
<td>3,600/1,100/1,100</td>
<td>3,600/1,100/1,100</td>
</tr>
<tr>
<td>Plant performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power (gross MW)</td>
<td>598</td>
<td>745</td>
<td>733</td>
<td>604</td>
<td>733</td>
</tr>
<tr>
<td>Power (net MW)</td>
<td>550</td>
<td>556</td>
<td>550</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Heat rate (net Btu/kWh)</td>
<td>0.662</td>
<td>10,505</td>
<td>10,143</td>
<td>9,250</td>
<td>10,831</td>
</tr>
<tr>
<td>Capacity factor (%)</td>
<td>85</td>
<td>80</td>
<td>85</td>
<td>85</td>
<td>85</td>
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<tr>
<td>Expected emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOx (lb/MBtu)</td>
<td>0.060</td>
<td>0.048</td>
<td>Note a</td>
<td>0.060</td>
<td>Note a</td>
</tr>
<tr>
<td>SOx (lb/MBtu)</td>
<td>0.040</td>
<td>0.010</td>
<td>Note a</td>
<td>0.080</td>
<td>Note a</td>
</tr>
<tr>
<td>Particulate (lb/MBtu)</td>
<td>0.015</td>
<td>0.007</td>
<td>Note a</td>
<td>0.012</td>
<td>Note a</td>
</tr>
<tr>
<td>Hg (lb/TBtu)</td>
<td>0.704</td>
<td>0.571</td>
<td>Note a</td>
<td>0.820</td>
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<tr>
<td>Expected CO2 emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CO2 removal efficiency (%)</td>
<td>0</td>
<td>90</td>
<td>92.5</td>
<td>0</td>
<td>92.5</td>
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<tr>
<td>CO2 produced (mmt/yr)</td>
<td>3.26</td>
<td>3.64</td>
<td>3.82</td>
<td>3.68</td>
<td>4.31</td>
</tr>
<tr>
<td>CO2 captured (mmt/yr)</td>
<td>0</td>
<td>3.28</td>
<td>3.53</td>
<td>0</td>
<td>3.99</td>
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<tr>
<td>CO2 released (mmt/yr)</td>
<td>3.26</td>
<td>0.36</td>
<td>0.29</td>
<td>3.68</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Notes: CCS = carbon capture and sequestration, MBtu = thousand Btu, mmt = million metric tons, NA = not applicable.

a. Below practical measurement limits.
b. Integrated gasification combined cycle (IGCC) is based on the General Electric IGCC system with CO2 capture per DOE/NETL-2007/1281 Report, Case 2.
c. Air-fired emissions based on 90% removal expected.

WHY COAL?

WASTE COAL

Clean Up Coal

Fines by Nature – Fire

Stoker Units

$\frac{3}{4}$” to 1 $\frac{1}{4}$” in size

(Estimated 500 – 1000 Stoker Units in Operation)

Briquette Post Clean Up

Use in Stoker Units

Ship Safely for Pulverized Coal Units
WHY COAL?

WASTE COAL

In order to Briquette, a Binder is required

Fuel Streamers / State of Indiana
Jointly Engaged Purdue University
To Develop a Binder