Coal Essentials for the Future

Marty W. Irwin

CCTR Advisory Panel Meeting
West Lafayette
August 30, 2006
## Current CCTR Projects

<table>
<thead>
<tr>
<th>Topic</th>
<th>Topic</th>
<th>Institution &amp; Location</th>
<th>Total Budget</th>
<th>Contact Person &amp; Contract Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-CTR002</td>
<td>Coal To Liquids</td>
<td>Coal Transformation Laboratory, Purdue West Lafayette</td>
<td>$150,000</td>
<td>F.T. Sparrow April 1, 2006 ~ March 31, 2007</td>
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<tr>
<td>6-CTR003</td>
<td>Clean Coal Technologies</td>
<td>PEMRG, Purdue, West Lafayette</td>
<td>$150,000</td>
<td>Ronald Rardin April 1, 2006 ~ March 31, 2007</td>
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<tr>
<td>6-CTR004</td>
<td>Indiana Coking Coals</td>
<td>Purdue Calumet Hammond</td>
<td>$100,000</td>
<td>Robert Kramer April 1, 2006 ~ March 31, 2007</td>
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<td>6-CTR005</td>
<td>Coal Transportation</td>
<td>Purdue North Central Westville</td>
<td>$25,000</td>
<td>Tom Brady April 1, 2006 ~ December 31, 2006</td>
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<tr>
<td>CCTR06-01</td>
<td>Coal Characteristics</td>
<td>IGS, Indiana Geological Survey, Bloomington</td>
<td>$100,000</td>
<td>Maria Mastalerz July 1, 2006 ~ June 30, 2008</td>
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<tr>
<td>CCTR06-02</td>
<td>Indiana Coal Fines</td>
<td>REMA, R Mourdock Inglefield</td>
<td>$111,980</td>
<td>Richard Mourdock August 1, 2006 ~ May 30, 2007</td>
</tr>
</tbody>
</table>
Where We Are ~ Primary Energy Use
(2001 Trillion Btu)

Per Cent of Source | Per Cent of Sector

COAL
1,567.0 53%

PETROLEUM
837.3 28%

NATURAL GAS
513.7 17%

RENEWABLES
47.5 2%

ELECTRIC POWER
1,239.0 42%

INDUSTRIAL
829.0 28%

TRANSPORTATION
613.6 21%

RESIDENTIAL & COMMERCIAL
284.5 9%

Data Source: http://www.eia.doe.gov/emeu/states/_states.html
Relatively Stable Low Coal Prices

Low energy price helps the economy of the state. If we have a least cost option, let’s use it.

Coal use Trend

(000 tons)
Indiana Center for Coal Technology Research
Located in The Energy Center at Discovery Park, Purdue University

Indiana Coal Production is Not Keeping Pace with its Coal Consumption

Indiana coal use as % of all coal use

Use/Prod
Linear (Use/Prod)

year 1=1987
How to Get There?
Convert Coal to a Usable Resource

Potential Coal-Derived Products

Coal → Coal Gasification → Syngas

- Ammonia Fertilizers
- Methanol/DME/Propylene
- Electricity (IGCC)

  → Fischer-Tropsch

  - Diesel Fuel/Kerosene/Jet Fuel
  - Naphtha/Gasoline/Detergents
  - Waxes/Lubricants
  - Steam/Electricity
  - Synthetic Natural Gas
  - Hydrogen
  - Carbon Dioxide

Source: GTI Gasification Symposium, December 2, 2004
Options After Gasification

Polygeneration Potential of Gasification

- Power & Steam
- Coal
- Gasification
- Synthesis Gas
- Methanol
- Methyl Acetate
- Acetic Anhydride
- Acetic Acid
- VAM
- Ketene
- Diketene & Derivatives
- Diketene & Derivatives
- Oxo Chemicals
- Polyolefins
- Ethylene & Propylene
- Ammonia & Urea
- Dimethyl Ether
- H₂
- Diesel/Jet/Gas Fuels
- Synthetic Natural Gas
- Naphtha
- Waxes
- Fischer-Tropsch Liquids
- Fuel/Town Gas
- Iron Reduction
- Eastman
Gasification Basics
Several Products are Available to be Made

- The basic process described above requires varying amounts of hydrogen. CH₄ is methane and is the basic product of coal gasification.
- To this you add Oxygen and the result is syngas: \(2\text{H}_2 + \text{CO}\).
- Syngas is the building block for coal based alternate energy production.
- The ratio of CO/H₂ can be adjusted to yield different products by adding Hydrogen.
- This is the \(N\), in \((2n+1)\text{H}_2+n\text{CO}\) yields \(\text{CnH}_2\text{n+2} + n\text{H}_2\text{O}\)
- For example: change the value of \(N\) changes the end product.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Product</th>
<th>N value</th>
<th>H/C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄</td>
<td>Methane</td>
<td>N=1</td>
<td>4.0</td>
</tr>
<tr>
<td>C₃H₈</td>
<td>Propane</td>
<td>N=3</td>
<td>2.67</td>
</tr>
<tr>
<td>C₈H₁₈</td>
<td>Gasoline</td>
<td>N=8</td>
<td>2.25</td>
</tr>
<tr>
<td>C₁₆H₃₄</td>
<td>Diesel fuel</td>
<td>N=16</td>
<td>1.89</td>
</tr>
</tbody>
</table>

- The further one processes Syngas the lower the H/C ratio.
- All based on the same syngas, \(2\text{H}_2 + \text{CO}\).
Indiana’s energy and economic come back will be outlined in the Hoosier Homegrown Energy Plan.

CCTR will work with the Indiana Office of Energy and Defense Development Group to detail how Indiana’s economy, quality of life and well being will once again be built on home grown energy.

New technologies will allow us to fully utilize our high sulfur coal, create new, homemade synthetic gas from coal and convert it into motor fuels and unleash our ingenuity on the goal of increased energy efficiency.
Some of the new, high paying jobs in our community will be in mining, and in energy operations and management. Purdue and Indiana Universities, Indiana State, IVY Tech, Vincennes University and others, will train highly skilled engineers to run sophisticated, computer driven power plans and private sector energy systems while others will manage coal mines and sequestration programs and energy distribution networks.

Purdue’s Energy Center will become a national center in clean coal technology, hydrogen and renewable energies. Indiana will build new coal gasification, coal processing, facilities, creating clean power and energy from local coal and shale and biomass resources. New technologies, opportunities and challenges will emerge.
CCTR Next Meeting

Tuesday, November 21, 2006

Purdue Calumet
Energy Efficiency and Reliability Center

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Hammond, IN 46323-2094
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219-989-2147