EXPANDING THE UTILIZATION OF INDIANA COALS

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Indianapolis
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CCTR
Indiana Center for Coal Technology Research

• **July 2002:** The CCTR is established, Indiana Senate Enrolled Act No. 29, July 2002.

• **July 2003:** House Enrolled Act No. 1166, creates CCTR Advisory Panel and provision for public education.

• **June 2004:** CCTR Advisory Panel appointed.

• **August 18, 2004:** First CCTR Workshop.

• **Fall 2004/Spring 2005:** Four Consultation Workshops are being planned.
What are the Surrounding States Doing?

Illinois

- **Coal Research Program** – granted over $60 million in last two decades, through Illinois Clean Coal Institute at SIU.
- **Coal Demonstration Program** – state’s $120 million has attracted over $200 million in federal funds, over $450 million in private and public cost-sharing.

Ohio

- **Coal Research Grant Program** – through Ohio Coal Development Office – almost $4 million to fund 19 projects in 2000.
- **Ohio Coal Research Consortium** – over $1 million/year at six universities.
What are the Surrounding States Doing?

Kentucky

- **Center for Applied Energy Research** at University of Kentucky – started in 1972 as *Kentucky Coal Utilization Research Program*.
- Total funding authorization was $50 million.
- Governor’s current budget provides $4 million for coal-bed methane production, $3 million for clean coal combustion.
CCTR BACKGROUND PAPERS

Recommended at June 2002 Workshop that two background papers be commissioned

(1) Background Paper # 1: (August 18, 2004) Indiana Coal Reserves and Characteristics

(2) Background Paper # 2: (August 18, 2004) Demand for Indiana Coal
CCTR PRIORITIES

August 18, 2004
Next step this afternoon: Three Break-Out Sessions

CCTR to commission, via the RFP route, three papers to be used for the four workshops being planned for this fall and winter. Each paper is to evaluate current knowledge, and identify barriers to progress, in: (i) Indiana Coal Demand, (ii) Indiana Coal Supply, and (iii) Indiana Coals and the Environment. To suggest a research agenda.

The objective for all three sessions today is the same; to put together a tentative list of the major issues, barriers, and opportunities in each of the three areas which will define the scope of work spelled out in the RFP for each of the three papers.
COAL PRODUCTION BY COAL-PRODUCING REGION, 2003 (10^6 tons & Percent Change from 2002)

Figure 1. Coal Production by Coal-Producing Region, 2003

U.S. Total: 1,069.5 Million Short Tons (-2.3%)

Western 547.3 (-0.6%)

Interior 146.2 (-0.3%)

Appalachian 375.0 (-5.4%)

Source: http://www.eia.doe.gov/cneaf/coal/page/special/fig1.html
COAL RESERVES IN THE U.S. AND INDIANA

• Current U.S. recoverable reserves are 498 billion tons, enough to last for over 450 years.

• Indiana recoverable reserves are 9.6 billion tons, enough to last for over 250 years (producing 35 million tons per year).

• Indiana has more energy underground in the form of coal reserves than the U.S. does in the form of oil and gas reserves.
INDIANA COAL FACTS - 2002

- Indiana mines are part of the Interior Coal-Producing Region, Illinois Coal Basin.

- Economic impact: $675 million.

- Employment impact: >14 thousand people.

- Strong link: coal with low cost electricity.

- Coal is a significant contributor to the economy of the state.
CONCLUSION

• Coal will be a larger force in the U.S. and Indiana economy than it is now

• How can we secure a role for Indiana coals in this future without compromising our environment?
APPLIED R&D PROGRAMS FOR COAL

Helping to strengthen the economy of Indiana:

**BY:** Assisting in the development of strategic long-term coal related proposals

**THROUGH:** Appropriate policies, most cost effective new technology investments, reduced transportation costs, regional cooperation

**WITH:** Increases in Indiana’s coal production

**WHILE:** Having concern for health and environment
Production of 35 million tons of coal in 2002

Indiana coal has high heat content and high sulfur content

78% of production is from surface mining. Is there a gradual return to underground mining? At present Indiana has highest percentage of surface mining in the Midwest (next highest is Ohio with 49%)
INDIANA COAL TRADING

Indiana is a major importer of coal

• Consumption 66 million tons in 2002
• Imports 34 million tons
• Exports 3 million tons

Where do coal imports come from and where do coal exports go to?

This network of trade flows needs to be understood for future planning.
INDIANA COAL TRADE FACTS AND RESPONSE

• Complex flow of coal supplies

• Indiana imports ½ of its total coal needs

• Wyoming is biggest supplier of out-of-state coal

• Majority of coal imports are for electricity generation
  
  ➢ Strategy for **import substitution**?
  
  ➢ Strategy for **increase in exports**?
  
  ➢ Investment strategy for **increased mine production**?
INDIANA COAL IMPORTS - 2002

State Consumption Total of 66,269 Thousand short tons & methods of transportation

Wyoming: 13,606 Total
13,606 Electricity Generation
Rail 7,189 River 6,417

Montana: 1,441 Total
1,441 Electricity Generation
Rail

Illinois: 5,935 Total
5,839 Electricity Generation
Rail 3,445 River 930 Truck 1,464
96 Industrial Plants
River

Utah: 281 Total
281 Industrial Plants
Rail

Colorado: 227 Total
227 Industrial Plants
Rail

Kentucky: 994 Total
314 Electricity Generation
Rail 178 Truck 136
86 Coke Plants
Rail 75 Truck 11
594 Industrial Plants
Rail 507 River 49 Truck 38

Alabama: 540 Total
540 Coke
Rail

Ohio: 124 Total
105 Electricity Generation
Rail 36 River 6 Truck 63
20 Industrial Plants
Truck

Pennsylvania: 429 Total
419 Electricity Generation
River 350 Truck 68 (Bituminous)
9 Residential/Commercial
1 Industrial Plants
Truck (Anthracite) Both Res. & Ind.

Virginia: 2,602 Total
2,111 Electricity Generation
Rail 1,114 River 968 Truck 28
4,634 Coke Plants
Rail 4,163 River 420 Truck 51
1,197 Industrial Plants
Rail 949 River 246 Truck 2

West Virginia: 7,942 Total
2,111 Electricity Generation
Rail 1,114 River 968 Truck 28
4,634 Coke Plants
Rail 4,163 River 420 Truck 51
1,197 Industrial Plants
Rail 949 River 246 Truck 2

Virginia: 2,602 Total
1,157 Electricity Generation
Rail 481 River 677
754 Coke Plants
Rail 754
691 Industrial Plants
Rail 676 River 15

State Totals: 48,643 Electricity Generation
6,014 Coke Plants, 11,281 Industrial Plants, 331 Resid/Com

Source: http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/d_in.html
LOW SULFUR IMPORTS TO INDIANA

Indiana Production Profile

73% consumed for Indiana electricity

Wyoming Production Profile

Wyoming consumes < 1/12 of all it produces
Wyoming produces 1/3 of nation’s coal

Major imports of Wyoming’s low sulfur coal have dramatically affected Indiana’s coal trade situation as result of more stringent environmental standards.
2002 WYOMING EXPORTS TO MIDWEST

Wyoming consumes only 28.5 million tons and exports to Midwest (million tons):

IL - 7.0, \textbf{IN} - 13.6, KY - 1.7, OH - 9.6, MI - 13.1, WI - 20.0, and many other states

Midwest total imports of WY coal is 65 million tons

How can Indiana increase coal production and substitute for WY Midwest exports?
INDIANA COAL EXPORTS - 2002

State Production Total of 35,391 Thousand short tons & methods of transportation

**Wisconsin:** 757 Total
- 385 Electricity Generation
- Rail
- 372 Industrial Plants
- Rail 68, River 304

**Iowa:** 146 Total
- 9 Electricity Generation
- River
- 137 Industrial Plants
- Rail 105, River 32

**Minnesota:** 8 Total
- 8 Electricity Generation
- Rail

**Missouri:** 19 Total
- 19 Industrial Plants
- River

**Illinois:** 468 Total
- 466 Electricity Generation
- River 140, Truck 326
- 2 Industrial Plants
- Railroad 2

**Kentucky:** 1,499 Total
- 1,461 Electricity Generation
- Rail 808, River 481, Truck 171
- 39 Industrial Plants
- Truck

**Ohio:** 178 Total
- 178 Electricity Generation
- River

**Tennessee:** 6 Total
- 6 Residential/Commercial
- River

**Florida:** 162 Total
- 162 Electricity Generation
- River

**In state:** 32,146 Total
- 23,370 Electricity Generation
- Rail 9,311, River 502
- Conveyer 577, Truck 12,980
- 8,455 Industrial Plants
- Truck
- 321 Residential/Commercial

**State Totals:** 26,038 Electricity Generation
- 9,023 Industrial Plants, 327 Residential/Commercial

Source: http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/o_in.html
What has caused the decline in Indiana’s coal trade and what response is to be made to this?
COAL CONSUMPTION
IN NEIGHBORING STATES

2002 Consumption and Production for Electricity

<table>
<thead>
<tr>
<th></th>
<th>Consumption (10^6 tons)</th>
<th>Production (10^6 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL</td>
<td>12.6</td>
<td>5.0</td>
</tr>
<tr>
<td>IN</td>
<td>43.8</td>
<td>21.5</td>
</tr>
<tr>
<td>KY</td>
<td>30.7</td>
<td>17.8</td>
</tr>
<tr>
<td>OH</td>
<td>29.4</td>
<td>11.3</td>
</tr>
<tr>
<td>MI</td>
<td>32.1</td>
<td>0.0</td>
</tr>
<tr>
<td>WI</td>
<td>22.8</td>
<td>0.0</td>
</tr>
</tbody>
</table>

These 6 states produce 56 million tons of coal for generating in-state electricity but consume 171 million tons for electricity – massive imports into Midwest.
COAL AND MIDWEST ELECTRICITY SUPPLIES

• The neighboring states to IN are very dependent on coal for power generation, less so for IL (35%).

• IN generates highest proportion using coal (94% of MWh). Next comes KY and OH (90%).

• IL, MI & WI have ¼ of power generation from nuclear stations (OH 7%).

• Heaviest dependence on natural gas is in IL (26%).
TRANSPORTATION & INVESTMENT

• Coal transportation rates were coming down, now uncertain, and are still costly ($13/ton from WY).
• Mine prices of WY coals are low.

• Low sulfur content of imported WY coal and long contractual agreements (low sulfur & high transport costs or high sulfur & low transport cost).
• Long-term investments in new technology or short-term transportation operational costs.
• Tough decisions to make.

Notes: Multimode includes shipments that use any combination of rail, truck, barge, and colliery transportation. Import records are excluded.
REGIONAL TRADE CONCLUSION

• Midwest imports have been increasing and exports decreasing.

• Can Indiana increase it’s share of this 100 million tons of regional imports?

• Can Indiana significantly increase its exports to MI and WI?
COOPERATION WITH NEIGHBORS

- The Midwest states are all very dependent on coal imports from the Western Region and Indiana exports suffer.

- Similarly to the electricity network of the region and the creation of MISO can there be a similar regional level of cooperation with coal technology development?

- A regional approach could have important consequences for the location of the FutureGen project?
FUTURE PRODUCTION AND TRADE

What are the key issues to be tackled through the CCTR for helping increase Indiana’s coal production:

**Approach:** To be solely for the interest of Indiana and irrespective of the Midwest neighbors or full cooperation with neighbors? (Buy IN or Buy IL Basin?)

**Investments:** How to be most cost effective for:
(1) Mines, (2) Power Plants,
(3) Transportation of coal to plants

**New Technology:** What are the options available and what are their comparative costs?
EXPANDING INDIANA COAL USE BY THE IRON AND STEEL INDUSTRY

• Currently, very little Indiana coals utilized by the industry.

• Two opportunities – in coke blends and blast furnace injection.

• Two studies – IGS Report 64, DOE Clean Coal Technology Report.

• Coke blends: Indiana coals limited by strength, moisture problems – nonetheless, “Indiana coal could be successfully incorporated in amounts up to 45% of the blend” – potential between 2 to 3-½ million tons/year.
EXPANDING INDIANA COAL USE BY THE IRON AND STEEL INDUSTRY

- **Blast furnace injection**: could replace up to 40% of coke charge; in competition with gas. Coals with high combustibility, high coke/coal replacement ratios, low sulfur preferred.

- **Total potential**: 4 ½ to 5 ½ million tons/year.

- **Problem**: best Indiana coals for both uses are Brazil formation, with limited reserves.
INDIANA’S GENERATING STATIONS

• The majority of Indiana’s coal, 73% in 2002, went to power stations (23.4 of the 32.1 million tons of in-state coal and 48.6 million tons of Indiana’s total coal consumption).

• The ten largest Indiana power stations all use coal and represent 74% of Indiana’s utility station power.

• Where do the coal supplies for these major installations come from? What are the emissions from these largest stations?
## Indiana’s Ten Largest Power Stations

<table>
<thead>
<tr>
<th>Plant</th>
<th>Operating Company</th>
<th>Net Summer Capability (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gibson</td>
<td>PSI Energy Inc</td>
<td>3,131</td>
</tr>
<tr>
<td>2. Rockport</td>
<td>Indiana Michigan Power Co</td>
<td>2,600</td>
</tr>
<tr>
<td>3. R M Schahfer</td>
<td>Northern Indiana Pub Serv Co</td>
<td>1,780</td>
</tr>
<tr>
<td>4. Petersburg</td>
<td>Indianapolis Power &amp; Light Co</td>
<td>1,672</td>
</tr>
<tr>
<td>5. Clifty Creek</td>
<td>Indiana-Kentucky Electric Corp</td>
<td>1,209</td>
</tr>
<tr>
<td>6. Cayuga</td>
<td>PSI Energy Inc</td>
<td>1,096</td>
</tr>
<tr>
<td>7. Merom</td>
<td>Hoosier Energy REC Inc</td>
<td>1,000</td>
</tr>
<tr>
<td>8. Tanners Creek</td>
<td>Indiana Michigan Power Co</td>
<td>980</td>
</tr>
<tr>
<td>9. Elmer W Stout</td>
<td>Indianapolis Power &amp; Light Co</td>
<td>924</td>
</tr>
<tr>
<td>10. Wabash River</td>
<td>PSI Energy Inc</td>
<td>918</td>
</tr>
</tbody>
</table>
COAL IMPORTS TO INDIANA’S LARGEST POWER STATIONS

Indiana Coal Imports in 2000 to 10 Largest Power Stations

(Thousands of short tons)

<table>
<thead>
<tr>
<th>Power Station</th>
<th>Total Imports</th>
<th>Wyoming</th>
<th>Illinois</th>
<th>W.Virginia</th>
<th>Kentucky</th>
<th>Virginia</th>
<th>Ohio</th>
<th>Pennsylvania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schahfer</td>
<td>1,780MW</td>
<td>3,127</td>
<td>1,151</td>
<td>502</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavuva</td>
<td>1,096MW</td>
<td>356</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gibson</td>
<td>3,232MW</td>
<td>1,600</td>
<td>1,151</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rockport</td>
<td>2,600MW</td>
<td>7,747</td>
<td>1,151</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clift Creek</td>
<td>1,209MW</td>
<td>3,041</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total coal imports to Indiana’s 10 largest power stations in 2000: 21,625 thousand short tons

Percentage of Imports

- Wyoming 65.0%
- Illinois 14.6%
- W.Virginia 11.0%
- Kentucky 5.1%
- Virginia 3.0%
- Ohio 0.9%
- Pennsylvania 0.4%

Power stations, Peterburg, Merom, EW Stout, & Wabash River use 100% Indiana coal

Power stations, Rockport, RM Schahfer, & Clifty Creek use 0% Indiana coal (major Wyoming coal importers)
COAL AND SULFUR EMISSIONS

• There is 9 times as much sulfur in the Indiana coal compared with the Wyoming coal imports

• How much lower sulfur coal is to be found in Indiana?
SO\textsubscript{2} AND INDIANA POWER STATIONS

- Indiana total SO\textsubscript{2} emission, 786,000 Tons.

- Three of Indiana’s large power stations emit 45% of this SO\textsubscript{2} total emission.

- Although Indiana is such a big importer of low sulfur coals it is still 4\textsuperscript{th} in the nation of highest SO\textsubscript{2} emitting states.
HOW TO DECIDE WHICH COAL?

• The decision process for coal selection and contracting agreements need to be well understood.

• SUFG forecasts Indiana needing 5,870MW of new base load plant by 2021. What technology should be chosen?

• Peabody Coal has announced it’s intention to build 3000MW of new coal fired stations (in IL and KY). Latest pollution control equipment is paid for from the saving in transportation costs.
INDIANA OUTPUT AND EMPLOYMENT MEASURES

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Coal Mining</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross State Product (million 2001$)</td>
<td>189919</td>
<td>301</td>
<td>0.16</td>
</tr>
<tr>
<td>Establishments (2002)</td>
<td>151573</td>
<td>50</td>
<td>0.03</td>
</tr>
<tr>
<td>Employment (2002)</td>
<td>2832553</td>
<td>2836</td>
<td>0.10</td>
</tr>
<tr>
<td>Annual Wages (2002$/person)</td>
<td>32603</td>
<td>55205</td>
<td>169.32</td>
</tr>
</tbody>
</table>


- Relatively small portion of Indiana’s economy.
- Less than one percent of GSP, employers, and employment.
- Average wages well above statewide average.
LOCATIONS OF INDIANA’S COAL MINES AND COAL-FIRED POWER PLANTS

- Concentrated in southwestern portion of Indiana.
- Largest production in Gibson, Pike, Knox, Vigo, and Greene Counties.
- Economic impacts, especially employment, concentrated.

Source: Energy Information Administration/State Coal Profiles
U.S. COAL PRODUCTION DIRECT REQUIREMENTS PER DOLLAR DELIVERED

<table>
<thead>
<tr>
<th>Sector</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry, and Fishing</td>
<td>0.0009</td>
</tr>
<tr>
<td>Mining</td>
<td>0.1005</td>
</tr>
<tr>
<td>Construction</td>
<td>0.0034</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.1669</td>
</tr>
<tr>
<td>Transportation and Utilities</td>
<td>0.1548</td>
</tr>
<tr>
<td>Wholesale and Retail Trade</td>
<td>0.0446</td>
</tr>
<tr>
<td>Services</td>
<td>0.0404</td>
</tr>
<tr>
<td>Value Added</td>
<td>0.4886</td>
</tr>
<tr>
<td>Total</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

- Production requirements: the economic activity used in coal production.
- U.S. national averages. Similar data not publicly available for Indiana.
- Value added is portion of output that goes to wages, taxes, and return on investment.

Source: Bureau of Economic Analysis, National Input Output Accounts.
INDIANA RIMS II MULTIPLIERS

(1) The total dollar change in output that occurs in all industries for each additional dollar of output delivered to final demand by the industry.
(2) The total dollar change in earnings of households employed by all industries for each additional dollar of output delivered to final demand by the industry.
(3) The total change in number of jobs that occurs in all industries for each additional 1 million dollars of output delivered to final demand by the industry.
(4) The total dollar change in earnings of households employed by all industries for each additional dollar of earnings paid directly to households employed by the industry.
(5) The total change in number of jobs in all industries for each additional job in the industry.

NOTE. Multipliers are based on the 1999 Annual Input–Output Table for the Nation

<table>
<thead>
<tr>
<th>Coal Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 2.2435</td>
</tr>
<tr>
<td>(2) 0.5653</td>
</tr>
<tr>
<td>(3) 13.4217</td>
</tr>
<tr>
<td>(4) 2.3437</td>
</tr>
<tr>
<td>(5) 5.0512</td>
</tr>
</tbody>
</table>

Source: Bureau of Economic Analysis.
INDIANA RIMS II MULTIPLIERS (cont.)

• Derived using a tool called Input-Output analysis.

• Based on data similar to that shown on previous overhead for all industries in an economy.

• Explicitly accounts for the interaction between various components of an economy.

• Multipliers are used to summarize the economic impact of change in economic activity.
• Economic impact of coal production is larger than direct measure of GSP (value added) and employment.
• Applying the multipliers yields estimates:

$675 million economic activity
14,325 jobs

• Indiana coal mining has economic impact beyond those directly attributed to mining.
Assumptions used and multipliers result in estimates of economic impact, employment, and household income.

Quantity and price assumptions are key to estimates.
**COAL-FIRED SHARE OF ELECTRICITY GENERATION (%) AND AVERAGE RETAIL ELECTRICITY PRICE (cents/kWh), INDIANA AND SURROUNDING STATES**

<table>
<thead>
<tr>
<th>State</th>
<th>Coal Share (%)</th>
<th>Electricity Price (cents/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>46.1</td>
<td>6.97</td>
</tr>
<tr>
<td>Indiana</td>
<td>93.7</td>
<td>5.34</td>
</tr>
<tr>
<td>Kentucky</td>
<td>90.4</td>
<td>4.26</td>
</tr>
<tr>
<td>Ohio</td>
<td>90.4</td>
<td>6.66</td>
</tr>
<tr>
<td>Michigan</td>
<td>56.5</td>
<td>6.92</td>
</tr>
</tbody>
</table>

Source: Energy Information Agency, State Electricity Profiles, 2002

- Indiana enjoys some of the lowest priced electricity in the nation.
- Low electricity prices due in large part to coal-fired electricity generation.
Economic impact of coal production larger than estimates on previous overheads due to the unmeasured impact of electricity prices.

A more detailed study of the relationship between coal, electricity, and economic activity may be desirable.
COAL BY WIRE

• Indiana electric utilities currently export about 850 MW under firm capacity agreements.

• Additional 1,200 MW exported from Clifty Creek plant.

• Depending upon load patterns and availability of generation units, Indiana may be net electricity importer or exporter.

• EIA and SUFG project substantial need for base load electric generation resources over next 15 to 20 years.
ESTIMATES OF INDIANA ECONOMIC IMPACT OF 500 MW COAL-FIRED ELECTRIC GENERATION

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>MW</td>
<td>500</td>
</tr>
<tr>
<td>Capacity Factor</td>
<td>%</td>
<td>75</td>
</tr>
<tr>
<td>Generation</td>
<td>MWh</td>
<td>3,285,000</td>
</tr>
<tr>
<td>Heat Rate</td>
<td>Btu/kWh</td>
<td>9,500</td>
</tr>
<tr>
<td>Heat Content</td>
<td>$10^6$ Btu</td>
<td>31,207,500</td>
</tr>
<tr>
<td>Coal Price</td>
<td>$/10^6$ Btu</td>
<td>1.25</td>
</tr>
<tr>
<td>Coal Cost</td>
<td>$ million</td>
<td>39.01</td>
</tr>
<tr>
<td>Total Economic Impact</td>
<td>$ million</td>
<td>87.52</td>
</tr>
<tr>
<td>Coal Mining Jobs</td>
<td>Persons</td>
<td>232.54</td>
</tr>
<tr>
<td>All Other Jobs</td>
<td>Persons</td>
<td>942.08</td>
</tr>
<tr>
<td>Total Jobs</td>
<td>Persons</td>
<td>1,174.62</td>
</tr>
<tr>
<td>Total Household Income</td>
<td>$ million</td>
<td>49.47</td>
</tr>
</tbody>
</table>

- Conventional pulverized coal-fired plant assumed.
- Input-Output multiplier based estimates.
HYPOTHETICAL EXAMPLE OF DELIVERED COAL COST AND ELECTRICITY FUEL COST

<table>
<thead>
<tr>
<th>Miles</th>
<th>$/Ton</th>
<th>$/10^6 Btu</th>
<th>$/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>21.25</td>
<td>1.00</td>
<td>9.50</td>
</tr>
<tr>
<td>100</td>
<td>22.25</td>
<td>1.05</td>
<td>9.95</td>
</tr>
<tr>
<td>200</td>
<td>23.25</td>
<td>1.09</td>
<td>10.39</td>
</tr>
<tr>
<td>300</td>
<td>24.25</td>
<td>1.14</td>
<td>10.84</td>
</tr>
<tr>
<td>400</td>
<td>25.25</td>
<td>1.19</td>
<td>11.29</td>
</tr>
<tr>
<td>500</td>
<td>26.25</td>
<td>1.24</td>
<td>11.74</td>
</tr>
<tr>
<td>600</td>
<td>27.25</td>
<td>1.28</td>
<td>12.18</td>
</tr>
<tr>
<td>700</td>
<td>28.25</td>
<td>1.33</td>
<td>12.63</td>
</tr>
<tr>
<td>800</td>
<td>29.25</td>
<td>1.38</td>
<td>13.08</td>
</tr>
<tr>
<td>900</td>
<td>30.25</td>
<td>1.42</td>
<td>13.52</td>
</tr>
<tr>
<td>1000</td>
<td>31.25</td>
<td>1.47</td>
<td>13.97</td>
</tr>
</tbody>
</table>
HYPOTHETICAL EXAMPLE OF DELIVERED COAL COST AND ELECTRICITY FUEL COST

• Trade-off between transporting coal to generation plant near load versus electricity transmission to load from distant plant.
• Simple analysis illustrates concept.
• Real world much more complicated:
  ▪ coal transport mode and availability
  ▪ electricity transmission cost and availability
FUTURE COMPETING TECHNOLOGIES FOR POWER GENERATION

• Power generation from coal becomes more competitive as the capacity factor increases

• It appears likely that future base load needs in Indiana (6000 MW by 2021) will come from coal based plants while the peaking and cycling demands will be met by gas fired turbines and combined cycle plants
How extensive a role is IGCC technology to have in Indiana and the Midwest?
FUTURE COAL-BASED POWER GENERATION TECHNOLOGIES

• Requirements for future coal-based power plants include
  – High Efficiency
  – Low Emissions (including CO\textsubscript{2})
  – Versatility

• Competing technologies include
  – Pulverized Coal Steam Turbine
  – Integrated Coal Gasification Combined Cycle (IGCC)
  – Flue Gas Recycle

• The IGCC process best fits the criteria for future plants, exhibiting a high efficiency, low emissions with the possibility of economical CO\textsubscript{2} capture, and versatility to produce power, syngas, or hydrogen. The sulfur is captured in a form that provides an additional economic advantage.
# PERFORMANCE COMPARISON OF MAJOR COMPETING IGCC TECHNOLOGIES

<table>
<thead>
<tr>
<th>Process</th>
<th>Shell (Hot Gas Clean Up)</th>
<th>Texaco (Quench Cooling)</th>
<th>E–Gas (Hot Gas Clean Up)</th>
<th>Kellogg Transport (Air Blown)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Turbine Power (MW)</td>
<td>272.4</td>
<td>272.7</td>
<td>272.6</td>
<td>272.6</td>
</tr>
<tr>
<td>Steam Turbine Power (MW)</td>
<td>187.5</td>
<td>152.3</td>
<td>171.1</td>
<td>162.6</td>
</tr>
<tr>
<td>Misc./Aux Power (MW)</td>
<td>47.7</td>
<td>42.0</td>
<td>43.3</td>
<td>-20.0</td>
</tr>
<tr>
<td>Total Plant Power (MW)</td>
<td>412.2</td>
<td>382.9</td>
<td>400.4</td>
<td>415.4</td>
</tr>
<tr>
<td>Efficiency, HHV (%)</td>
<td>48.0</td>
<td>39.7</td>
<td>47.6</td>
<td>49.8</td>
</tr>
<tr>
<td>Total Capital Requirement, ($1000)</td>
<td>564,963</td>
<td>500,599</td>
<td>538,933</td>
<td>484,062</td>
</tr>
<tr>
<td>$/kW</td>
<td>1,370</td>
<td>1,307</td>
<td>1,346</td>
<td>1,165</td>
</tr>
<tr>
<td>Net Operating Costs ($1000)</td>
<td>42,562</td>
<td>48,411</td>
<td>41,888</td>
<td>45,388</td>
</tr>
<tr>
<td>Cost of Electricity (cents/kWh)</td>
<td>4.07</td>
<td>4.25</td>
<td>4.04</td>
<td>3.81</td>
</tr>
</tbody>
</table>
SUMMARY OF ISSUES RAISED IN THE WHITE PAPER

• Complete list of questions in the handout.

• **Basic Issue**: How can Indiana increase the use of Indiana coal through a state needs-directed R&D program? To do this, should we form a partnership with other Illinois basin coal producing states?

• **In the short run**: How can we obtain a higher fraction of the 100 million tons/year now imported into Midwest markets? To do this, how can we increase the economic advantage of using IBC rather than PRB coals?

• **In the long run**: How can we help make the Midwest the “clean coal technology (CCT) capital of the world”? – By encouraging the use of CCT to satisfy the Midwest’s emerging needs for new generation capacity.
CONTACTS

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