Factors that Affect the Design & Implementation of Clean Coal Technologies in Indiana
(Draft Final Report)

Presentation to the
Center for Coal Technology Research

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by
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The Project Team

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• Francois Botha, ICCI
• Bill Simmons, Coalteck
Scoping Study Vision

• How emerging Clean Coal Technology (CCT) solutions can be shaped & encouraged within Indiana
• Goal to increase environmentally responsible use of Indiana coal
• Focus on electric power generation, although chemical & other byproducts also considered
Clean Coal Technology (CCT)

- CCT \approx \text{methods for using coal with substantially reduced environmental emissions}
- Includes Integrated Gasification Combined Cycle (IGCC) with near zero emissions
- What coal-fired & combinations to include?
  - Supercritical PC (high temp & pressure)
  - Circulating Fluidized Bed (input with limestone)
  - Flue Gas Recycling (using & concentrating effluent)
Two Dimensions of Interim Rpt

- Study begins by considering two dimensions or issue bundles
- First is the technologies: how they work, history & maturity, preferred fuels, estimated costs, new & retrofit plants, pollution removal, reliability/availability, coke, chemicals & FT fuel production, external R&D funding
Two Dimensions of Interim Rpt

• Second is the **Indiana environment**: Indiana coal types, utility regulation, environmental regulation & compliance, human infrastructure, electricity demand growth, legacy boiler population, power transmission network, gas transmission network, coal transportation infrastructure
This Draft Final Report

- **Scenario Investigation**: analysis of how CCTs might evolve in the Indiana power context under alternative environmental regulation, cost & technology penetration hypotheses

- Hope to very roughly estimate implications for Indiana coal demand & electricity prices
This Draft Final Report

- **CCTR Research Plan**: What topics critical to CCT & Indiana coal use in the state require additional research as a result of the J2 scoping study?

- **Public/Private Action Plan**: What can & should be done to enhance CCT & Indiana coal use in the state?
Prospect of CO₂ Regulation

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Freeze time</th>
<th>Reduction time</th>
<th>Reduction (% or levels)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyoto Protocol</td>
<td></td>
<td>2008-2012</td>
<td>5.2</td>
<td>For 38 countries only</td>
</tr>
<tr>
<td>McCain-Lieberman</td>
<td>Worst case:</td>
<td>2010 2020</td>
<td>To 2000 levels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td></td>
<td>To 1990 levels</td>
<td></td>
</tr>
<tr>
<td>9 Northeastern states</td>
<td>2009-2019</td>
<td>2020 &amp; beyond</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td></td>
<td>2010 2020 2050</td>
<td>2000 levels 1990 levels</td>
<td>80% below 1990</td>
</tr>
</tbody>
</table>
Scenario Analysis
# Scenarios Around CO₂

<table>
<thead>
<tr>
<th>Scenario</th>
<th>CO₂ Recovery on New Baseload Required</th>
<th>CO₂ Recovery on 150% of New Baseload Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super Critical Pulverized Coal</td>
<td>PC no CO₂</td>
<td>PC CO₂ +50</td>
</tr>
<tr>
<td>IGCC with No Backup</td>
<td>IGnobk no CO₂</td>
<td>IGnobk CO2 +50</td>
</tr>
<tr>
<td>IGCC with Backup</td>
<td>IGbk no CO₂</td>
<td>IGbk CO₂ +50</td>
</tr>
<tr>
<td>Atmospheric Fluidize Bed Combustions</td>
<td>FB no CO₂</td>
<td>FB CO₂ +50</td>
</tr>
</tbody>
</table>
## Cost & Heat Rate Assumptions

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Heat rate</th>
<th>Capital cost</th>
<th>Fixed O&amp;M (5)</th>
<th>Variable O&amp;M</th>
<th>Heat rate</th>
<th>Capital cost</th>
<th>Fixed O&amp;M (5)</th>
<th>Variable O&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGCC (no CO₂ no backup)</td>
<td>8,800</td>
<td>$1,350/kW (1)</td>
<td>$40/kW-year</td>
<td>$0.8/MWh</td>
<td>8,800</td>
<td>$1,350/kW (1)</td>
<td>$40/kW-year</td>
<td>$0.8/MWh</td>
</tr>
<tr>
<td>IGCC (no CO₂ w/ backup)</td>
<td>8,800</td>
<td>$1490/kW (7)</td>
<td>$41/kW-year</td>
<td>$0.85/MWh</td>
<td>8,800</td>
<td>$1490/kW (7)</td>
<td>$41/kW-year</td>
<td>$0.85/MWh</td>
</tr>
<tr>
<td>IGCC (w/ CO₂ no backup)</td>
<td>11,200</td>
<td>$1750/kW</td>
<td>$41/kW-year</td>
<td>$0.85/MWh</td>
<td>11,200</td>
<td>$1750/kW</td>
<td>$41/kW-year</td>
<td>$0.85/MWh</td>
</tr>
<tr>
<td>IGCC (w/ backup &amp; CO₂)</td>
<td>11,200</td>
<td>$1,900/kW (4)</td>
<td>$42</td>
<td>$0.90/MWh</td>
<td>11,200</td>
<td>$1,900/kW (4)</td>
<td>$42</td>
<td>$0.90/MWh</td>
</tr>
<tr>
<td>PC-SC (no CO₂)</td>
<td>9,600</td>
<td>$1,200/kW (2)</td>
<td>$35/kW-yr</td>
<td>$0.7/MWh</td>
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<td>$1,200/kW (2)</td>
<td>$35/kW-yr</td>
<td>$0.7/MWh</td>
</tr>
<tr>
<td>AFBC (no CO₂)</td>
<td>9,700</td>
<td>$1,120/kW (3)</td>
<td>$31</td>
<td>$0.85/MWh</td>
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<td>$1,120/kW (3)</td>
<td>$31</td>
<td>$0.85/MWh</td>
</tr>
<tr>
<td>PC-SC (with CO₂) [3]</td>
<td>11,600</td>
<td>$2,100/kW (6)</td>
<td>$37</td>
<td>$0.80/MWh</td>
<td>11,600</td>
<td>$2,100/kW (6)</td>
<td>$37</td>
<td>$0.80/MWh</td>
</tr>
<tr>
<td>AFBC (with CO₂) [3]</td>
<td>11,860</td>
<td>$2,000/kW (6)</td>
<td>$33</td>
<td>$0.95/MWh</td>
<td>11,860</td>
<td>$2,000/kW (6)</td>
<td>$33</td>
<td>$0.95/MWh</td>
</tr>
</tbody>
</table>
### Availability & Recovery Assumptions

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Availability</th>
<th>Comments</th>
<th>Percent of CO₂ Recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGCC (no CO₂ and no backup gasifier)</td>
<td>80</td>
<td>90% is assumed for the case with backup</td>
<td>85</td>
</tr>
<tr>
<td>PC-SC (no CO₂)</td>
<td>86</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>AFBC (no CO₂)</td>
<td>85</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>IGCC (with CO₂ but no backup)</td>
<td>78</td>
<td>88% for the case with CO₂ and backup</td>
<td>85</td>
</tr>
<tr>
<td>PC-SC (with CO₂)</td>
<td>84</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>AFBC (with CO₂)</td>
<td>83</td>
<td></td>
<td>85</td>
</tr>
</tbody>
</table>
SUFG Modeling System

Industrial, Commercial and Residential Electric Energy

Retail Electricity Prices

Baseload, Cycling and Peaking Resource Needs

Regulated Increases in Rates to Accommodate Resource Needs
Simplifying Assumptions

- SUFG Forecast assumptions on macro economics
- CO₂ limits in effect after 2010, study through 2023
- New baseload is CCT & CO₂ per scenario
- Retrofit simulated by adding 50% to new capacity and making it “must take”
- New plants assumed to use Indiana coal
- Generic plants without geography or sequestering
- Indiana is a closed system – no trade or other sources
- Cycling & peaking capacity expansion assumed natural gas
Energy Demand & Price

2023 Electricity Data

Scenarios

Price (c/KWh)

Demand (GWh)

2023 Electricity Price

2023 Electricity Use

Scenarios:
- PC noCO2
- IGnobk noCO2
- IGbK noCO2
- FB noCO2
- PC CO2
- IGnobk CO2
- IGbK CO2
- FB CO2
- PC CO2+50
- IGnobk CO2+50
- IGbK CO2+50
- FB CO2+50
CO$_2$ Emission over Time

![CO2 Emission Graph](image)

- **CO2 Emitted**: 240,000 to 380,000 Million Lbs
- **Year Range**: 2011 to 2023
CO$_2$ in 2023 by Scenario

Total 2023 CO2 Comparison
Cumulative Capacity Expansion

Total Cumulative Capacity Additions

- Peak Capacity Additions
- Cycling Capacity Additions
- BaseLoad Capacity Additions

Scenario:
- PC noCO2
- IKnobk noCO2
- IGbik noCO2
- FB noCO2
- PC CO2
- IKnobk CO2
- IGbikCO2
- FB CO2
- PC CO2+50
- IKnobk CO2+50
- IGbik CO2+50
- FB CO2+50
Coal Usage

Total 2023 Coal Usage

Scenario

- PC noCO2
- IG nobk noCO2
- FB noCO2
- PC CO2
- IG nobk CO2
- IGbk CO2
- FB CO2
- PC CO2+50
- IG nobk CO2+50
- IGbk CO2+50
- FB CO2+50

Other Coal Sources
Indiana Coal

Million mBtu
CCTR Research Plan
Statewide Optimization for CO$_2$

- Policy tool for assessing implementation of CCT, and potentially, CO$_2$ regulation & sequestration

- Work in two phases
  - Phase I – further investigation of component issues
  - Phase II – optimization modeling
Statewide Optimization for CO$_2$

- Component issues
  - CO$_2$ capture technologies
  - New CCT technologies
  - Configuration design for availability & min cost
  - CO$_2$ sequestration (location, pipelines, etc.)
  - Power transmission from mine mouth plants
  - Cap & trade impacts
  - Better cost estimates
Statewide Optimization for CO$_2$

- Optimization model
  - Choose construction and upgrades
  - Meet projected demand
  - Comply with CO$_2$ regulations

- Treat state in regions so that transmission geography and cap & trade can be incorporated
Retrofitting for CCT

• Of new plants built with upgrade in mind
• Systems of old plants
  – Least cost
  – Interaction among plants to maintain system reliability
Co-Production

• Combinations of power, transportation fuels, fertilizer, etc.
  – Big opportunity with power to exploit variation of demand over day and season
  – Obama-Lugar may bring transportation fuel investment

• First part, optimization of single co-production facilities, probably to maximize investment return

• Also, regulation of co-production
  – In the rate base?
  – Who decides priorities between power and others?
CCT Uncertainties & Risks

- Dealing with cost unpredictability
- Using CCT to hedge natural gas market volatility
- CCT to boost national security, e.g. in military fuels
- Risks in carbon sequestration
- Impact of power price increase on economics & employment, and how to mitigate the impact
Public-Private Action Plan
Indiana Clean-Coal Summit

• CCT and probably CO$_2$ regulation are coming
• Scenarios suggest something like 12K MW needed through 2023
• Uncertainties about costs and CO$_2$, technology maturity, sitting, permitting, etc. has produced some paralysis
Indiana Clean-Coal Summit

- Need to assemble state officials, coal industry, power industry, consumer groups, etc. to find a way to accelerate CCT
- What extra incentives are needed?
- Can they be tied to use of Indiana coal?
Sequestration Replaces Interest in Coal Characteristics

- Many CCTs, especially IGCC, are able to use wide variety of coals
  - No need to emphasis detail coal characteristics
- Much more needs to be understood about sequestration
  - Cost, risks, locations, adjacency to power transmission and mines
Preparation for Increased Coal Production

• If CCTs are implemented, coal demand will increase
• Could be dramatic for Indiana coal if incentives have strings
• Coal industry needs to prepare for this increase in capacity
• Community colleges need to enhance training of coal mining personnel
Long Term Transmission Agreements

• Federal ISO regulations for pricing power transmission rights pushing in the direction of short term FTRs

• Investment in new plants depends in part in partnering and shared cost of investment
  – This is made risky by uncertainty about cost to bring from production site to own market

• Need for federal regulatory reform to facilitate longer term transmission contracts
FutureGen

- Huge federal opportunity
  - Important chance to build human technical capital
- Indiana has been passive relative to other states
- Indiana has advantages
  - Coal reserves
  - Sequestration sites
  - Regulated rates and capital cost recovery
  - Wabash River project
  - Purdue and its agencies
- State activity must accelerate, probably in partnership with Illinois