The Case for Integrated Gasification Combined Cycle Technology

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AEP: An introduction

AEP Facts at a Glance

Largest U.S. Electricity Generator and coal user

- 11 States (7-East & 4-West)
- 36,000 MW Generation
- 78 MM tons of coal per year
- 39,000 Miles Transmission
- 210,000 Miles Distribution
- 5 Million Customers
- 20,000 Employees
- US$ 14.5 Billion Revenue
- US$ 36.7 Billion in Assets

<table>
<thead>
<tr>
<th>Coal</th>
<th>NG</th>
<th>Nuclear</th>
<th>Hydro</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>75%</td>
<td>15%</td>
<td>6%</td>
<td>2%</td>
<td>2%</td>
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</table>
Now is the Time to Upgrade our Nation’s Electricity Infrastructure

- 70% load growth in past 25 years
  - Little new baseload capacity added
  - Little new transmission added
- Nuclear generation capacity reaching output limit
  - 1990 66% capacity factor
  - 2004 91% capacity factor
- Coal generation capacity becoming fully utilized
  - 1990 59% capacity factor
  - 2004 74% capacity factor
- Demand expected to grow another 20% over next 10 years
  - Long lead time for baseload generation capacity
Electric Power’s Future

- Population growth and increased electrification requires about 250-300 GW of baseload generating capacity over next 25 years
- No silver bullet ... Need a portfolio
- Future demand probably met largely by coal:
  - Gas supply issues and price volatility in North America
  - LNG imports will exacerbate U.S. trade imbalance
  - Nuclear could be revived, but probably decades away from a major resurgence
  - Renewables (particularly wind) promising, but infrastructure/intermittency limits penetration
U.S. Forecasts Largest Coal Generation Capacity Installation in 40 Years

Low-Cost Electricity from Coal: Coal Fuels 50%+ of U.S. Electricity

Retail Cost Per kWh & Percent of Coal Generation

$\approx$ average retail price per kilowatt hour for 2004

% = percent of total generation from coal for 2004

The Path Toward Near-Zero Emissions from Coal-Fueled Generating Plants

* Estimate
Source: EPA's Clean Air Markets database; EIA 2004 Annual Energy Outlook; GE Energy; SFA Pacific.
Ultra-Supercritical Pulverized Coal

- For technical or financial reasons, IGCC technology may not be available for new coal generation
- To achieve maximum efficiency, AEP plans to build ultra-supercritical pulverized coal plants where IGCC is not feasible
- Ultra-supercritical PC plants have main boiler steam temperatures >1100°F and pressures >3600 PSI
- The technology costs 1-3% more than supercritical PC plants

<table>
<thead>
<tr>
<th>Technology</th>
<th>PC</th>
<th>PC</th>
<th>PC</th>
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<tbody>
<tr>
<td>Steam Cycle</td>
<td>USC</td>
<td>Supercritical</td>
<td>Subcritical</td>
</tr>
<tr>
<td>Throttle Pressure, psig</td>
<td>3500</td>
<td>3500</td>
<td>2400</td>
</tr>
<tr>
<td>Steam Temperature, F</td>
<td>1110/1125</td>
<td>1000/1000</td>
<td>1000/1000</td>
</tr>
<tr>
<td>Fuel</td>
<td>Lignite</td>
<td>Lignite</td>
<td>Lignite</td>
</tr>
<tr>
<td>Fuel HHV, Btu/lb</td>
<td>6360</td>
<td>6360</td>
<td>6360</td>
</tr>
<tr>
<td>FGD Technology</td>
<td>Wet FGD</td>
<td>Wet FGD</td>
<td>Wet FGD</td>
</tr>
<tr>
<td>Gross Turbine Heat Rate, Btu/kwh</td>
<td>7247</td>
<td>7526</td>
<td>7733</td>
</tr>
<tr>
<td>Aux Power, %</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>Boiler Efficiency, %</td>
<td>0.825</td>
<td>0.825</td>
<td>0.825</td>
</tr>
<tr>
<td>Net Unit Heat Rate (Full Load), Btu/kwh</td>
<td>9653</td>
<td>10025</td>
<td>10300</td>
</tr>
<tr>
<td>CO2 Emissions (Full Load), lb/MBtu</td>
<td>218</td>
<td>218</td>
<td>218</td>
</tr>
<tr>
<td>CO2 Emissions (Full Load), Tons/MWH</td>
<td>1.05</td>
<td>1.09</td>
<td>1.12</td>
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</table>
PRE-COMBUSTION Treatment of Pollutants
• High pressure
• Low Volume
• Concentrated stream (easier to treat)

CO2 Flexibility for CO2 Sequestration (Concentrated Stream)

HRS G

Steam Turbine

Combustion Turbine

Electricity

Air

Compressed Air to ASU

Electricity

Air Separation Unit (ASU)

Low Temp Gas Cooling

Shift Rx (option)

Hg Removal 90+% Removal

Acid Gas Removal

Sulfur Recovery Claus/Scot

CO/H2 98+% Removal

Sulfur

Coal + H2O

GE "Quench" Gasifier

Slurry

O2

Particulate Scrubber

Fines/Char

Slag/Frit

H2O

Particulate

Precombustion

Treatment of Pollutants

Flexible for CO2 Sequestration (Concentrated Stream)
IGCC: Feedstock & by-product flexibility

- **Biomass**
- **Coal**

**Refinery By-products**
- Petroleum Coke
- Oil tars

**Marketable By-products, e.g.:**
- Sulfur
- Sulfuric Acid
- Slag / Frits

**Syngas**

**Hydrogen**

**Electricity**

**Liquid Chemicals**
- Methanol
- Diesel Fuels
CO₂ Capture – Eastern Bituminous Coal

Carbon capture (“scrubbing”) is a difficult and expensive process:
- CO₂ is a very stable molecule
- CO₂ concentration is very low in flue gases
- Amine processes (MEA) are the only currently proven approach – high capital cost
- A large amount of steam is required to regenerate the amine (strip the CO₂ from the “carbon getter”) – large efficiency penalty

<table>
<thead>
<tr>
<th>Impact of Adding CO₂ Capture</th>
<th>Pulverized Coal</th>
<th>IGCC</th>
<th>NGCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost</td>
<td>+65% to 75%</td>
<td>+30% to 40%</td>
<td>+85% to 90%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>-30% to 35%</td>
<td>-18% to 22%</td>
<td>-20 to 25%</td>
</tr>
<tr>
<td>Cost of Electricity</td>
<td>+63%</td>
<td>+38%</td>
<td>+53%</td>
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Source: AEP, EPRI, and US DOE
# Investing in IGCC

## Generation Technology Comparative Statistics

<table>
<thead>
<tr>
<th></th>
<th>PC</th>
<th>IGCC</th>
<th>NGCC</th>
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</thead>
<tbody>
<tr>
<td>Nominal Capacity (MW)</td>
<td>600</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Heat Rate (Btu/kWh)</td>
<td>8700</td>
<td>8600</td>
<td>7200</td>
</tr>
<tr>
<td>Total Plant Cost (EPC) ($/kW)</td>
<td>1700</td>
<td>1900</td>
<td>480</td>
</tr>
<tr>
<td>Production Cost ($/MWh)</td>
<td>17</td>
<td>16</td>
<td>57</td>
</tr>
<tr>
<td>Cost of Electricity, without CO2 Capture ($/MWh)</td>
<td>58</td>
<td>63</td>
<td>90</td>
</tr>
<tr>
<td>Estimated Cost of Electricity, with CO2 Capture ($/MWh)</td>
<td>94</td>
<td>87</td>
<td>137</td>
</tr>
</tbody>
</table>

- **Source**: Results of AEP analysis based on EPRI studies.
- Total Plant Cost (2005$’s) includes the cost to Engineer, Procure and Construct plant and owner’s direct costs; does not include interconnections, transmission lines, transmission upgrades, contingency or AFUDC.
- Assumes Northern Appalachian Coal price of $1.80/mmBtu for PC and IGCC, and natural gas price of $7.00/mmBtu for NGCC.
- Assumes 85% capacity factor for PC and IGCC, 25% for NGCC.
- Production Cost includes Fuel Cost and Variable Operations & Maintenance (VOM) cost.
- Cost of Electricity based on EPC cost, does not include the cost of Emission Credits.
- Cost of Electricity with CO2 capture does not include sequestration cost.

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**IGCC technology is strategic to keeping coal in the money**
Integrated Gasification Combined Cycle’s Promise

- **Lowest capital cost** (when mature) coal-based technology
- **Feedstock & product flexibility** (with added cost)
  - Coal, petcoke, or biomass feedstocks
  - Electricity, steam, syngas, liquid fuels, or chemical products
- **Most efficient** coal-based technology (when mature)
- **Best emission** characteristics among coal-based technologies
- **Most carbon-friendly** coal technology
- **The technology of choice** to KEEP COAL IN THE MIX
  - Strategically important to the energy security and economies of many states and the U.S.
AEP’s IGCC Investment

• **600 MW Plant built by 2010; Another 600 MW by 2013**
  – Front-End Engineering & Design and environmental permitting underway on both plants
  – Transmission studies requested of PJM

• **Sites being considered include:**
  – Meigs County, OH
  – Mason County, WV (adjacent to Mountaineer Plant)

• **Regulatory cost recovery**
  – Filed cost recovery plan with PUCO in 2005; Phase I approved
  – Filed Certificate of Convenience and Necessity in WV in 2006

• **R&D Activities**
  – Mountaineer Sequestration Project
  – FutureGen participation
Public policy tools to support IGCC:  
(Ohio example)

1. Public Utilities Commission suggested IGCC plant be built

2. Need pre-construction assurance investment is recoverable

3. AEP Ohio filed plan (March 2005) for recovering costs for 600 MW plant in operation mid-2010
   - Phase 3: Recover $1.033 billion estimated plant cost over its 40-year operating life with a regulated return on the investment. Case to be filed at conclusion of construction.
Leadership

• Choosing IGCC is not just a technology decision; it’s a leadership decision
  – If not AEP, then who?
  – If not coal, then what?

• Being a leader has its perils and risks
  – Partnerships and cooperation are necessary for success

• Federal and State Governments have a critical role
  – Provide incentives and remove roadblocks