Coal Capacity at Risk for Retirement in PJM:
Potential Impacts of the Finalized EPA Cross State Air Pollution Rule and Proposed National Emissions Standards for Hazardous Air Pollutants

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## Stylized Summary of Environmentally Related Rules Impacting Resource Adequacy

<table>
<thead>
<tr>
<th>Pollutant or target issue</th>
<th>GHG Tailoring Rule</th>
<th>Cross State Air Pollution Rule</th>
<th>NESHAP</th>
<th>CWA 316(b)</th>
<th>High Electricity Demand Day</th>
<th>Renewable Portfolio Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ and other GHG</td>
<td>SO₂ and NOₓ annual limits NOₓ seasonal limit</td>
<td>Mercury, other Heavy Metals, and Acid Gases</td>
<td>Cooling water intake structures</td>
<td>Ozone formation from NOₓ on hot days</td>
<td>Ensure a certain percentage of renewables</td>
<td></td>
</tr>
<tr>
<td>All fossil units</td>
<td>All fossil units Primarily coal</td>
<td>Coal and oil, primarily coal</td>
<td>All existing units</td>
<td>Oil and gas peaking</td>
<td>All units</td>
<td></td>
</tr>
<tr>
<td>BACT case-by-case, state-by-state</td>
<td>Limited cap &amp; trade. Use of FGD or DSI and SCR likely</td>
<td>MACT to be defined, likely FGD or DSI, ACI, fabric filter</td>
<td>BTA to be defined, likely not once thru cooling</td>
<td>NOₓ rate standard. Use of SCR and other controls likely</td>
<td>Mandated percentage of electricity sales from renewables</td>
<td></td>
</tr>
<tr>
<td>Mostly fixed costs</td>
<td>Fixed and variable costs – allowance prices</td>
<td>Mostly fixed costs, but also some VOM</td>
<td>Mostly fixed costs</td>
<td>Mostly fixed costs</td>
<td>Reduced net energy market revenues</td>
<td></td>
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</tbody>
</table>

**www.pjm.com**
PJM RTO
(MidAtlantic, AP, ComEd, AEP, Dayton, Duquesne, Dominion, & ATSI Regions)

Capacity By Fuel Type -- 177,579 MW installed generation capacity

- Natural Gas: 27,360 MW (16%)
- Gas Total Gen: 49,836 MW (11.7%)
- Oil: 14,923 MW (8.2%)
- Gas / Other Secondary: 19,396 MW (11%)
- Water: 7,821 MW (4.4%)
- Other: 2,382 MW (1.3%)
- Coal: 72,098 MW (41.1%)
- Nuclear: 33,600 MW (19.2%)

Percentage of 2010 Generation in parentheses
How Much Coal Generation is at Risk for Retirement?

- How many megawatts (MW) of coal-fired generation are at risk for retirement?
  - Proposed EPA rules would effectively require costly environmental retrofits or repowering to natural gas or force units to retire
  - How many coal units will retire, repower, or retrofit?
  - What is the current retrofit status of coal generation
  - What are the prospects for retaining existing coal units?
Big Question: What are the reliability implications of the CSAPR and NESHAP rules?

- **Resource adequacy**
  - Will there be sufficient resources to meet peak loads plus the installed reserve margin?

- **Local transmission reliability**
  - Will transmission upgrades be necessary to allow units to retire reliably?
  - Managing retrofit tie-in outages reliably
Key Takeaways

• Units more than 40 years old and less than 400 MW are the most at risk for retirement due to the CSAPR and NESHAP rules
  – This is about 30 percent of the current coal fleet in PJM

• 11,051 MW of coal requires more that the Net Cost of New Entry (Net CONE) of a natural gas combustion turbine to be economically viable under the CSAPR and NESHAP rules
  – On average these units are more than 50 years old and less than 200 MW and are considered at “high risk” for retirement
  – An additional 14,147 MW are at risk as they require between \( \frac{1}{2} \) Net CONE and Net CONE to be economically viable

• PJM anticipates resource adequacy over the entire RTO will be maintained

• Retirements may pose local reliability issues requiring transmission upgrades to ensure transmission and operating reliability
Environmental Regulations - Control Implications

Selective Non-Catalytic Reduction
- Lower cost but also lower removal rates

Selective Catalytic Reduction
- Reduces NO\textsubscript{x} and enhances mercury removal

Low NO\textsubscript{x} Burners
- Reduces NO\textsubscript{x}

Steam Generator
- High efficiency boiler produces less emissions per Megawatt output

Dry Sorbent Injection
- Lower capital cost
- Alternative to Wet Lime FGD, but higher operating cost
- Most proven for sub-bituminous coals

Activated Carbon Injection
- Removes mercury
- Then captured in Fabric Filter

Fabric Filter
- Captures particulate matter and mercury

Wet ESP
- Reduces fine particulate and sulfuric acid mist

Scrubber
- Removes SO\textsubscript{2} and mercury

Fabric Filter
- Captures particulate matter and mercury

Bottom Ash
- A by-product useful in concrete and other products, or stored

Coal & Pet Coke

Pulverizers

PC Boiler with Low NO\textsubscript{x} Combustion System

Economizer

SCR

NH\textsubscript{3} Injection

Air Heater

Limestone

Gypsum
- A by-product useful in wallboard

Scrubber
- Removes SO\textsubscript{2} and mercury

Fabric Filter
- Captures particulate matter and mercury

Fly Ash
- A by-product useful in concrete and other products, or stored

FD Fans

Chimney

Limestone

Gypsum
- A by-product useful in wallboard

Emission Monitoring
- Continuously monitors many types of emissions

Dry Sorbent Injection
- Lower capital cost
- Alternative to Wet Lime FGD, but higher operating cost
- Most proven for sub-bituminous coals

Cooling Towers
## Total Coal Capacity in PJM without Pollution Controls

<table>
<thead>
<tr>
<th></th>
<th>PJM RTO</th>
<th>MAAC</th>
<th>Rest of PJM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Coal</strong></td>
<td>78,613</td>
<td>18,761</td>
<td>59,852</td>
</tr>
<tr>
<td><strong>No SO₂ Controls</strong></td>
<td>30,069</td>
<td>4,281</td>
<td>25,788</td>
</tr>
<tr>
<td><strong>No SCR for NOₓ Reduction</strong></td>
<td>36,618</td>
<td>8,805</td>
<td>27,813</td>
</tr>
<tr>
<td><strong>No Fabric Filter</strong></td>
<td>69,115</td>
<td>13,020</td>
<td>56,095</td>
</tr>
<tr>
<td><strong>No SO₂ and No SCR</strong></td>
<td>22,866</td>
<td>2,723</td>
<td>20,143</td>
</tr>
<tr>
<td><strong>No SO₂ and No Fabric Filter</strong></td>
<td>29,457</td>
<td>3,756</td>
<td>25,701</td>
</tr>
</tbody>
</table>

Inclusive of DEOK and ATSI
Pollution Control Retrofit Costs for a 500 MW Coal Unit vs. Costs of New Natural Gas Technologies

<table>
<thead>
<tr>
<th>Control Technology</th>
<th>Capital Cost ($/kW)</th>
<th>Fixed O&amp;M ($/MW-yr)</th>
<th>Variable O&amp;M ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGD</td>
<td>$501</td>
<td>$8,150</td>
<td>$1.81</td>
</tr>
<tr>
<td>DSI</td>
<td>$40</td>
<td>$590</td>
<td>$7.92</td>
</tr>
<tr>
<td>SCR</td>
<td>$197</td>
<td>$720</td>
<td>$0.66</td>
</tr>
<tr>
<td>SNCR</td>
<td>$19</td>
<td>$260</td>
<td>$1.33</td>
</tr>
<tr>
<td>Fabric Filter + ACI</td>
<td>$155+$9</td>
<td>$630+$40</td>
<td>$0.15+$0.93</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control Technology</th>
<th>Capital Cost ($/kW)</th>
<th>Fixed O&amp;M ($/MW-yr)</th>
<th>Variable O&amp;M ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Cycle CT</td>
<td>$665-$975</td>
<td>$6,700-$6,980</td>
<td>$9.87-$14.60</td>
</tr>
<tr>
<td>Combined Cycle CT</td>
<td>$1,000-$1,150</td>
<td>$21,600</td>
<td>$3.23</td>
</tr>
</tbody>
</table>
Coal Capacity Factors Inclusive of ATSI and DEOK

Average Capacity Factor

2007 2008 2009 2010

All Coal
<=40 Years
>40 Years
<400 MW
>=400 MW
>40 Years and <400 MW
National Average Annual Delivered Price of Coal and Natural Gas 2006-2010

Forecast Prices from EIA Annual Energy Outlook 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Gas</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>$6.94</td>
<td>$1.69</td>
</tr>
<tr>
<td>2007</td>
<td>$7.11</td>
<td>$1.77</td>
</tr>
<tr>
<td>2008</td>
<td>$9.01</td>
<td>$2.07</td>
</tr>
<tr>
<td>2009</td>
<td>$4.74</td>
<td>$2.21</td>
</tr>
<tr>
<td>2010</td>
<td>$5.08</td>
<td>$2.26</td>
</tr>
<tr>
<td>2011</td>
<td>$4.94</td>
<td>$2.27</td>
</tr>
<tr>
<td>2012</td>
<td>$4.93</td>
<td>$2.23</td>
</tr>
<tr>
<td>2013</td>
<td>$5.00</td>
<td>$2.23</td>
</tr>
<tr>
<td>2014</td>
<td>$5.04</td>
<td>$2.24</td>
</tr>
<tr>
<td>2015</td>
<td>$5.23</td>
<td>$2.31</td>
</tr>
<tr>
<td>2016</td>
<td>$5.38</td>
<td>$2.31</td>
</tr>
</tbody>
</table>
Compliance Cost and Economic Environment: Key Takeaways

• Retrofits to comply with air rules are very costly putting pressure on fixed costs
  – Economies of scale to retrofit costs...cost/MW is higher for smaller units

• Significantly reduced gas-coal spreads and demand are adding pressure on the revenue side of the equation
  – Some controls also have significant variable costs and add to this pressure
  – Smaller, older units have lower revenues per MW

• Conjecture:
  – Older, smaller units will be at greater risk for retirement if they require retrofits
### Unit Characteristics Screen: Key Takeaways
### Units More than 40 Years Old and Less than 400 MW

<table>
<thead>
<tr>
<th></th>
<th>PJM</th>
<th>MAAC</th>
<th>Rest of PJM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>22,907</td>
<td>5,769</td>
<td>17,138</td>
</tr>
<tr>
<td><strong>No SO₂ Controls</strong></td>
<td>17,387</td>
<td>2,560</td>
<td>14,827</td>
</tr>
<tr>
<td><strong>No Fabric Filter</strong></td>
<td>20,104</td>
<td>3,729</td>
<td>16,375</td>
</tr>
<tr>
<td><strong>No SO₂ Control and No Baghouse</strong></td>
<td>16,775</td>
<td>2,035</td>
<td>14,740</td>
</tr>
<tr>
<td><strong>No SCR</strong></td>
<td>18,762</td>
<td>4,456</td>
<td>14,306</td>
</tr>
<tr>
<td><strong>No SO₂ Control and No SCR</strong></td>
<td>14,541</td>
<td>2,236</td>
<td>12,305</td>
</tr>
</tbody>
</table>
Necessary Revenue to Continue Operating under CSAPR and NESHAP

Required Revenues in $/MW\text{-}day of Installed Capacity

- Avg Rev Req Low Gas 09-10
- Avg Rev Req High Gas 07-08
- Avg Rev Req All Gas 07-10

0-100 MW
100-200 MW
200-300 MW
300-400 MW
400-500 MW
500-600 MW
600-700 MW
700-800 MW
>800 MW
## Capacity with Needed Revenues under CSAPR and NESHAP

Benchmarked against Net CONE in MAAC

<table>
<thead>
<tr>
<th>MW of Installed Capacity</th>
<th>&lt;0.5 Net CONE</th>
<th>0.5-1.0 Net CONE</th>
<th>1.0 - 1.5 Net CONE</th>
<th>&gt;1.5 Net CONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Yr High Gas</td>
<td>17,625.70</td>
<td>1,016.10</td>
<td>113.00</td>
<td>0.00</td>
</tr>
<tr>
<td>20 Yr All Gas 07-10</td>
<td>14,194.70</td>
<td>3,543.00</td>
<td>888.00</td>
<td>129.10</td>
</tr>
<tr>
<td>20 Yr Low Gas</td>
<td>12,634.70</td>
<td>2,926.00</td>
<td>1,705.00</td>
<td>1,489.10</td>
</tr>
</tbody>
</table>

- 0.5 Net CONE (ICAP) = $113.40/MW-day
- Net CONE (ICAP) = $226.79/MW-day
- 1.5 Net CONE (ICAP) = $340.19/MW-day
Capacity with Needed Revenues under CSAPR and NESHAP
Benchmarked against Net CONE in Rest of RTO

- 0.5 Net CONE (ICAP) = $160.42/MW-day
- Net CONE (ICAP) = $320.84/MW-day
- 1.5 Net CONE (ICAP) = $481.26/MW-day

<table>
<thead>
<tr>
<th>MW of Installed Capacity</th>
<th>&lt;0.5 Net CONE</th>
<th>0.5-1.0 Net CONE</th>
<th>1.0 - 1.5 Net CONE</th>
<th>&gt;1.5 Net CONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Yr High Gas</td>
<td>41,654.40</td>
<td>1,801.00</td>
<td>696.00</td>
<td>645.00</td>
</tr>
<tr>
<td>20 Yr All Gas 07-10</td>
<td>37,065.40</td>
<td>4,409.00</td>
<td>2,554.00</td>
<td>768.00</td>
</tr>
<tr>
<td>20 Yr Low Gas</td>
<td>26,010.40</td>
<td>10,929.00</td>
<td>4,595.00</td>
<td>3,262.00</td>
</tr>
</tbody>
</table>
Summary of Additional Revenues Needed Relative to Net CONE with 20 Yr Recovery—Low Gas

<table>
<thead>
<tr>
<th>Additional Revenue Needed</th>
<th>PJM</th>
<th>MAAC</th>
<th>Rest of PJM</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.5 Net CONE</td>
<td>38,334</td>
<td>12,634</td>
<td>25,700</td>
</tr>
<tr>
<td>0.5 Net CONE – 1.0 Net CONE</td>
<td>14,147</td>
<td>2,908</td>
<td>11,239</td>
</tr>
<tr>
<td>&gt; 1.0 Net CONE</td>
<td>11,051</td>
<td>3,194</td>
<td>7,857</td>
</tr>
</tbody>
</table>

- For the 11,051 MW at “high” or “very high risk”, the average age is more than 50, average size less than 200 MW.

- For the 14,147 “at risk” the average age is 37, average size almost 400 MW

- For the remaining capacity “at low risk”, average age is 34, average size almost 500 MW
• 6,985 MW UCAP (7,350 MW ICAP) less coal capacity cleared in the 2014/15 BRA than in the 2013/2014 BRA

• Approximately 7,000 MW of FRR coal capacity (outside RPM) has been announced as retiring by 2015
  – Most of this capacity falls into the high or very high risk categories

• Reserve margin for 2014/2015 is projected at 19.6%, even with less coal capacity clearing

• Accounting for FRR announcements still leaves PJM above the 15.3% target
Potential Impacts on Local Transmission Reliability

- Large volume of likely retirements increases the probability of the need for some transmission upgrades to allow units to retire reliably.

- PJM request in its NESHAP comments to EPA:
  - Allow for at least a 1 year extension to 2016 for units deemed critical for reliability to allow transmission upgrades to be built to allow a unit to retire.
  - Unit must provide advance notice (2 years prior to effective compliance date) to provide sufficient lead time to construct transmission upgrades.
  - Possibility of extension beyond 2016 on a case-by-case basis through consent decrees.