Impact of Coal Displacement on Unit and System Operations

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Key Points

• The price of natural gas is key to the displacement of coal-fired baseload generation, but it is not the only factor.

• Other factors include:
  – The size and efficiency of the regional fleets of natural gas combined cycle (NGCC) generators.
  – The relative inefficiency of coal units.
  – The market-insensitive nature of coal prices and resulting generation costs (at least to date).
  – Stagnant market for power (the pie is not growing).
  – Over the longer term: The cost of maintaining aging plants, including the cost of environmental compliance.
Primary Data Sources

• EIA
  – Power plant generation and delivered fuel costs: data collected on the Form EIA-923.
  – Power plant capacity and heat rates: data collected on the Form EIA-860.
  – All data is public other than tested heat rates, and can be found at [http://www.eia.gov/cneaf/electricity/page/data.html](http://www.eia.gov/cneaf/electricity/page/data.html).
  – *Data for 2011 and 2012 is preliminary and subject to change.*

• Other Sources
  – Coal prices are proprietary data from SNL Financial ([http://www.snl.com/](http://www.snl.com/)).
  – Henry Hub cash gas prices are from the FRED database maintained by the St. Louis Federal Reserve Bank ([http://research.stlouisfed.org/fred2/](http://research.stlouisfed.org/fred2/)).
Background: Overall Trends
The fuel mix is changing (1)

Electricity generation by fuel, Jan 2006 – August 2012: Thousand Mwh


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The fuel mix is changing (2)
Electricity generation by fuel, Jan 2006 – August 2012: Percent of Monthly Total

The fuel mix is changing (3)

Difference Between Coal and Gas Net Generation, Jan 2006 – August 2012: Thousand MWh

Generation Shares: a longer-term perspective

Natural gas’s share of generation capacity has grown over past decades

Natural gas prices have reached long-term lows in past 2 years

Source: FRED database, St. Louis Federal Reserve Bank (http://research.stlouisfed.org/fred2/).
Natural gas has seen increased production despite weak prices

Natural gas in underground storage, Lower 48 states, BCF

Source: EIA, Weekly Natural Gas Storage Report data files (http://ir.eia.gov/ngs/ngs.html). Notes: Data is for the end of week. The end-of-week dates shown are for 2012 reporting; 2011 data has been matched to those dates as closely as possible. For additional information on the data collection, estimation methodology, and computation of the minimum and maximum range values see the notes at the website cited in the source note.
Coal prices have generally stayed within historical ranges: *Central App*

NYMEX Big Sandy
12,000 btu/lb
1.67% Sulfur
Barge
Prompt Quarter Spot Price, $ per Short Ton

Source: SNL Financial
Coal prices have generally stayed within historical ranges: *PRB*

**Wyoming PRB**
- 8,800 btu/lb
- 0.8% Sulfur
- Rail
- Prompt Quarter Spot Price, $ per Short Ton

Source: SNL Financial
Coal supply has been ample with large stocks at power plants

Generation Has Been Stagnant

Sources: EIA estimates using the EIA-923 database.
A warm winter of 2011-12 suppressed overall power demand

Demand growth continues to slow

Annual growth in electricity consumption

percent growth (3-year rolling average)

<table>
<thead>
<tr>
<th>Period</th>
<th>Annual Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>9.8</td>
</tr>
<tr>
<td>1960s</td>
<td>7.3</td>
</tr>
<tr>
<td>1970s</td>
<td>4.7</td>
</tr>
<tr>
<td>1980s</td>
<td>2.9</td>
</tr>
<tr>
<td>1990s</td>
<td>2.4</td>
</tr>
<tr>
<td>2000-2010</td>
<td>1.0</td>
</tr>
<tr>
<td>2010-2035</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Source: EIA, Annual Energy Outlook 2012

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Analysis of Study Group of Plants
Study Group of Power Plants (1)

• Plants that were in operation at the beginning of 2007, plus subsequent capacity additions.

• Minimum summer net capacity on 1/1/2007:
  – Coal-fired plants: 250 Mw
  – Natural gas combined cycles (NGCC): 100 Mw.

• Primary business selling power to the public (no industrial or commercial cogenerators). In EIA parlance, this is the “Electric Power Sector.”
## Study Group of Power Plants (1)

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of Plants</th>
<th>Mw at end of 2011</th>
<th>% of U.S. Total Mw for Type, 2011</th>
<th>% of U.S. Total Mwh for Type, 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>295</td>
<td>287,164</td>
<td>91%</td>
<td>93%</td>
</tr>
<tr>
<td>NGCC</td>
<td>313</td>
<td>187,495</td>
<td>83%</td>
<td>81%</td>
</tr>
</tbody>
</table>
Study Regions

Source: Map created by EIA using Ventyx (Energy Velocity).
The Most Significant Declines in Coal Generation Have Been in the East and Midwest

<table>
<thead>
<tr>
<th>Region</th>
<th>CY 2007 (GWh)</th>
<th>July 2011 - June 2012 (GWh)</th>
<th>Change in GWh</th>
<th>% Change</th>
<th>Share of Total Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISNE</td>
<td>15,798</td>
<td>3,463</td>
<td>(12,334)</td>
<td>-78%</td>
<td>3%</td>
</tr>
<tr>
<td>NYISO</td>
<td>16,306</td>
<td>5,171</td>
<td>(11,134)</td>
<td>-68%</td>
<td>3%</td>
</tr>
<tr>
<td>PJM</td>
<td>382,158</td>
<td>266,045</td>
<td>(116,113)</td>
<td>-30%</td>
<td>28%</td>
</tr>
<tr>
<td>FRCC</td>
<td>54,292</td>
<td>39,193</td>
<td>(15,099)</td>
<td>-28%</td>
<td>4%</td>
</tr>
<tr>
<td>SOUTHEAST</td>
<td>483,695</td>
<td>331,184</td>
<td>(152,512)</td>
<td>-32%</td>
<td>37%</td>
</tr>
<tr>
<td>MISO</td>
<td>442,593</td>
<td>379,410</td>
<td>(63,183)</td>
<td>-14%</td>
<td>15%</td>
</tr>
<tr>
<td>SPP</td>
<td>136,718</td>
<td>135,818</td>
<td>(901)</td>
<td>-1%</td>
<td>0%</td>
</tr>
<tr>
<td>ERCOT</td>
<td>115,215</td>
<td>97,372</td>
<td>(17,843)</td>
<td>-15%</td>
<td>4%</td>
</tr>
<tr>
<td>OTHER WECC</td>
<td>221,311</td>
<td>195,906</td>
<td>(25,404)</td>
<td>-11%</td>
<td>6%</td>
</tr>
<tr>
<td>CISo</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,868,086</td>
<td>1,453,563</td>
<td>(414,523)</td>
<td>-22%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Data calculations by EIA from the EIA-923 database; map created by EIA using Ventyx (Energy Velocity).
The Most Significant Changes in NGCC Generation Have Also Been in the East and Midwest

<table>
<thead>
<tr>
<th></th>
<th>CY 2007 (GWh)</th>
<th>July 2011 - June 2012 (GWh)</th>
<th>Change in GWh</th>
<th>% Change</th>
<th>Share of Total Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISNE</td>
<td>49,378</td>
<td>54,699</td>
<td>5,321</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>NYISO</td>
<td>28,118</td>
<td>30,515</td>
<td>2,397</td>
<td>9%</td>
<td>2%</td>
</tr>
<tr>
<td>PJM</td>
<td>41,634</td>
<td>104,858</td>
<td>63,224</td>
<td>152%</td>
<td>40%</td>
</tr>
<tr>
<td>FRCC</td>
<td>77,447</td>
<td>80,347</td>
<td>2,899</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>SOUTHEAST</td>
<td>77,106</td>
<td>155,790</td>
<td>78,684</td>
<td>102%</td>
<td>50%</td>
</tr>
<tr>
<td>MISO</td>
<td>25,707</td>
<td>41,435</td>
<td>15,728</td>
<td>61%</td>
<td>10%</td>
</tr>
<tr>
<td>SPP</td>
<td>32,733</td>
<td>42,347</td>
<td>9,614</td>
<td>29%</td>
<td>6%</td>
</tr>
<tr>
<td>ERCOT</td>
<td>114,881</td>
<td>127,929</td>
<td>13,048</td>
<td>11%</td>
<td>8%</td>
</tr>
<tr>
<td>OTHER WECC</td>
<td>112,967</td>
<td>89,943</td>
<td>(23,024)</td>
<td>-20%</td>
<td>-15%</td>
</tr>
<tr>
<td>CISO</td>
<td>53,576</td>
<td>43,287</td>
<td>(10,288)</td>
<td>-19%</td>
<td>-7%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>613,547</td>
<td>771,150</td>
<td>157,603</td>
<td>26%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Data calculations by EIA from the EIA-923 database; map created by EIA using Ventyx (Energy Velocity).
# Regional Distribution of Capacity

<table>
<thead>
<tr>
<th>Study Region</th>
<th>Coal Mw</th>
<th>NGCC Mw</th>
<th>Coal % of U.S. Total</th>
<th>NGCC % of U.S. Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISNE</td>
<td>2,241</td>
<td>10,704</td>
<td>1%</td>
<td>6%</td>
</tr>
<tr>
<td>NYISO</td>
<td>2,318</td>
<td>6,349</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>PJM</td>
<td>61,411</td>
<td>20,407</td>
<td>21%</td>
<td>11%</td>
</tr>
<tr>
<td>FRCC</td>
<td>8,217</td>
<td>22,514</td>
<td>3%</td>
<td>12%</td>
</tr>
<tr>
<td>SOUTHEAST</td>
<td>72,752</td>
<td>36,598</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>MISO</td>
<td>70,082</td>
<td>13,045</td>
<td>24%</td>
<td>7%</td>
</tr>
<tr>
<td>SPP</td>
<td>22,227</td>
<td>12,866</td>
<td>8%</td>
<td>7%</td>
</tr>
<tr>
<td>ERCOT</td>
<td>16,248</td>
<td>28,432</td>
<td>6%</td>
<td>15%</td>
</tr>
<tr>
<td>OTHER WECC</td>
<td>31,667</td>
<td>27,142</td>
<td>11%</td>
<td>14%</td>
</tr>
<tr>
<td>CISo</td>
<td>-</td>
<td>9,438</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>287,164</td>
<td>187,495</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Data calculations by EIA (EIA-860 database); map created by EIA using Ventyx (Energy Velocity).
Efficiency of Coal and NGCC Units

The Southeast appears to have a concentration of highly efficient NGCC units.

Source: EIA-860 survey database (non-public data).
FOB mine spot coal prices had a late and, in the east, limited response to the decline in gas prices.

Sources: Coal prices from SNL; Henry Hub price from St. Louis Fed (FRED database).
NGCC Production Costs Track Natural Gas Spot Prices

Sources: Henry Hub price from St. Louis Fed (FRED database); production costs are EIA estimates using delivered fuel prices (EIA-923 database) and tested heat rates (EIA-860 database).
Rigidity in Coal Plant Production Costs (1)

Sources: Coal prices from SNL; Henry Hub price from St. Louis Fed (FRED database); production costs are EIA estimates using delivered fuel prices (EIA-923 database) and tested heat rates (EIA-860 database).
Rigidity in Coal Plant Production Costs (2)

Sources: Coal prices from SNL; Henry Hub price from St. Louis Fed (FRED database); production costs are EIA estimates using delivered fuel prices (EIA-923 database) and tested heat rates (EIA-860 database).
Differences in Representative Production Costs

Sources: Coal prices from SNL; production costs are EIA estimates using delivered fuel prices (EIA-923 database) and tested heat rates (EIA-860 database).
Overlap in Coal and NGCC Representative Production Costs, Southeast Region

NGCC production cost range (+/- 1 standard deviation).

Coal production cost average and +/- 1 SD range.
Capacity Factor Trends for Coal Plants

Source: Data calculations by EIA from the EIA-923 and EIA-860 databases.
Capacity Factor Trends for NGCC Plants (1)

Source: Data calculations by EIA from the EIA-923 and EIA-860 databases.
Capacity Factor Trends for NGCC Plants (2)

Source: Data calculations by EIA from the EIA-923 and EIA-860 databases.
• The recent advantage of natural gas over coal in power markets is largely a function of the rapid fall in natural gas prices and inflexibility in the coal generation sector.

• Price stability has historically been a strength of coal. However, in a market in which gas prices are low or dropping rapidly price stability becomes a disadvantage. It is unclear to what extent the current price rigidity in the coal market is driven by financial need (stable revenues to support large and long-lived capital investments by railroads and miners) or are simply traditional business practices.

• Coal pricing flexibility may evolve, but it would require more willingness by coal producers and transporters to accept risk. However, if the coal market is entering a long-term period of stagnation, or if costs are inflexible, this may not be the path to profit maximization.
Concluding Comments (2)

• In any case, greater pricing flexibility does not necessarily provide a solution for coal generators competing with natural gas. Coal spot prices have experienced significant volatility (see slide 25) but multi-year supply contracts with fixed or non-market indexes (e.g., PPI, CPI) insulated coal buyers. If coal contract prices were linked to market indexes, coal buyers would see competitive gains versus low priced gas only if coal prices moved in synch with natural gas. This may not be the case, considering the disparate factors (one example: whether Australian mines are experiencing strikes or floods) that can influence coal prices.

• Other rigidities in the coal power sector include the limited operational flexibility of steam electric plants, differences in coal qualities, and the willingness and ability of railroads to change service conditions and patterns.
Concluding Comments (3)

• For natural gas, past disadvantages – price and demand volatility, and overbuilt combined cycle capacity – are now advantages. Combined cycle plants have been built or modified to efficiently handle intermediate loads, creating a wide space for these plants in daily and seasonal dispatch. Market-driven pricing keeps gas contract prices in sync with the spot market (good as long as prices are low or declining). Surplus NGCC capacity is available to displace coal generation.
Concluding Comments (4)

• Other factors which may prove important:
  – Growing need for fast ramping capacity in markets with large amounts of variable renewable power and/or demand response. Gas-fired are more suitable for this need than coal.
  – Dispatch of peaking turbines ahead of coal, perhaps associated with efforts by operators to revise air permits to allow more operating hours.

• This is, of course, a market that was unimaginable just a few years ago. Perhaps the fundamental question is which sector, coal or gas generation, can best flourish in an environment of lower prices and great uncertainty.
For more information

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