Complementing Wind and Solar: Is the Natural Gas Infrastructure Up to the Job?

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Harvard Electric Policy Group
Sixty-Third Plenary Session
June 3, 2011
Washington, DC
Purpose of INGAA Foundation Study

- Renewables integration discussed extensively by policy makers and electric power industry stakeholders
- Role of natural gas-fired generation recognized
- Yet little specific analysis of supply implications and issues that may affect natural gas pipeline infrastructure and services
FIRMING RENEWABLE ELECTRIC POWER GENERATORS: OPPORTUNITIES AND CHALLENGES FOR NATURAL GAS PIPELINES

March 16, 2011
Prepared for The INGAA Foundation, Inc. by:
ICF International
F-2011-02
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105 GW of renewables capacity projected during the next 15 years, the vast majority of which may be characterized as intermittent generation.

This generation will be accompanied by nearly 70 GW of new gas generating capacity.

Already existing gas-fired capacity will also be relied on for incremental generation needs.

<table>
<thead>
<tr>
<th>Cumulative Capacity Additions (GW)</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>50.7</td>
<td>66.5</td>
<td>88.3</td>
</tr>
<tr>
<td>Biomass</td>
<td>2.1</td>
<td>3.4</td>
<td>4.3</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.8</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Landfill Gas</td>
<td>1.1</td>
<td>2.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Solar PV</td>
<td>2.5</td>
<td>4.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>1.9</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>Total Renewables</strong></td>
<td><strong>59.0</strong></td>
<td><strong>80.2</strong></td>
<td><strong>105.6</strong></td>
</tr>
<tr>
<td>Combined Cycle</td>
<td>3.7</td>
<td>19.7</td>
<td>59.1</td>
</tr>
<tr>
<td>Combustion Turbine</td>
<td>0.6</td>
<td>3.7</td>
<td>9.9</td>
</tr>
<tr>
<td><strong>Total Gas-Fired</strong></td>
<td><strong>4.3</strong></td>
<td><strong>23.3</strong></td>
<td><strong>69.0</strong></td>
</tr>
</tbody>
</table>
This report is focused on firming the “forecast error” (the yellow range) associated with wind generation.
Natural Gas Pipeline Issues

• Natural gas pipeline fundamentals
• Pipeline service to electric generators
• Unique issues associated with serving firming generators
Natural Gas Pipeline Fundamentals

• Natural gas pipelines -- designed to support customers’ primary firm gas delivery obligations

• There is no reserve margin
  – No extra capacity exists above the coincidental peak day firm capacity

• Most pipelines are designed to provide uniform service over a 24-hour period (ratable takes)
  – There is a limit on the amount of hourly flexibility that a pipeline can deliver
Natural Gas Pipeline Fundamentals

• Much of the time, pipeline systems have considerable flexibility
  – Because not all firm customers are exercising their entitlement to capacity
  – This creates flexibility to
    • Serve interruptible customers
    • Accommodate demands for service on a non-ratable basis
Natural Gas Delivery:
Commercial Performance v. Operational Reality

• Natural gas typically moves through a transmission pipeline at about 20 mph

• Yet, natural gas can be scheduled for receipt by a pipeline and delivered many miles away all within a day. How does this happen?

• Pipeline operators manage the physical inventory of customer-owned gas in the pipeline using “line pack” – pipeline-owned gas and pipeline pressure -- to ensure the delivery of scheduled volumes.
Serving Electric Generators

• Gas-fired generators in restructured power markets have little incentive to hold firm pipeline capacity
  – Most of the time, there is flexibility to serve generators that are interruptible shippers
  – But what happens when firm customers take their full entitlement to service?

• What happens to system pressure and line pack when generators ramp up quickly on short notice?
Natural Gas and Electric Power Scheduling

• Even generators with firm pipeline service have challenges
  – Uniform natural gas day vs. grid-specific electric day
  – Notice of generator dispatch often comes after deadline for timely pipeline nomination
  – FERC “no bump rule” can frustrate late nominations
  – Issues identified previously, but not resolved

• A uniform “energy day” will not address fundamental question about whether generators hold sufficient pipeline capacity to ensure reliability
Serving Electric Generators

• While natural gas pipelines ordinarily have considerable flexibility:
  – What happens to generators when firm pipeline customers take their full entitlement to service?
  – What happens to system pressure and line pack when generators ramp up quickly on short notice?
Natural Gas Pipeline Service to Firming Generators

- Special challenges – economic and operational
  - Cost recovery issues -- infrastructure and services may be utilized on a sporadic, infrequent basis
  - Deliverability issues -- major changes in gas requirements may occur with only minutes notice
Unit Costs Associated with Gas Transportation to Firming Facilities

- Utilization of gas transportation facilities required for firming plants could be quite low – 5% to 15% utilization.

- Capital costs must be spread over that relatively low utilization.

- Thus, per unit costs of the facilities could be quite high – 6 to 10 times greater than comparable facilities operating at 100% load factor.
  - Cost recovery tends to be an issue for low utilization facilities.
Planning for Intermittent Generation – *Dynamic Flow Modeling Example for Gas Pipeline Facilities*

The **Base System Configuration** assumes a 10” lateral to the firming power plant.

**An Enhanced Configuration** assumes a 14” lateral.

Compressor
Initial discharge pressure 700 psia

Mainline 83 miles, 16” pipeline
Lateral 25 miles

Supply
Fixed Demand (total 83 MMcfd)
Variable Demand

Firming gas-fired power plant
2-block GE LMS100
200 MW

Other gas-fired power plant

Wind Capacity
~800 MW
Conclusions

• Assuming that generators contract properly for pipeline capacity, there are no operational impediments to natural gas pipelines serving gas-fired generators (including rapid ramping) reliably
  – It is an economic question – a combination of natural gas ratemaking and electric power cost recovery issues

• Integrating renewable electric generation will necessitate changes in how the grid is operated and will create costs and necessitate decisions about cost responsibility.

• Gas-fired generation is an option. It should have an equal opportunity to compete and, if chosen, be given the ability to recover the costs incurred to ensure reliable electric service.