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

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# 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

The INGAA Foundation, Inc.

# Firming Renewable Electric Power Generators: Opportunities And Challenges For Natural Gas Pipelines

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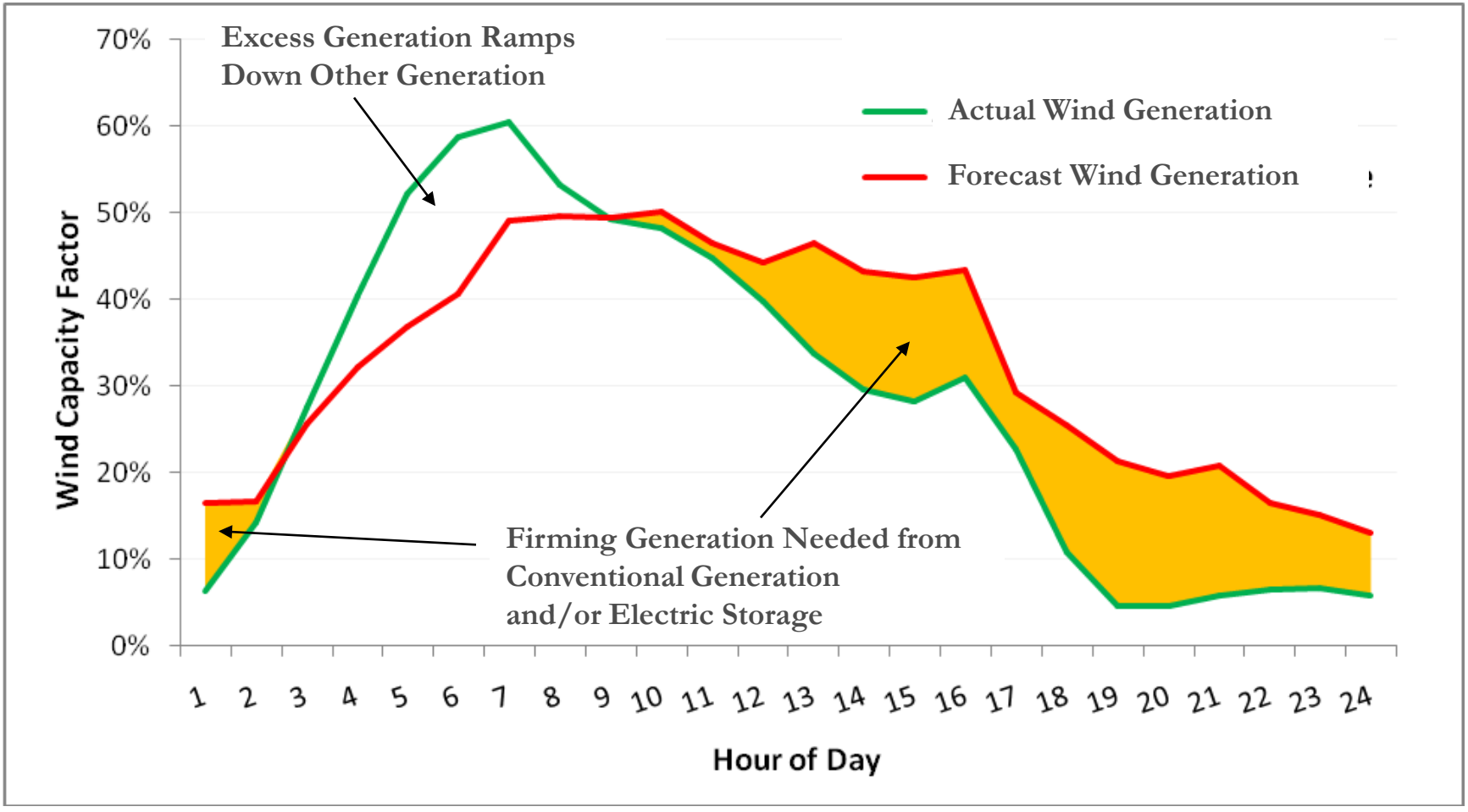
# Projected Renewable and Gas-Fired Capacity Additions

- 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.

| Cumulative Capacity Additions (GW) | 2015 | 2020 | 2025 |
|---|---|---|---|
| Wind | 50.7 | 66.5 | 88.3 |
| Biomass | 2.1 | 3.4 | 4.3 |
| Geothermal | 0.8 | 1.3 | 1.7 |
| Landfill Gas | 1.1 | 2.1 | 3.1 |
| Solar PV | 2.5 | 4.9 | 6.0 |
| Solar Thermal | 1.9 | 2.2 | 2.2 |
| ***Total Renewables*** | ***59.0*** | ***80.2*** | ***105.6*** |
| Combined Cycle | 3.7 | 19.7 | 59.1 |
| Combustion Turbine | 0.6 | 3.7 | 9.9 |
| ***Total Gas-Fired*** | ***4.3*** | ***23.3*** | ***69.0*** |

# Firming Intermittent Wind Generation




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

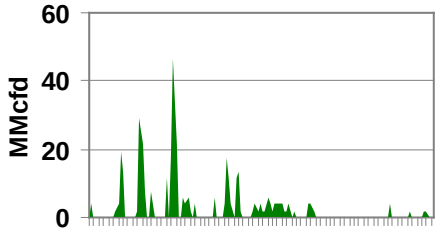
| Gas Plant Daily Requirement | Annual Maximum Volume at 100% Load Factor | Revenue Requirement | 100% Load Factor Rate | Unit Cost at 15% Utilization | Unit Cost at 5% Utilization |
|---|---|---|---|---|---|
| MMcfd | MMcf per Year | Dollars | $/MMBtu | $/MMBtu | $/MMBtu |
| 25 | 9,125 | $912,500 | $0.10 | $0.67 | $2.00 |

- 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*

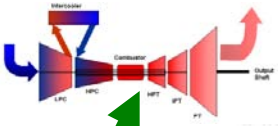
The ***Base System Configuration*** assumes a 10" lateral to the firming power plant

***An Enhanced Configuration*** assumes a 14" lateral




**Wind Capacity ~800 MW**

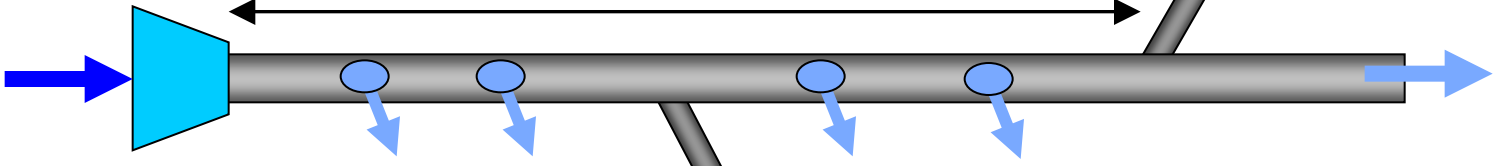
**Firming gas-fired power plant**
***2-block GE LMS100***
***200 MW***



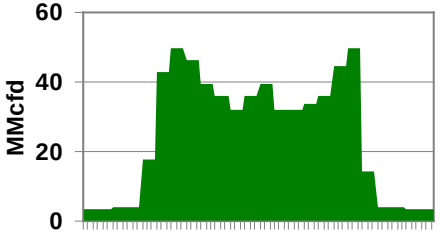
**Compressor initial discharge pressure 700 psia**

**Mainline 83 miles, 16" pipeline**

**Lateral 25 miles**



**Other gas-fired power plant**




**Supply**

**Fixed Demand (total 83 MMcfd)**

**Variable Demand**

# 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.