# Integrating Variable Renewable Power Generation and Natural Gas Infrastructure

## 2012 Energy Summit: Plugging into Natural Gas

**Sponsored by**
**Northwest Gas Association, Bonneville Power Administration, Pacific Northwest Utilities Conference Committee**

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# Variable Renewable Power (VRP) is growing in importance

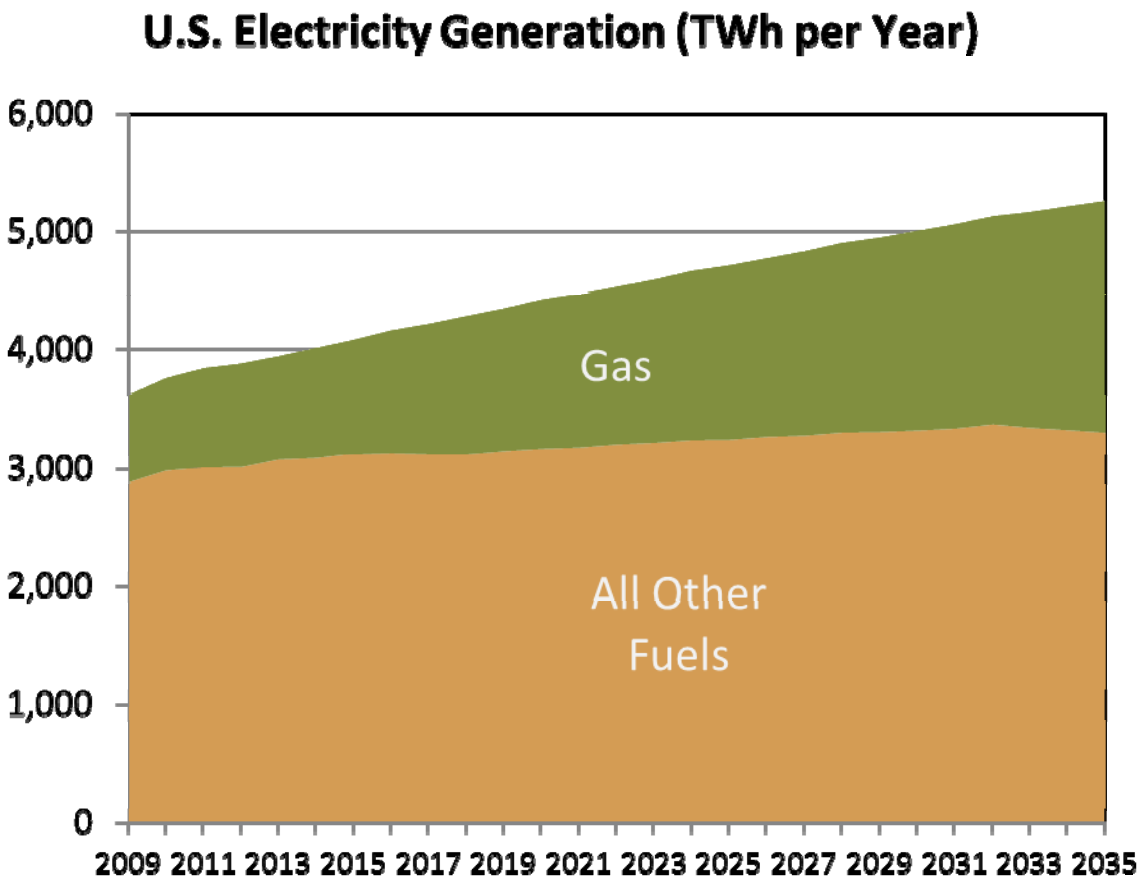
- VRP is becoming a larger component of the power generation fleet.
  - ~140 GW is currently in place; 32% is wind
  - ~105 GW could be built by 2025, including ~ 88 GW of wind
- The growth of VRP, and wind power, suggests a need for additional gas generation to provide firming support with implications for the gas infrastructure and operations
- ICF has done 3 recent studies on renewables and natural gas
  - California Energy Commission (2009)
  - Wyoming Infrastructure Authority (2011)
  - INGAA Foundation (2011)

# VRP affects on gas systems indirectly

- VRP and natural gas system integration is primarily about wind power
- Variability in wind generation creates a need for other generation assets to respond to load requirements when wind is not available
  - Improved forecasting, storage technologies, “smart grid”
- The technology of choice in most regions has been gas-fired generation
  - In the PNW, hydro makes an ideal firming resource, but limits on hydro will lead to greater reliance on gas
- The variability in gas demand to meet firming requirements raises a number of questions for the gas infrastructure
  - System design for maintaining pipeline pressures
  - Operational discontinuities – matching daily to hourly requirements
  - Tariff and contract services and their costs

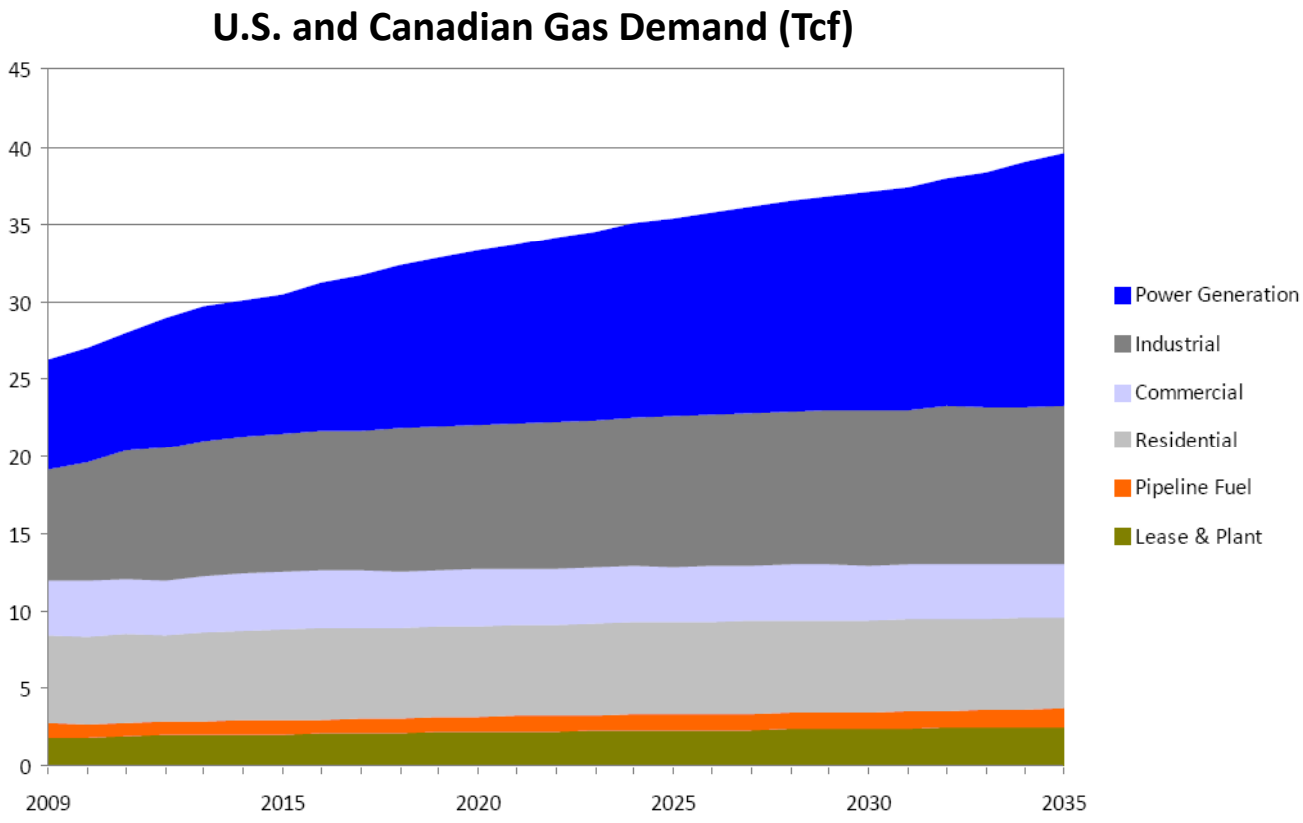
# VRP is part of the larger power and gas integration issue

- The U.S. has about 460 GW of gas-fired generating capacity
- Load factors for gas-fired plants are low, so existing plants can provide much of the growth in gas-fired generation.
- By 2035, gas will fire 37% of all power generation.



# Power generation will have a growing impact on gas pipeline operations

- About 75% of the demand growth is for power generation.
- Generators have different use profiles from *traditional* shippers.
- Power market design is different from gas market design
- Contract carriage and cost causation principles guide gas infrastructure decisions

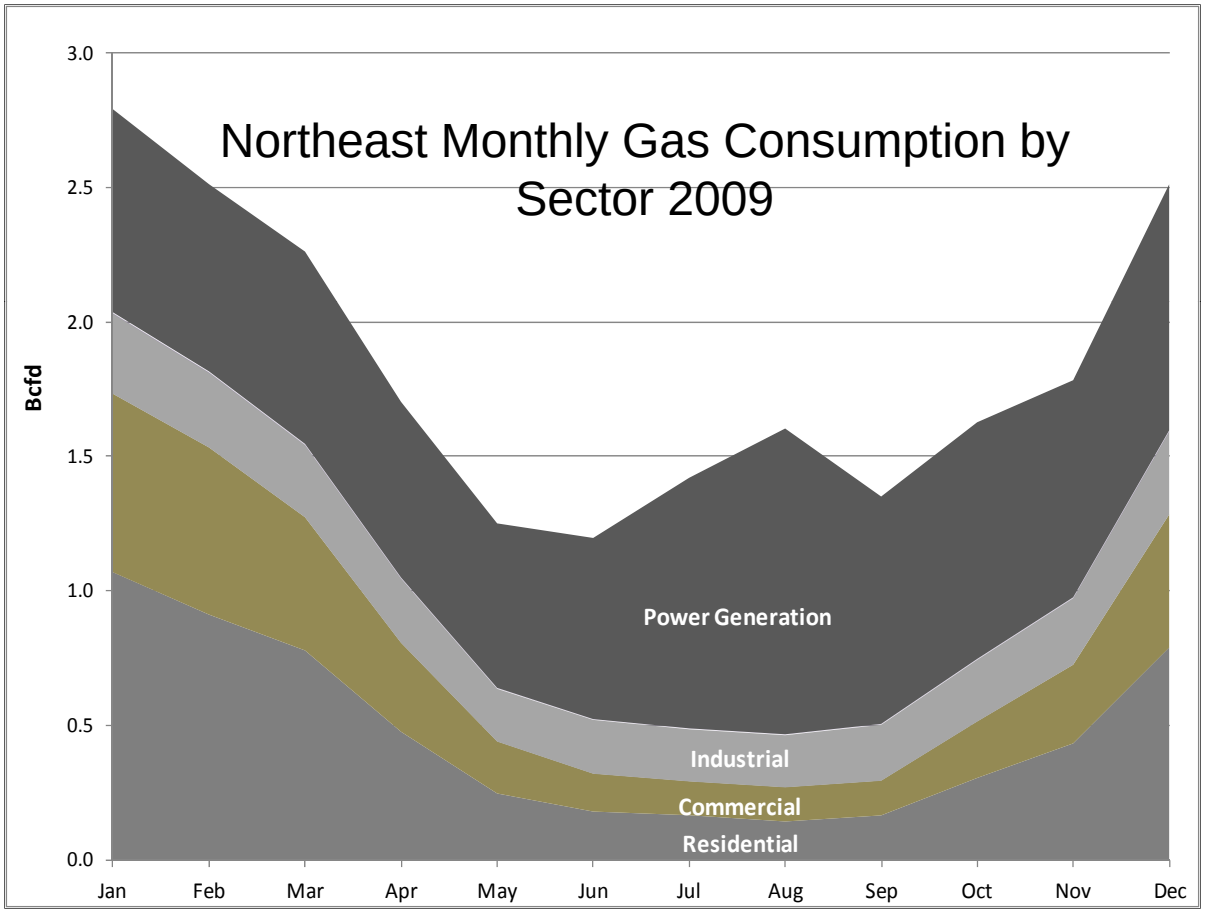


# The gas and power relationship has evolved over 25 years

- PURPA brought the first wave of gas QFs
  - Firm fixed power prices at avoided costs
  - Firm gas supply and transportation with backup fuel
- Energy Policy Act (1992) and the rise of wholesale power markets
  - EWGs more focused on competitive pricing
  - Gas plants least risky and investment grew
  - Abundant gas, low prices, pipeline capacity turn back in the 1990s
  - IT capacity on pipelines generally adequate
  - Over investment in gas-fired generation
- As power demand has increased and more gas generation deployed, incidents with plant dispatch and gas scheduling have occurred in some locations

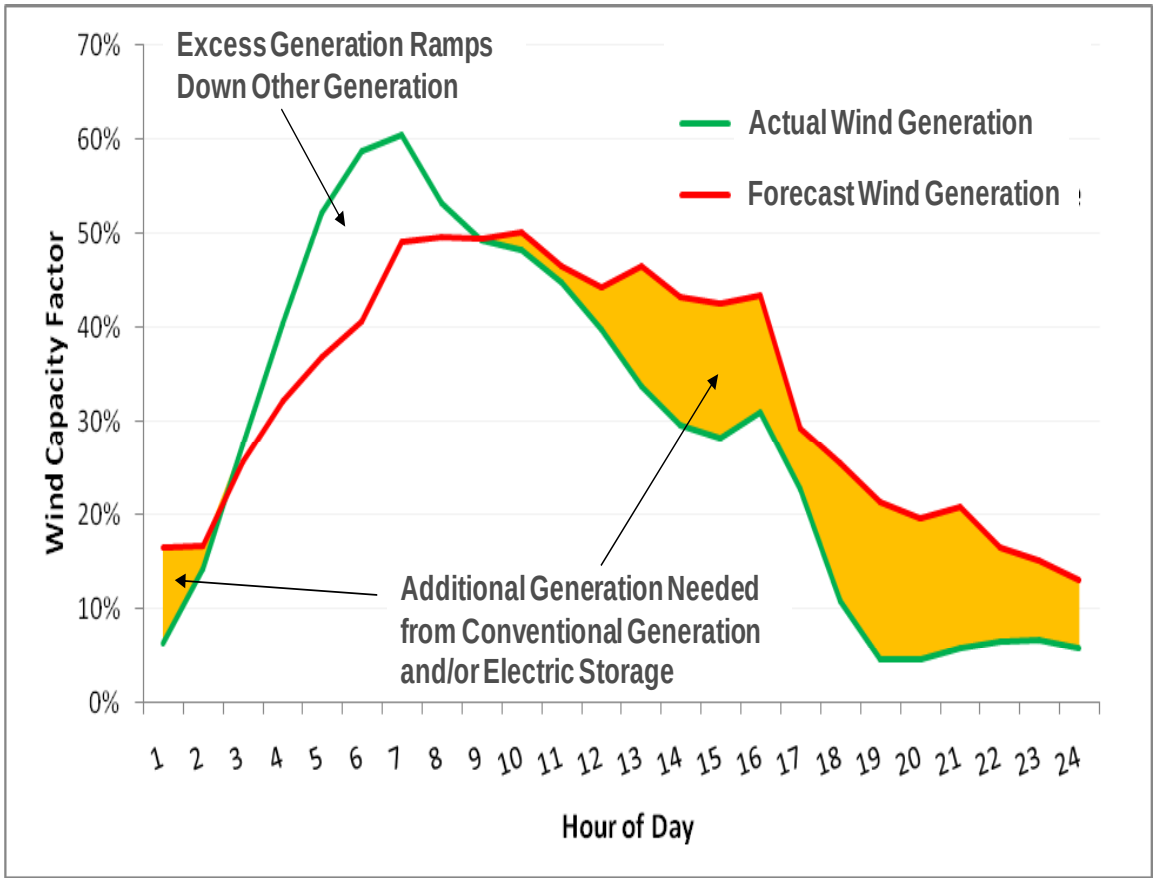
# Case Study: Northeast Gas Consumption

- The peak month for power generation is almost as large as peak month for residential
- Annual power sector consumption is greater than R/C combined.
- Gas demand for power has increased in the winter months R/C peak is growing.
- Spare winter IT capacity is diminishing in some markets.



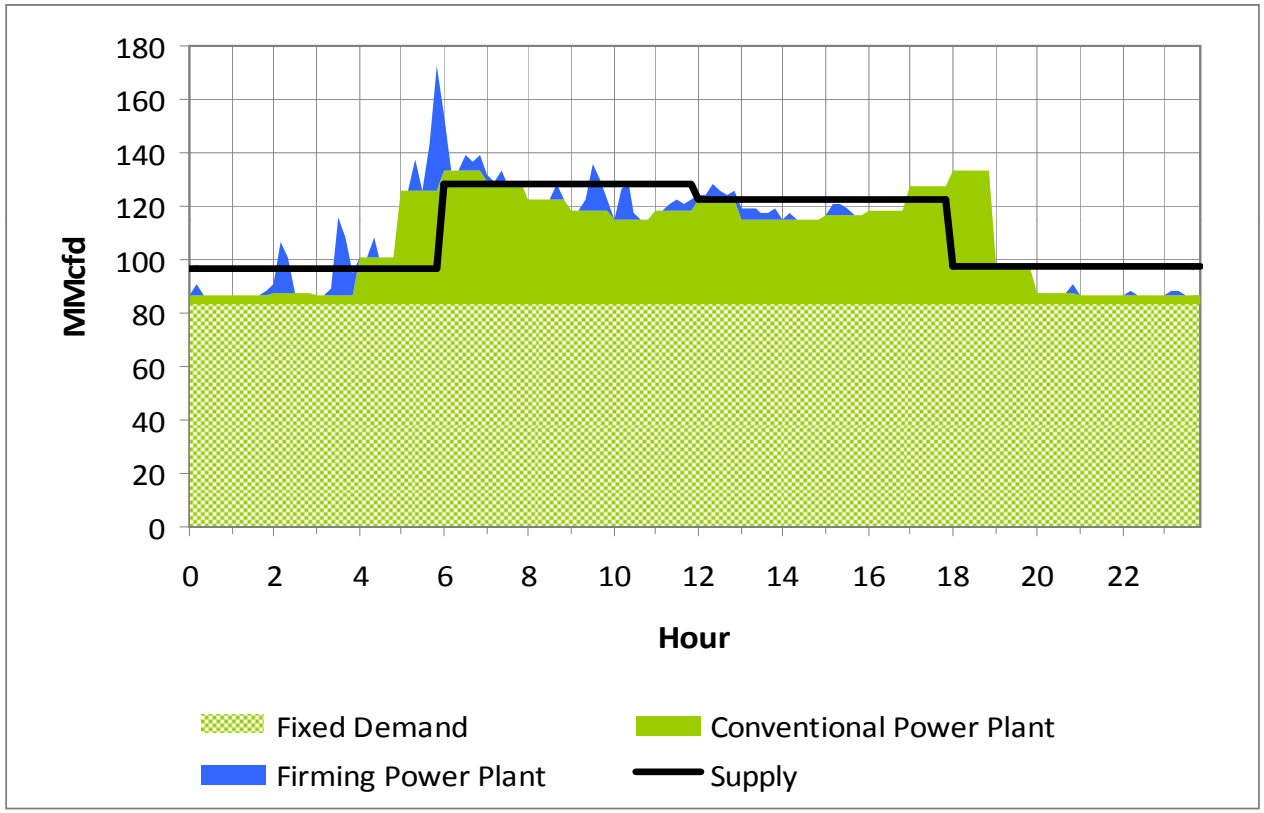
# The key gas issue in VRP lies in managing forecast error under gas system rules

- Long term planning, VRP displaces gas-fired generation
- Short term (day of market), VRP forecast error affects gas systems in two ways:
  - Excess wind backs down units previously scheduled where gas deliveries are "in the pipe" – what to do with the unneeded gas
  - Insufficient wind requires quick start-up gas generation where gas may not have been nominated and scheduled –
- Infrastructure must be designed to accommodate variations



# Matching firming gas requirements under present pipeline nomination/scheduling rules

- Pipelines require day ahead nominations and scheduling
- Intraday nomination changes limited to four periods
- Most pipelines can accommodate swings in line pack to meet ramp up
- Challenge lies in the spikes and when gas is scheduled and not needed



# Three scenarios with different implications for gas back up

- Wind power to meet electric demand growth, i.e. capacity
  - Reduces the amount of conventional generation needed, including intermediate gas
  - Capacity credit of 10% to 20 % requires substantial quick start natural gas back up capacity – 90% to 80% of wind capacity
  - Potentially significant increases to gas infrastructure – pipelines and storage
- Wind power implemented under RPS, no demand growth
  - New wind will back down marginal generation, usually gas
  - Much lower requirement for new quick start capacity, under 20 % of the wind generation
  - Not likely to require significant gas infrastructure due to existing gas plants and modest increases in gas generation
- Wind power must provide its own firming generation to eliminate forecast error
  - The amount of back-up will depend on wind configuration (to moderate forecast error) and resulting estimated error
  - Moderate addition of gas fired generation
  - Gas infrastructure impacts likely to be highly localized

# New gas infrastructure for firming VRP generation is modest

- Requirements for new gas infrastructure depend on several factors
  - The amount of firming gas fired generation required
  - Nature of the gas units required and whether existing units can be used
  - Regional gas system conditions (pipeline load factors, storage availability)
- INGAA study estimated that nationally for 88 GW of wind by 2025, the need for firming gas generation would be up to 33 GW., generating about 45,500 GWh
  - up to 5 Bcf/d of incremental delivery capacity
  - up to 440 Bcf of incremental gas demand
- Load factors on incremental delivery capacity were estimated at 15%

# Regional impacts can be more significant

- Total investment is estimated between $2 billion and $15 billion for increment “midstream” infrastructure (gathering transmission, storage)
  - Represents about 10 % of total expected investment in midstream assets through 2030
- Census regions with the most VRP in need of natural gas generation firming will see more investment
  - East North Central (Great Lakes States)
  - Middle Atlantic (NY, NJ, PA)
  - Mountain 1 (Northern Rockies states)
  - Pacific 1 (Pacific Northwest)
  - West North Central (Northern Plains states)
  - West South Central (Texas)
- Gas infrastructure needs will vary greatly due to existing networks of pipe, storage, gas load diversity

# In practice, pipelines are very flexible and provide reliable service

- Most of the time rapid swings in demand can be accommodated
  - Pipelines plan for this in daily operations with line pack, storage, customer load diversity
- Difficulties can arise under certain circumstances
  - Large, sudden swings in gas demand
  - During peak or near peak conditions  when operating flexibility is constrained or
  - During very low flow conditions when not a lot of gas is in the pipe
- Nevertheless, the pipeline system has been able to ensure reliable fuel supply for power generators under adverse conditions

# The gas/power conundrum lies in costs and operating rules

- To ensure the availability of gas requires Firm Transportation and Firm As-needed Supply
  - Both come at a premium
- The effect of low load factor usage is significant
- Many gas generators have relied on IT capacity:
  - IT = 100% LF rate
  - Firm = 15% LF rate
- Not included are storage, no-notice, park & loan

| | Firm Transportation Gas Cost | | | |
|---|---|---|---|---|
| Load Factor | 100% | 50% | 25% | 15% |
| Gas | $4.00 | $4.00 | $4.00 | $4.00 |
| FT Reservation | $0.60 | $1.20 | $2.40 | $4.00 |
| FT Commodity | $0.02 | $0.02 | $0.02 | $0.02 |
| Delivered Cost | $4.62 | $5.22 | $6.42 | $8.02 |
| Heat Rate | 10,000 | 10,000 | 10,000 | 10,000 |
| $/MWh | $46.20 | $52.20 | $64.20 | $80.20 |

# Pipeline operating rules can be changed to support gas firming generation

- Enhanced line pack in anticipation of expected forecast error
- Tailored  no-notice and gas storage services to allow fast delivery and cycling
- Increasing the number of nomination cycles and reducing length of each cycle to be more in like with power markets
- Gas rate schedules  to support ancillary service (firming) can be developed to reflect the costs of these gas firming services
- Would anyone sign up?
  - Pricing in wholesale electricity markets suggest not
  - Other bi-lateral markets may be more supportive
  - Major issue is term of service when new facilities are required

# Gas supply contracts can be "shaped" to supply firming gas

- Supply aggregators (marketers) combine supply with assets -- FT pipeline capacity, storage, customer and supply diversity, and risk management – to supply firming gas.
- Gas supply contracts can include
  - Base load and other medium- and short-notice delivery tranches
  - With call options for short-notice supply; put options to off-load supply
  - With tranche pricing tied to delivery notice term
- The capabilities of marketers to provide shaped supply will depend on the underlying infrastructure

# Some amount of new natural gas infrastructure will be required

- ICF studies have identified in broad terms the level of infrastructure additions suggested by various VRP scenarios.
  - Power market design
  - Alternative and electric storage technologies
  - Region specific infrastructure configurations
  - Ownership
- Power market design is a major question
  - Should firming be a responsibility of the VRP generators?
  - Is firming a system product, like ancillary services?
  - Should firming responsibilities and costs be spread across the system (CASIO PIRP)?

# The larger issue is that of power and gas integration and coordination

- Electric generation is the most promising growth market for natural gas
- With the new reality of North American shale gas, reliance on natural gas can provide electricity to consumers at a lower cost than other alternatives
  - Natural gas has advantages in terms of environmental impacts, risk, costs. and energy security
  - Other technologies are evolving nevertheless
- A portfolio with gas is economically efficient, but the how and cost issues must be addressed
  - Leadership -- FERC, State Commissions, NERC

# What are the Huron to do?

# Further Reading

Electronic copies of the ICF White Paper on "Integrating Variable Renewable Electric Power Generators and the Natural Gas Infrastructure" are available at the ICF web site:

www.icfi.com

Click on "Insights" and "White Papers" which are arranged alphabetically by title

The INGAA Foundation paper , "Firming Renewable Electric Power Generators: Opportunities and Challenges for Natural Gas Pipelines" can be found at the INGAA Foundation web site:

http://www.ingaa.org/Foundation.aspx

Click on "Reports"

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