Coordinating Electric and Natural Gas Systems

ELECTRIC TRANSMISSION 301:

Coordinating Natural Gas/Electric Operations and Long-Term Resource Planning and Investment

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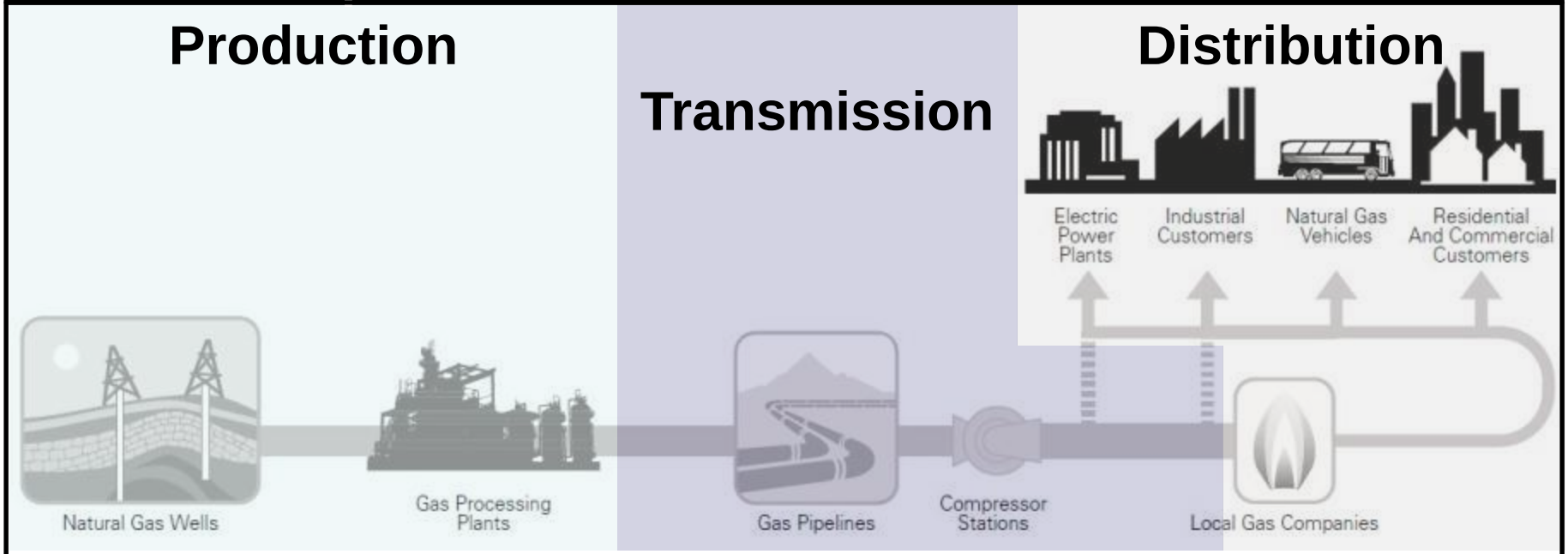
Overview

- Why is natural gas different from other fuels used for electricity generation?
- Why is interest in gas/electric integration and coordination growing?
- What are the relevant analytic and policy questions?
- How do we find the answers?

Overview: Understanding Natural Gas Value Chain Key to Power-Gas Integration

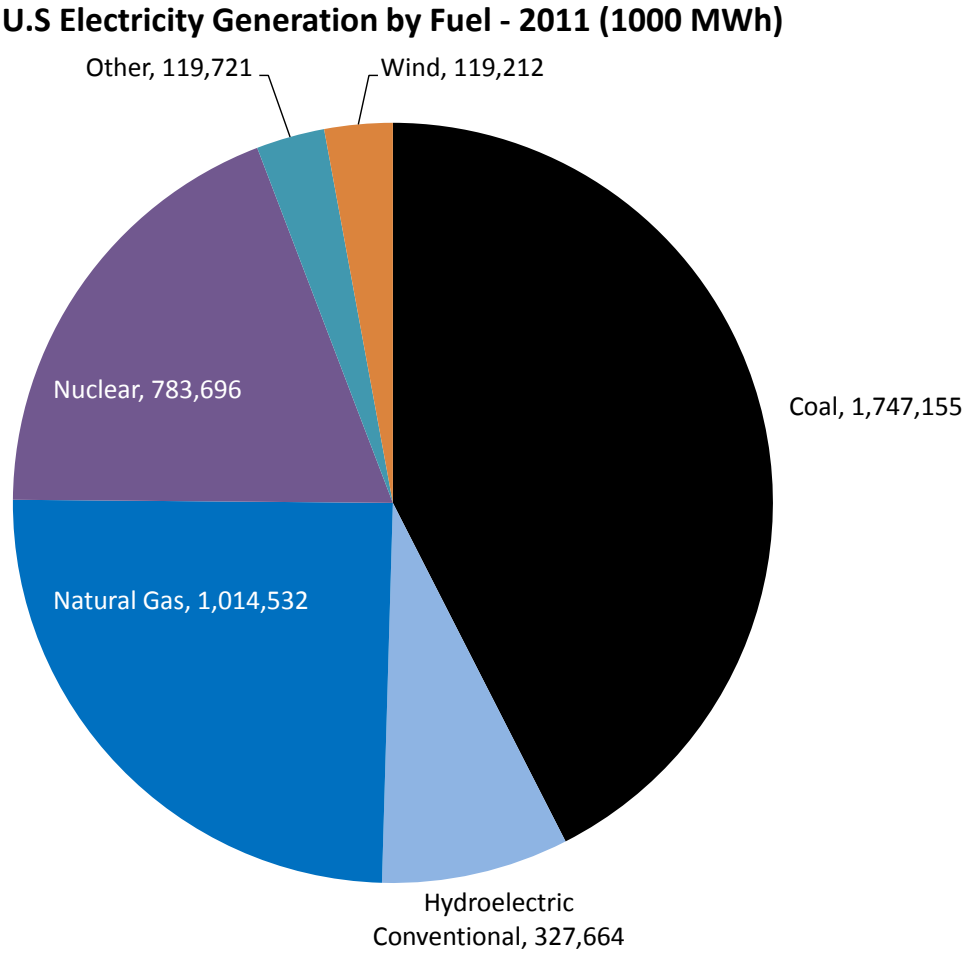
Simplified Illustration of Natural Gas Flow



Source: Natural Gas Council

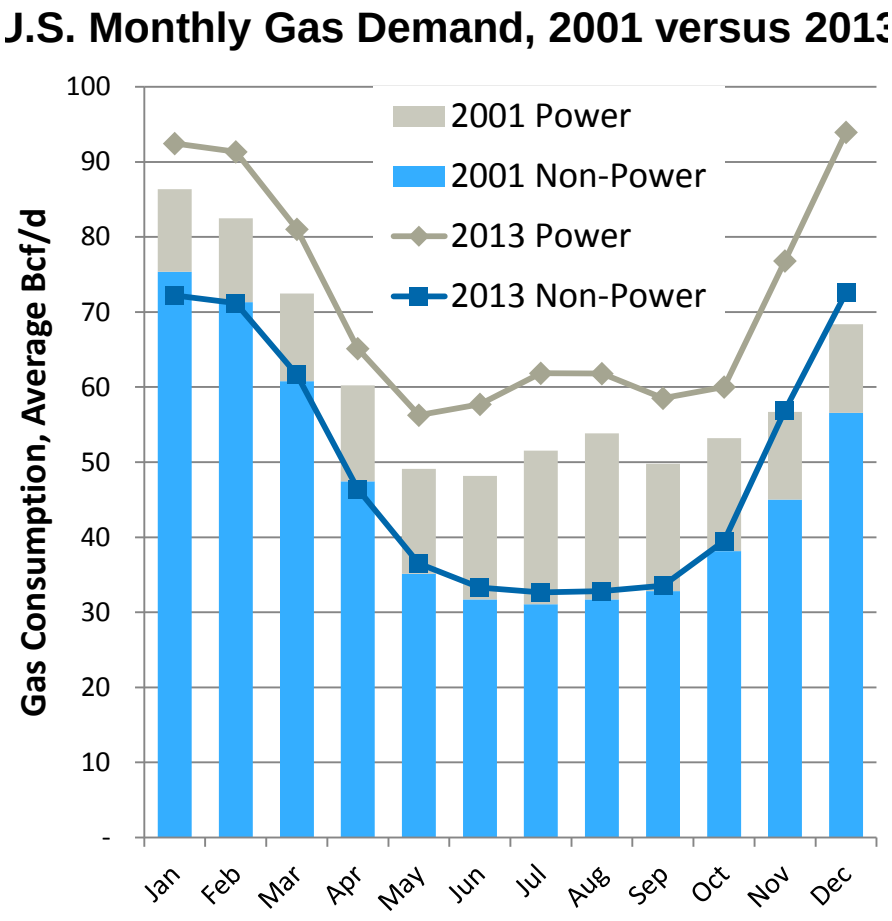
Of the Major Electricity Generating Energy Sources, Only Natural Gas:

- Is not easily stored onsite – therefore, real-time delivery is critical to support generators.
- Procurement cycle is several times per day – not synchronized with electricity markets.
- Is also widely used outside the power sector – therefore the concurrent demand from other sectors critically affects supply for the power sector.
- Is delivered by a regulated pipeline under standard tariff services that cannot be modified for individual generators.



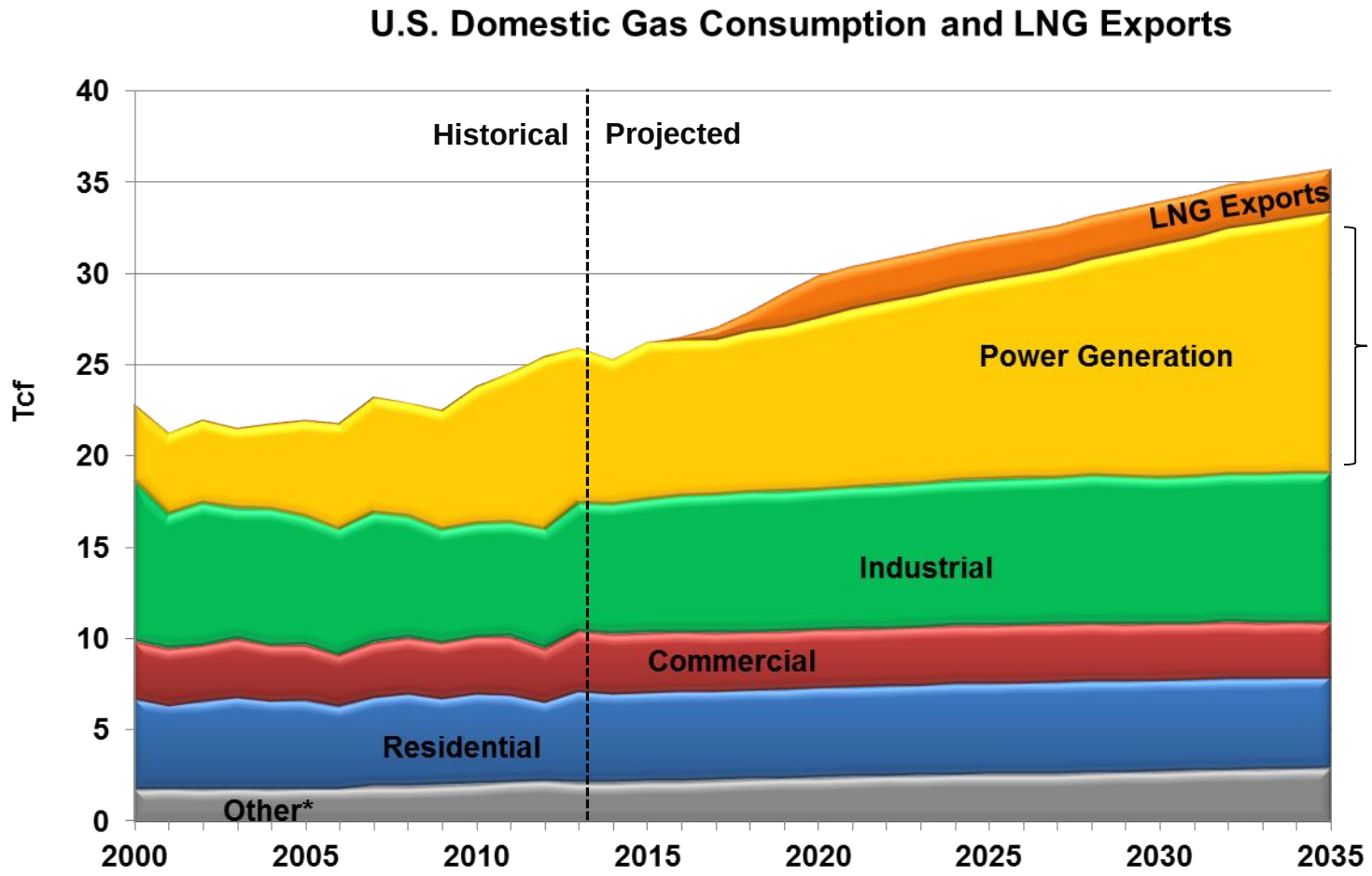
Gas-Electric Integration – Why has it Become Such a Big Issue?

- Over the past 15 years, growth in gas-fired capacity has been robust.
  - Gas accounted for over 40% of installed capacity and nearly 30% of total generation in 2013.
  - Increased use of gas to meet base load generation results in higher winter peak demand when a number of regional markets can be constrained.
  - Expectation for continued growth in gas-fired generation, much like the growth exhibited in ICF's base case.
- Natural gas is seen as playing a growing role in "firming" variable generation.
- There have been events in which gas supply/delivery limitations have affected electricity delivery – there is concern that there will be more.
- There is long-term, continuing concern over the operational and contractual differences between gas and electricity systems.



Source: EIA Natural Gas Consumption by End Use

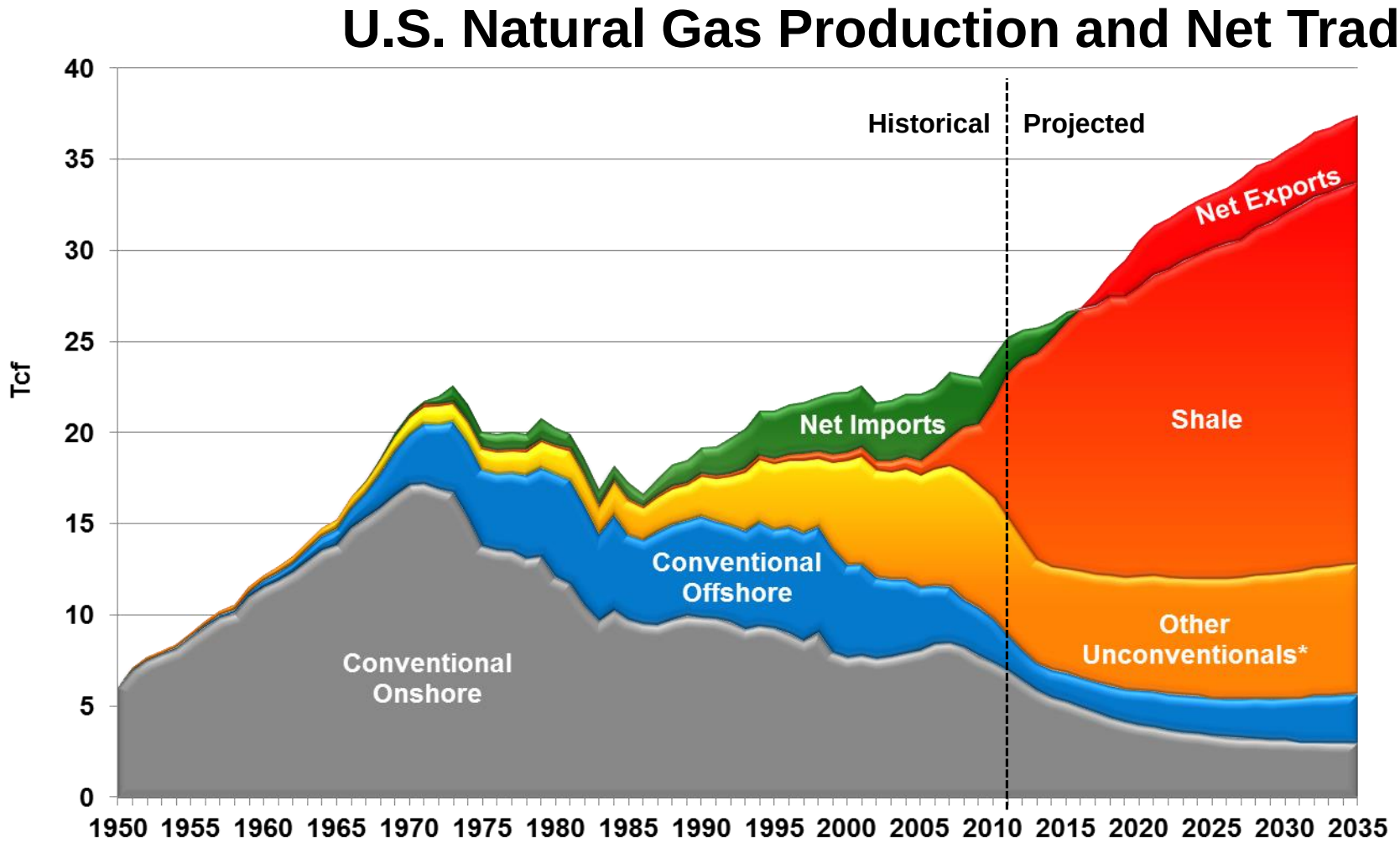
Power Sector Will Become Bigger Share of Gas Market



Power sector gas use is expected to comprise over 60% of incremental U.S. gas use growth between 2012 and 2035.

** Includes pipeline fuel and lease & plant*
Source: ICF GMM Q1 2014

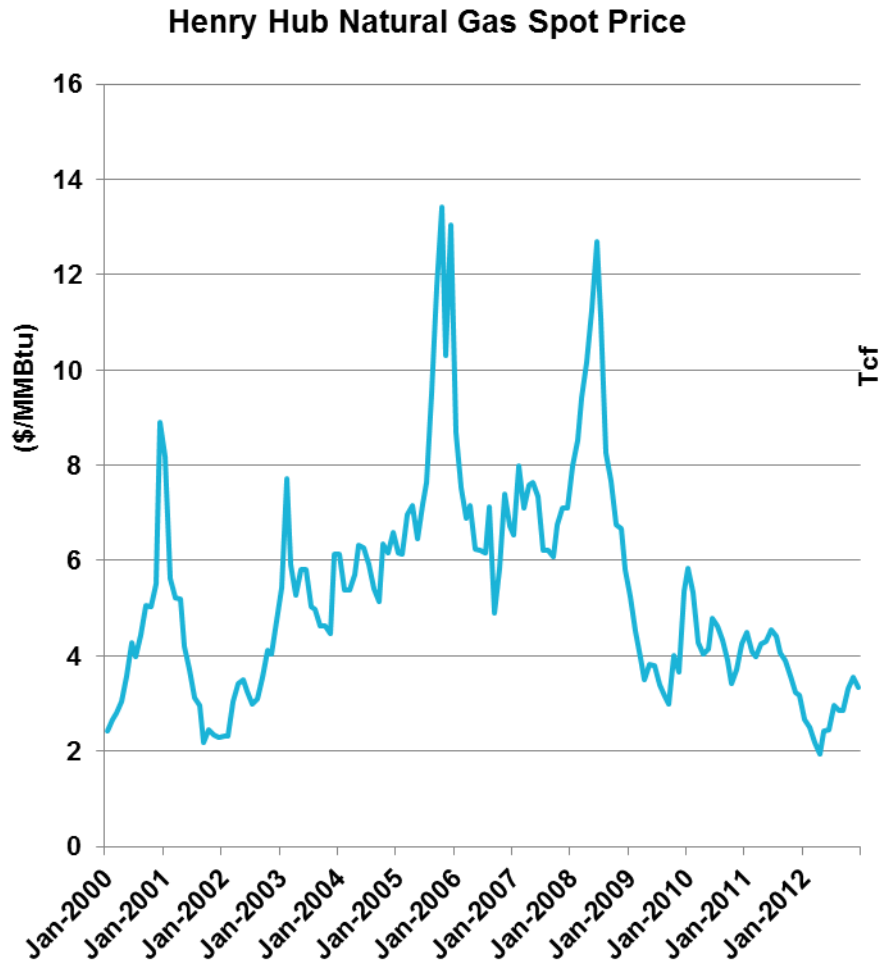
Market Expansion Supported by Growing Shale Gas Production

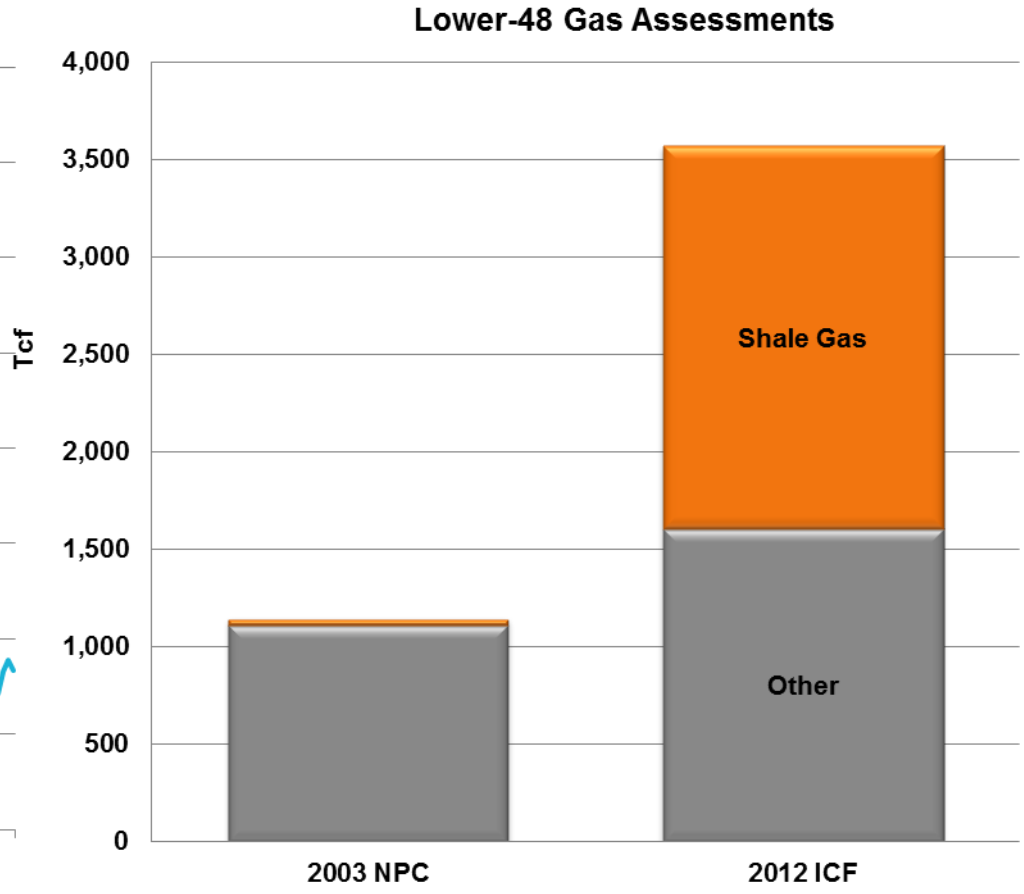


Sources: EIA and ICF estimates (1950-1999), ICF Gas Market Model (GMM)® Q1 2014 (2000-2025)

** Includes tight gas, associated gas from tight oil, and coalbed methane*

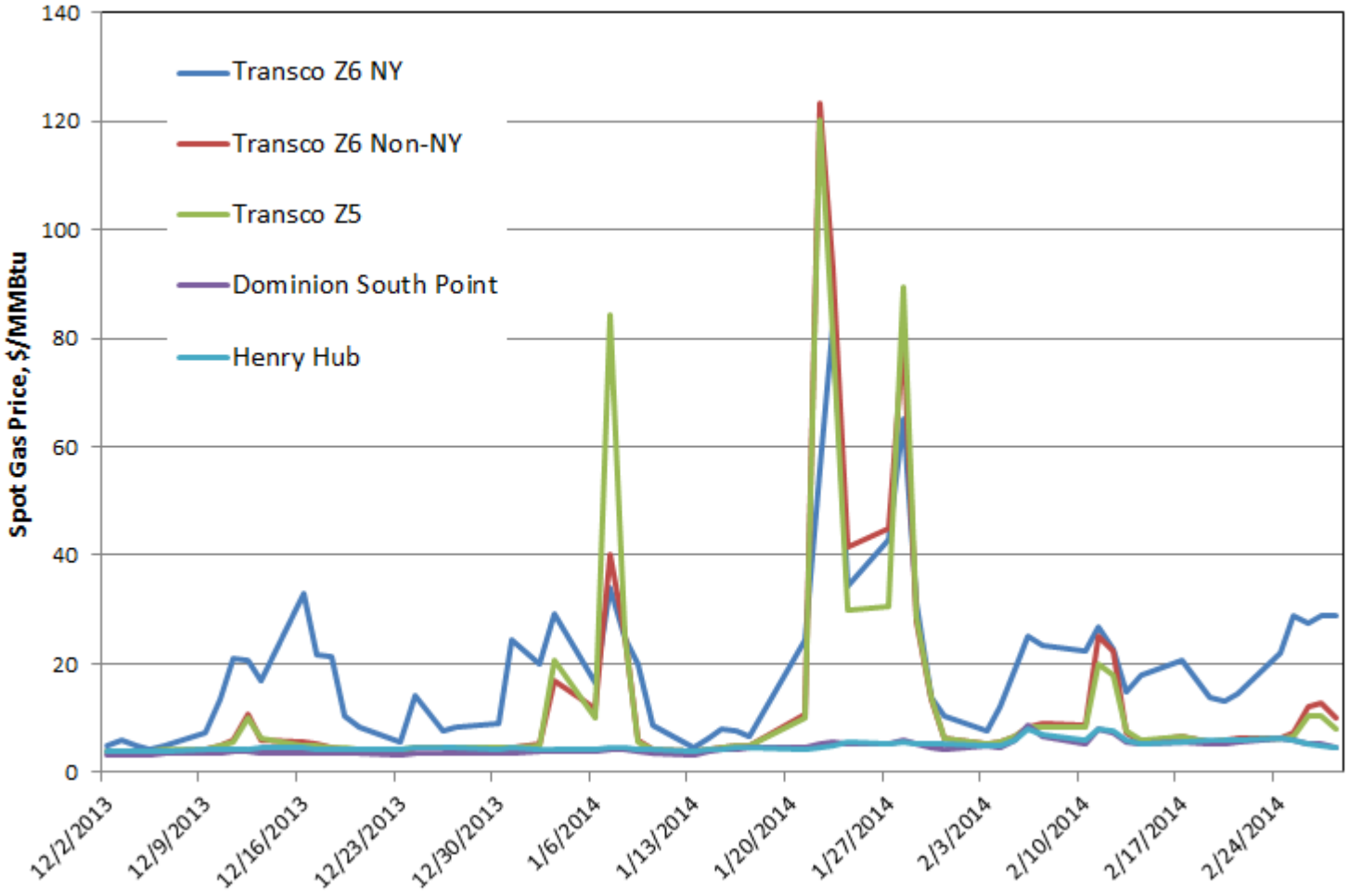
Increasing Shale Gas is Holding Down Prices





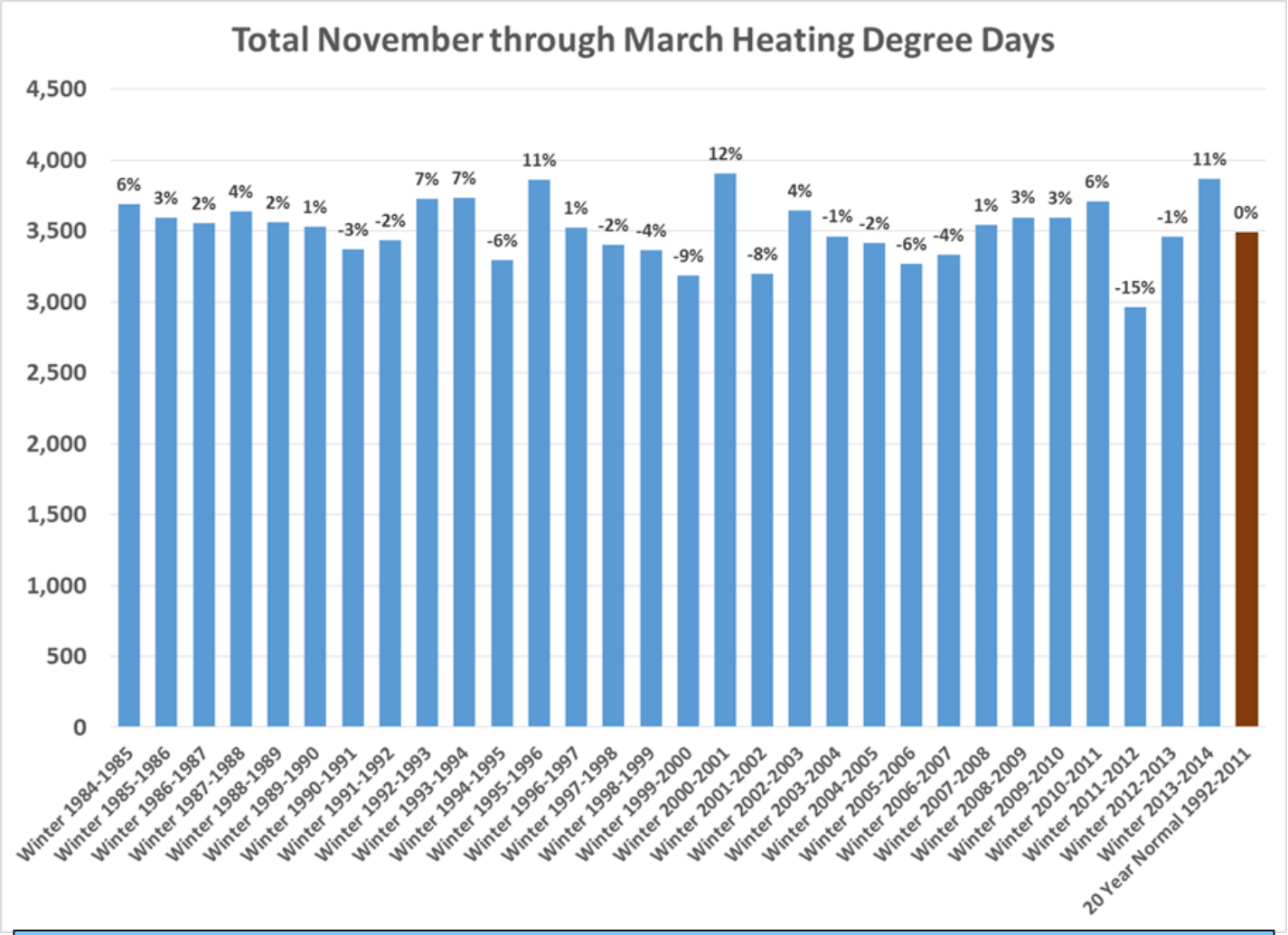
Source: http://www.eia.gov/dnav/ng/hist/rngwhhdm.htm

Although Wellhead Supplies are Plentiful, Past Winter Illustrates Effects of Inadequate Delivery Capacity



Bottom Line: A number of Northeastern markets were constrained over many days throughout this past winter.

U.S. Heating Degree Days



With about 3,900 heating degree days for the U.S., this winter was the 3rd coldest winter out of the past 30 winters.

Several Electricity Markets Lost Generating Capacity Due to Inadequate Natural Gas Supplies

- While there were no major disruptions to gas or electric systems this winter, we "skated very close to the edge."
  - ICF's power market experts estimate that PJM was within a few hundred MW of rolling blackouts.
  - During the polar vortex, gas prices spiked and fuel costs exceeded the electric wholesale price cap.
- PJM was not alone in gas supply constraints:
  - 2.2 GW lost in NYISO, mostly downstate.
  - 6.7 GW lost in MISO
  - 2.4 GW lost in SPP

January 6 & 7 2014 Electric Loads and Outages (MW)

ISO	Peak Load	Total Lost Generation (Forced Outages and Derates)	*Generation Lost Due to Fuel Supply Issues*
PJM	141,312	41,336	***9,718***
NYISO	25,738	4,135	***2,235***
MISO	107,770	32,813	***6,666***
SPP	36,602	3,185	***2,412***

Source: FERC Winter 2013-14 Operations and Market Performance Presentation, based on data provided by ISOs

Firm Pipeline Capacity

- Gas pipelines must show firm transportation contracts for their capacity to receive FERC certification for construction.
- Holders of firm pipeline capacity have first call but can release unused capacity at times of low demand, but only during pipeline nomination windows.
- Electric generators may use this capacity on an interruptible basis without paying for firm capacity.
- However, at peak gas demand periods, unused capacity may not be available so generators may not be able to receive fuel.
- In organized electricity markets, generators cannot recover firm pipeline charges through market payments and therefore rely on interruptible or released capacity, even when bidding “firm” electricity.

Operational Differences

- Gas load for electricity can change frequently and unpredictably during one day. Gas is usually nominated (bid) only four times per day.
- Electricity is delivered essentially instantaneously but actual gas delivery moves at only tens of miles per hour, so pipelines must plan well ahead for delivery.
- Gas generators may take gas that they have not contracted for in order to meet electricity demand.
- While these gas volumes are ultimately replaced through balancing provisions, the timing of the replacement does not prevent pressure transients that threaten delivery pressures along the pipeline.

Reliability Assessment

- Electric assets are often either ”on” or “off,” while gas assets usually maintain substantial capacity after component failures
- Critical electric assets, when inoperable singularly or in small groups, can lead to rapid, widespread service outage. Cascading failures are unlikely in a gas system.
- Electric system resiliency is most usefully analyzed using N-1 or N-2 analyses. These are also useful for gas systems, but weather variability and its effects on interruptible capacity are the more practical concern
- Redundancy and interconnects make both electricity and gas systems more reliable.

Key Questions to Address

- Is there sufficient gas supply (i.e., overall gas resources) from producers to satisfy peak demand in a given market? Will this outlook be affected by more stringent upstream environmental rules?
- Is there sufficient physical delivery capability to deliver gas to power plants at a time of peak demand?
- Do power plants have contractual call on supply and delivery capacity at a time of peak demand, and can the power plants be considered firm if they don't have firm gas supply? If not, what is the probability that interruptible gas service will be available?

Key Questions to Address (cont.)

- How can utilities, transmission organizations, and gas pipelines better coordinate the different scheduling and contracting practices to ensure reliable and efficient operation of the gas and electric systems?
- How and why might gas supply be limited under certain circumstances (e.g., well freeze offs and LNG disruption), and how would this impact gas and electric system reliability?
- How and why might delivery capacity be limited under certain circumstances (e.g., compressor or pipeline failure), and how would this impact gas and electric system reliability?
- What are the costs and feasibility of on-site storage (e.g., LNG storage) and dual fuel capability as solutions to these problems?

ICF's Role in Integration Studies

- ICF has been at the forefront in helping to understand and resolve these issues
- In 2012 to 2014, ICF completed studies for ISO-NE on regional gas supplies and their availability to electric generators.
- ICF wrote report to NERC on integrating natural gas reliability, availability and adequacy into long-term electric resource adequacy assessments
- ICF was chosen by NARUC and the Eastern Interconnect States' Planning Council (EISPC) to conduct a study on the long-term electric and natural gas infrastructure requirements throughout the Eastern Interconnection

Regional Integration Studies

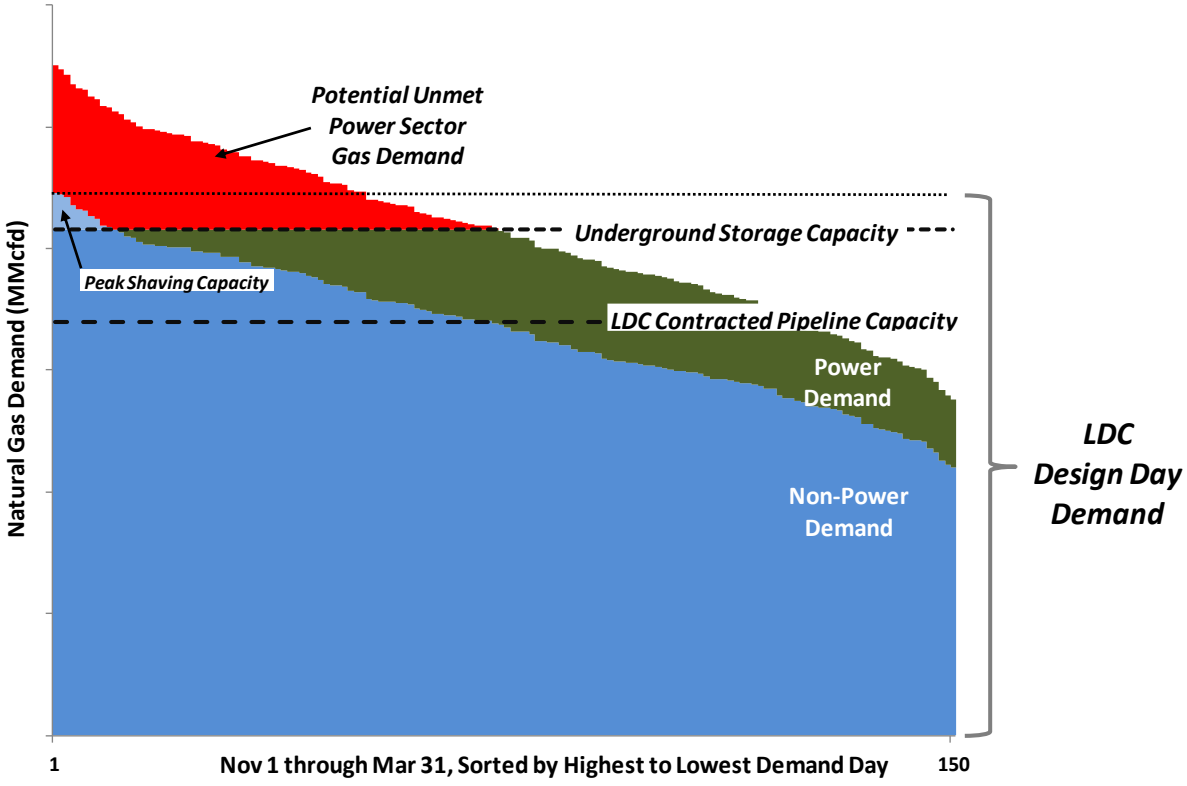
- ICF's analysis for **EISPC** focuses on projecting the potential for unmet fuel requirements and then assessing multiple options for meeting load:
- The Eastern Interconnect Planning Collaborative (**EIPC**), representing six ISO/RTO planning authorities is conducting another analysis focusing on the next 10 years.
- Western Interstate Energy Board (**WIEB**) is completing a study of the adequacey Western Interconnect gas infrastructure, with emphasis on serving power generation
- Electric Reliability Council of Texas **(ERCOT**) commissioned studies in the wake of the 2011 incident

FERC Initiatives

- To date, FERC initiatives have focused on coordinating gas-electric system operations, not on longer-term planning.
- FERC Order 787 allows interstate natural gas pipelines and electric transmission system operators to share non-public operational information with each other to make gas and power service more reliable.
- The March NOPR aims to shift the gas day scheduling to better align with electric daily scheduling, and add two more intraday nomination cycles to allow more flexibility scheduling of pipeline nominations.
- LDCs and Western pipelines have expressed concerns about changing gas day scheduling; additional costs and potential unintended consequences (would a new gas day schedule just shift the problem west?)
- Additional FERC orders address ISO/RTO system scheduling and how pipelines post information on released capacity.

Analytics of Adequacy of NG Infrastrcuture

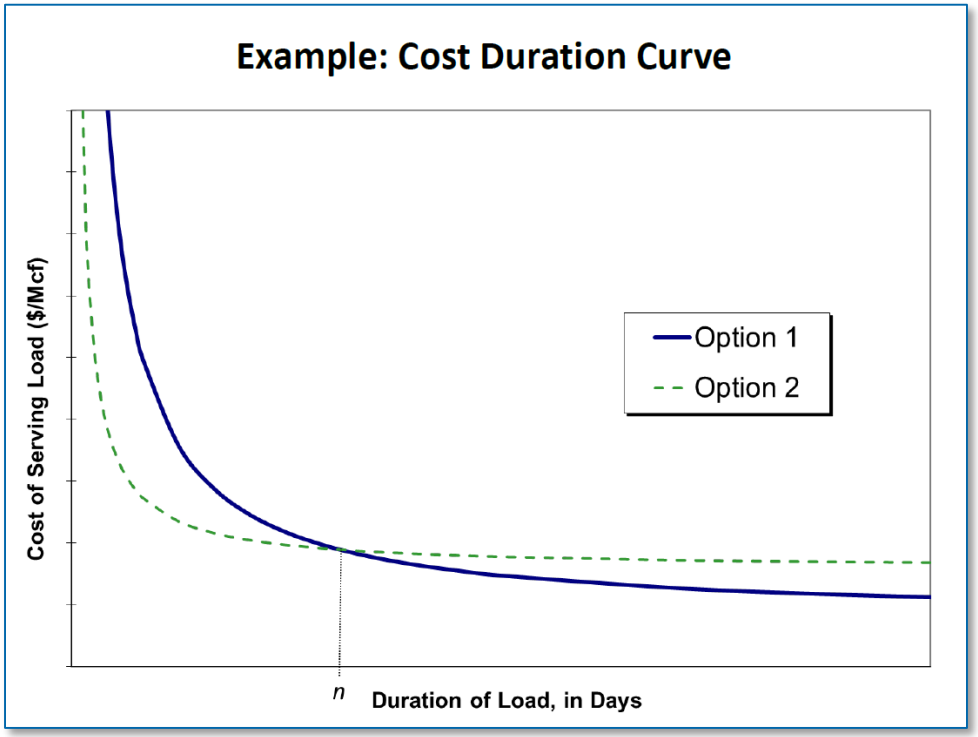
- Where LDCs hold nearly all pipeline capacity, power generator access depends on time of year and weather.
- Analysis of resource adequacy requires the ability to project available gas capacity as a function of economic/load growth and weather for non-power sectors.
- Must also be able to assess the interactions with regions upstream and downstream of the target region.



Example Natural Gas Daily Load Duration Curve

Selection of Optimum Mix of Fuel Sources

- Fuel Sources for gas or gas/oil power plants
  - Gas pipeline
  - Underground storage
  - High deliverability underground storage
  - Peakshaving plant
  - Above-ground compressed gas storage
  - Fuel switching
- Cost components include: capital, fixed O&M, non-fuel variable O&M, and fuel



Optimal mix will vary among regions

Principles and Objectives for Costs Recovery and Allocation

- Allocate infrastructure costs to customers who create the demand.
- Do not distort market prices.
- Enhance market liquidity and price transparency.
- Balance resource adequacy against willingness to pay.
- Make cost recovery system as transparent, simple, reasonable and consistent as possible in the eyes of ratepayers.

Conclusions

- The gas/electric integration issues have received the attention of many industry participants, stakeholders and regulators
- Focus is both on operational coordination (e.g. FERC regional conferences) and long-term resource adequacy (e.g. NERC studies).
- Major regional studies have been undertaken by EISPC, WIEB, EPIC and others.
- Expected events and trends:
  - Improvements in scheduling and coordination
  - Confirmation by regional studies of growing long-term reliance on gas and specific needs for additional natural gas infrastructure
  - Efforts to address generators ability to pay for firm gas pipeline capacity thru changes in electricity market design and other mechanisms
  - More delineation of rights and costs for non-rateable pipeline takes to accommodate intra-day gas load swings
  - More focus on planned maintenance schedules