*Driving Innovation ♦ Delivering Results*

# Tribal Leader Forum Series

**U.S. Department of Energy Oil & Gas Technical Assistance Capabilities**

**Strategic Energy Analysis and Planning**

**SEAP**

August 18, 2015

U.S. DEPARTMENT OF ENERGY | National Energy Technology Laboratory

# OUTLINE

- **Strategic Energy Analysis and Planning**
- **Natural Gas Supply and Demand**
- **Tribal Areas and Natural Gas Reserves**
- **SEAP Analysis of Natural Gas Issues**
  - Dual Fuel
  - Electric Interdependencies
- **SEAP Life Cycle Analysis**

# SEAP provides timely, focused analysis and planning for energy systems and technology

## SEAP Hierarchy of Analytic Approaches

- Rapid Strategic Response
- Systematic Energy Analysis & Planning (Publications & Presentations)
- Ongoing Domestic and Global Analysis of Resources, Technology, Commerce, Regulations and Forecast Trends, with Implications for NETL

## Analysis

***Assess environmental policy and impacts***
- *Regulations for GHG, criteria pollutants, water*
- *Power generation capacity*
- *Energy market trends*

***Assess cross-cutting issues***
- *Interface with EPA and Industries (e.g. Fracking)*

***Develop analytical framework for emerging issues***
- *$CO_2$ use in enhanced oil recovery*
- *Natural gas supply and costs; CCS possibilities*
- *New research opportunities*

## Planning

***Evaluate alternative future scenarios for power production***
- *Coal, Natural Gas, Nuclear, Wind, Solar, Hydro*

***Assess reliability/stability of energy and distribution systems***
- *Electricity transmission, natural gas pipelines*

***Apply expertise in Life Cycle Analysis***
- *Power systems*
- *Energy resources*
- *Other industries*

## Mission and Vision

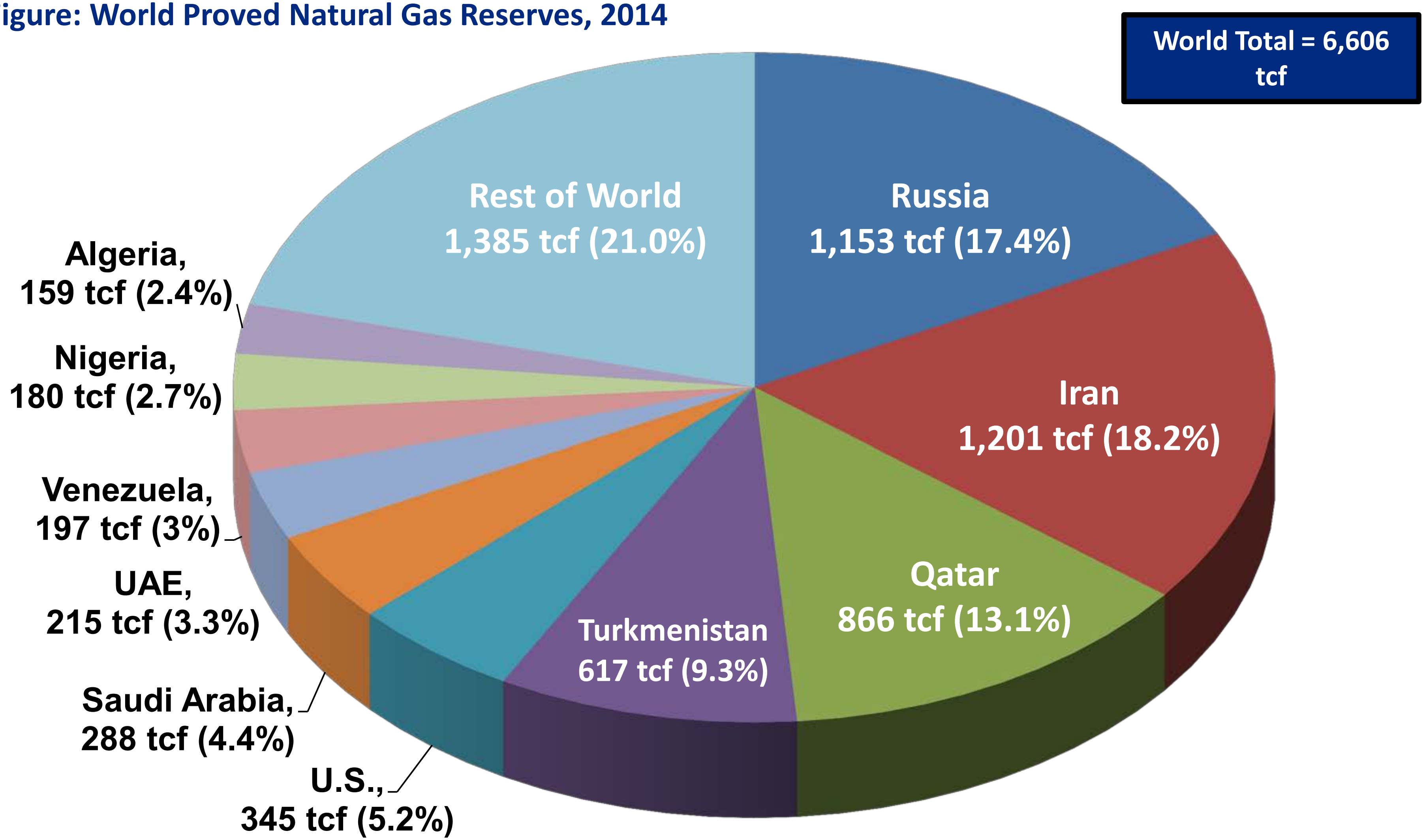
- **Assess current situation, near-term trends (out to 2030), and long-term issues (through 2050) within the energy industry and in the U.S. and world economy**
- **Assess long-term trends that may modify demand for energy and influence the choice of fuels and energy production technologies after 2030**
- **Develop energy technology scenarios and evaluate alternative scenarios to assess the role of technology in meeting domestic and global energy needs**
- **Identify solutions to energy issues related to resource availability and extraction, energy delivery and infrastructure, electric power integration, energy and national security, and options for mitigation of environmental impacts**
- **Provide input to decisions on national plans and programs, resource use, environmental and energy security policies, and research, development and deployment of energy technology**
- **Support NETL and DOE-FE Management in planning and analysis activities for DOE (e.g. QER, QTR, CCS Task Force, etc.)**

# OUTLINE

- Strategic Energy Analysis and Planning
- **Natural Gas Supply and Demand**
- Tribal Areas and Natural Gas Reserves
- SEAP Analysis of Natural Gas Issues
  - Dual Fuel
  - Electric Interdependencies
- SEAP Life Cycle Analysis

# World Proved Reserves

Figure: World Proved Natural Gas Reserves, 2014

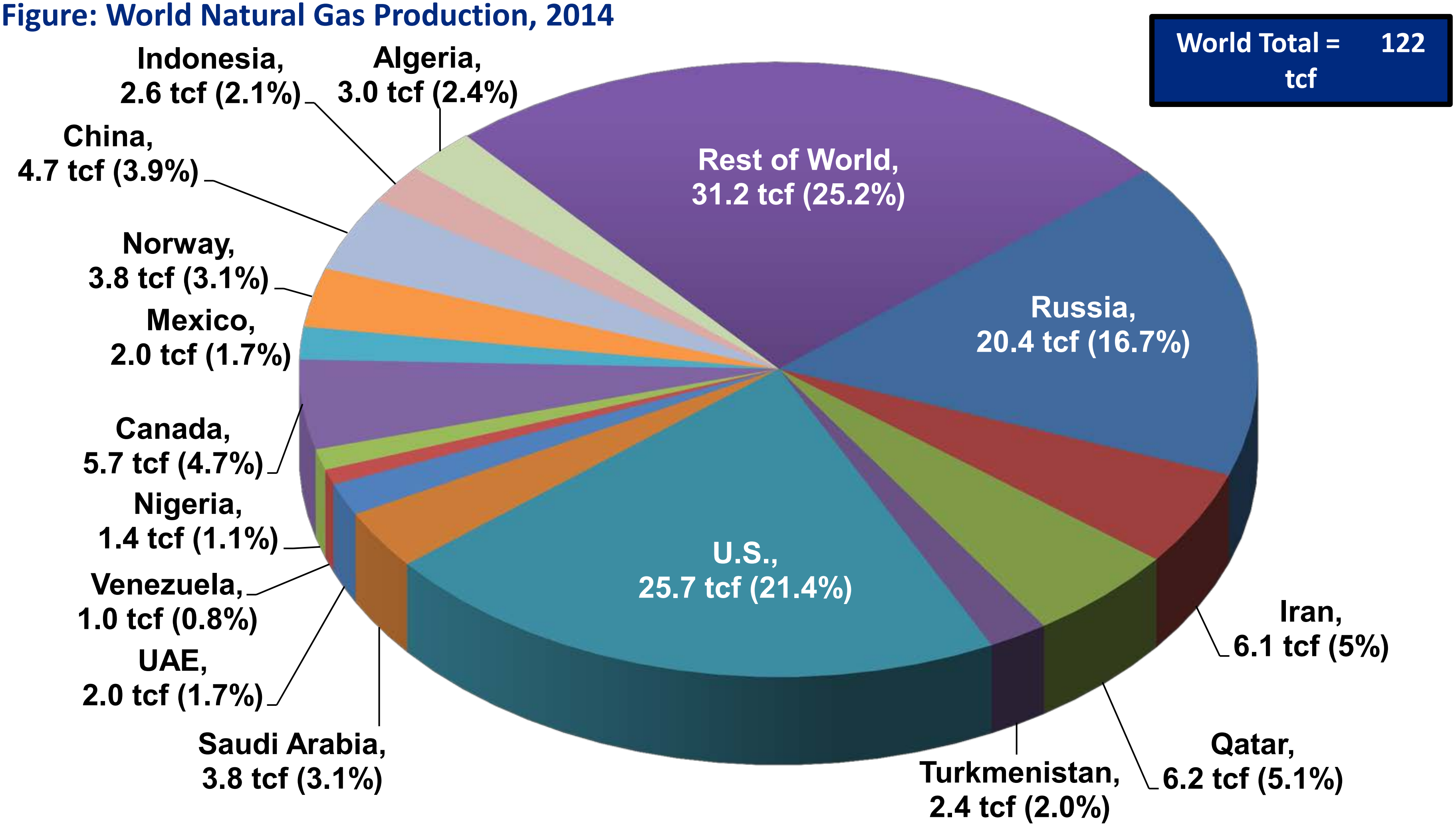





*Source: BP Statistical Review of World Energy 2015, http://www.bp.com/ (May not equal 100% due to rounding)*

# World Production

**Figure: World Natural Gas Production, 2014**

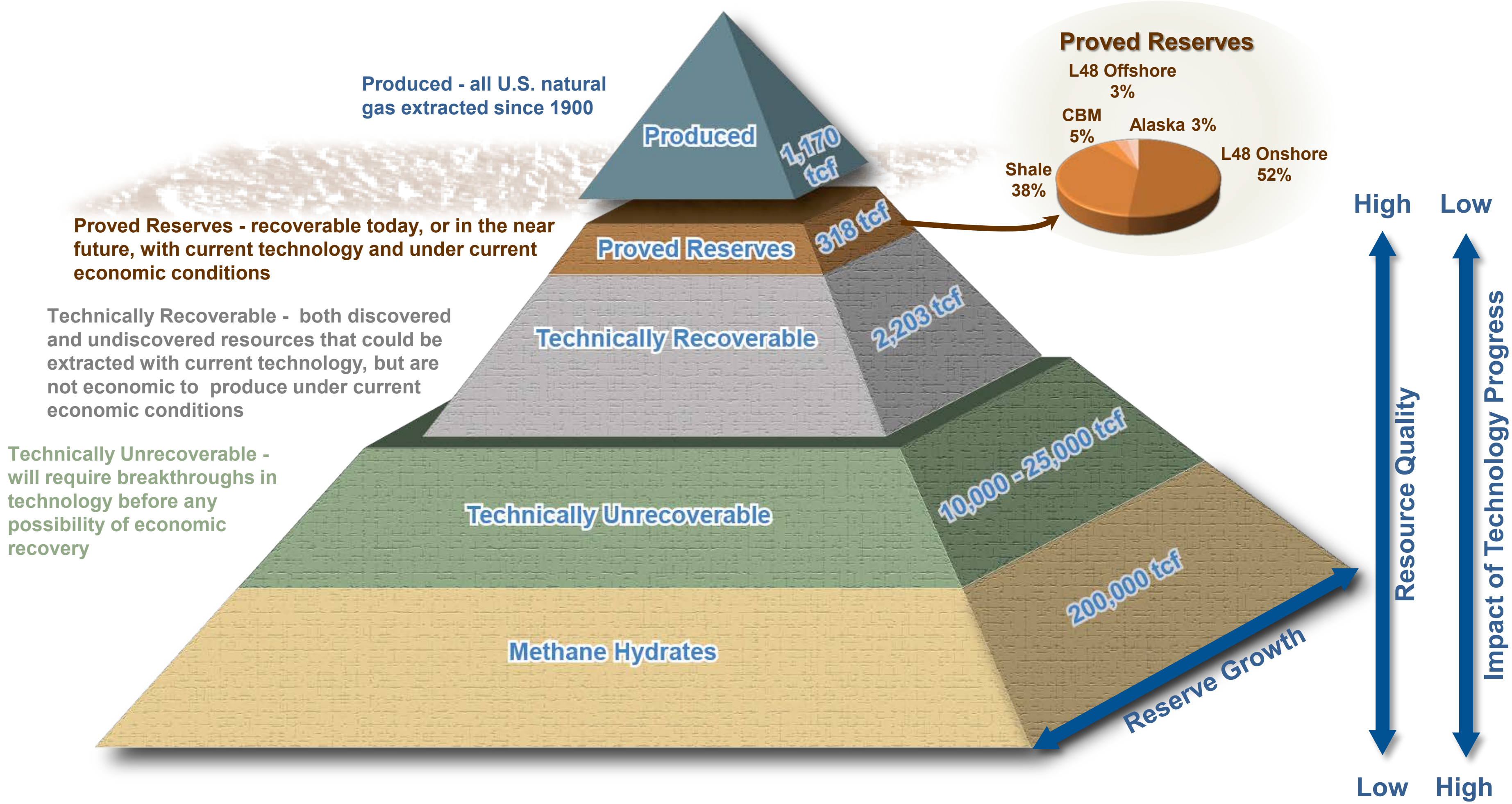





*Source: BP Statistical Review of World Energy 2015, http://www.bp.com/ (May not equal 100% due to rounding)*

# U.S. Natural Gas Resource Pyramid

## Figure: Natural Gas Resource Pyramid for Lower 48 States






*Source: EIA, US Crude Oil and natural Gas Proved Reserves and NETL – Concept from Kuuskraa, Oil & Gas Journal, June 8, 1996*

# Potential Gas Committee Assessments

**Table: Estimates of Potential Natural Gas Supply, Tcf**

| | 2000 | 2010 | 2012 | 2014 |
|---|---|---|---|---|
| Proved Reserves | 167.4 | 272.5 | 304.6 | 338.3 |
| Probable Reserves | 207.0 | 536.6 | 708.5 | 844.4 |
| Possible Reserves | 332.2 | 687.7 | 952.3 | 930.1 |
| Speculative | 397.8 | 518.3 | 558.7 | 586.1 |
| Coalbed Methane | 155.0 | 158.6 | 158.2 | 158.1 |
| **Total Supply*** | **1,259.4** | **2,173.7** | **2,682.3** | **2,853.2** |

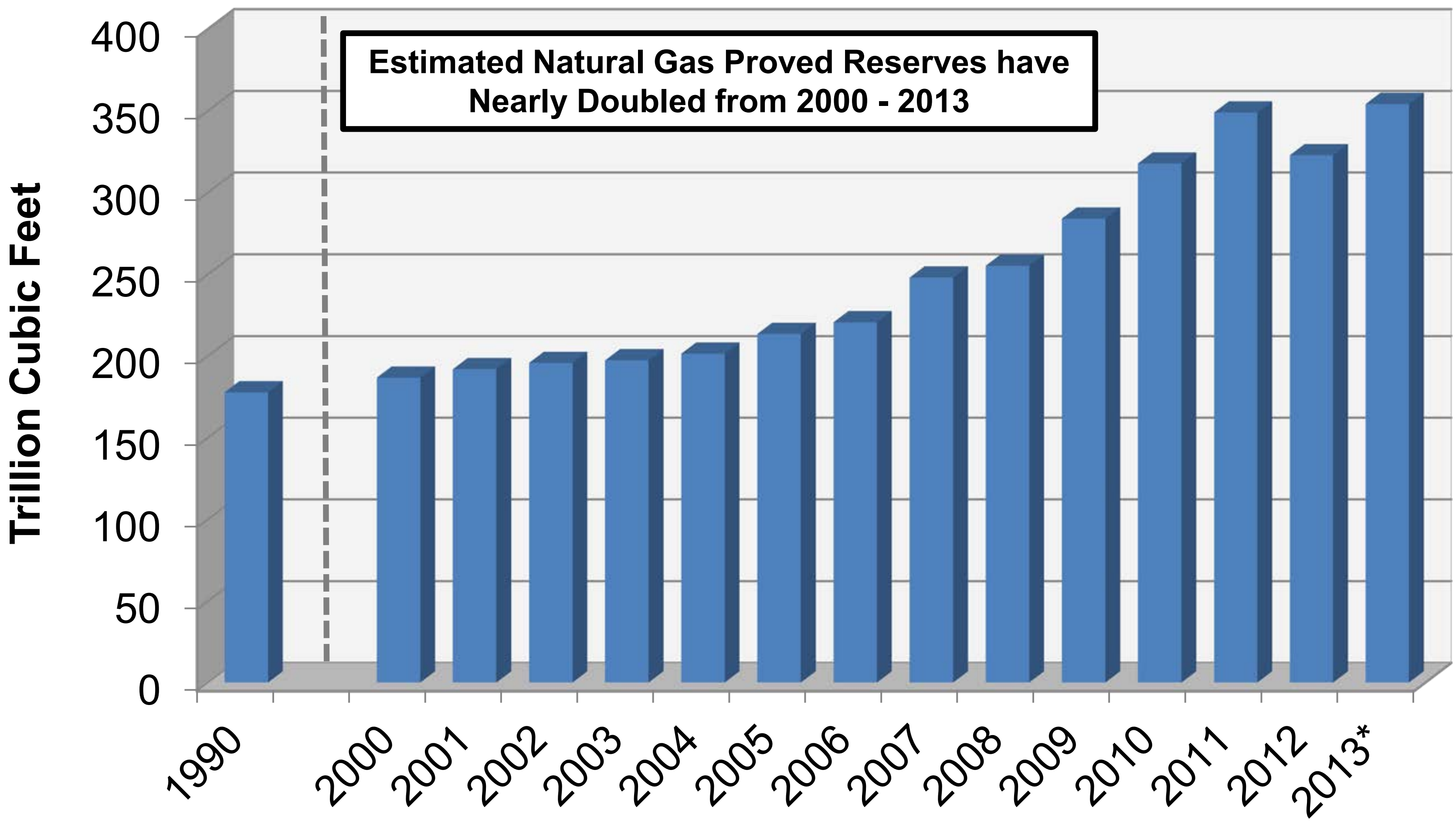
** Separately Aggregated Value, Subject to Rounding*



*Source: Potential Gas Committee, April 8, 2015, http://potentialgas.org/biennial-report*

# Total Natural Gas Proved Reserves

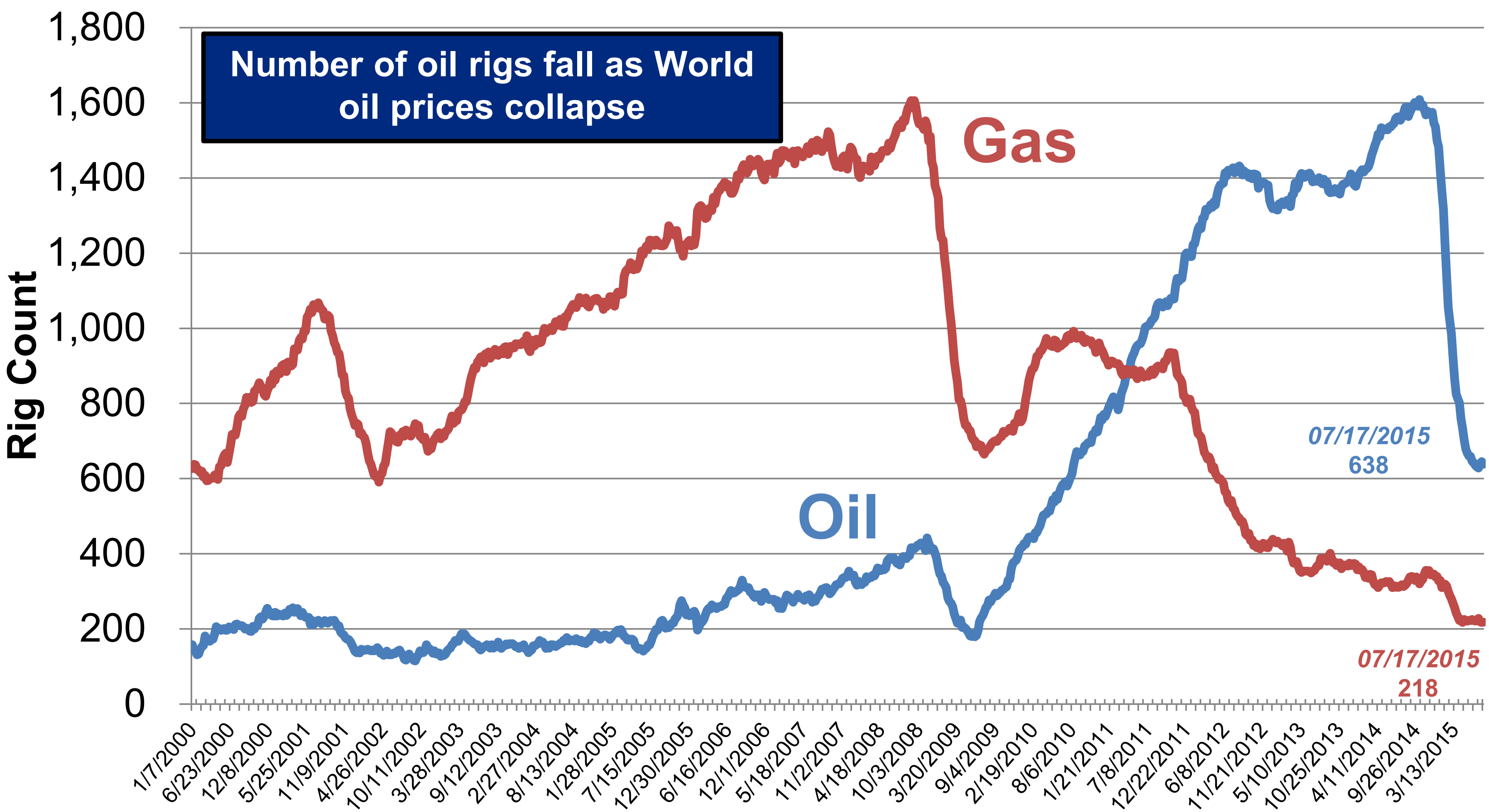
**Figure: Total Natural Gas Proved Reserves, Tcf**




** Latest available EIA value, year-end 2013*

# U.S. Rig Count

**Figure: U.S. Rig Count as of 07/17/2015 (Oil / Gas Split)**

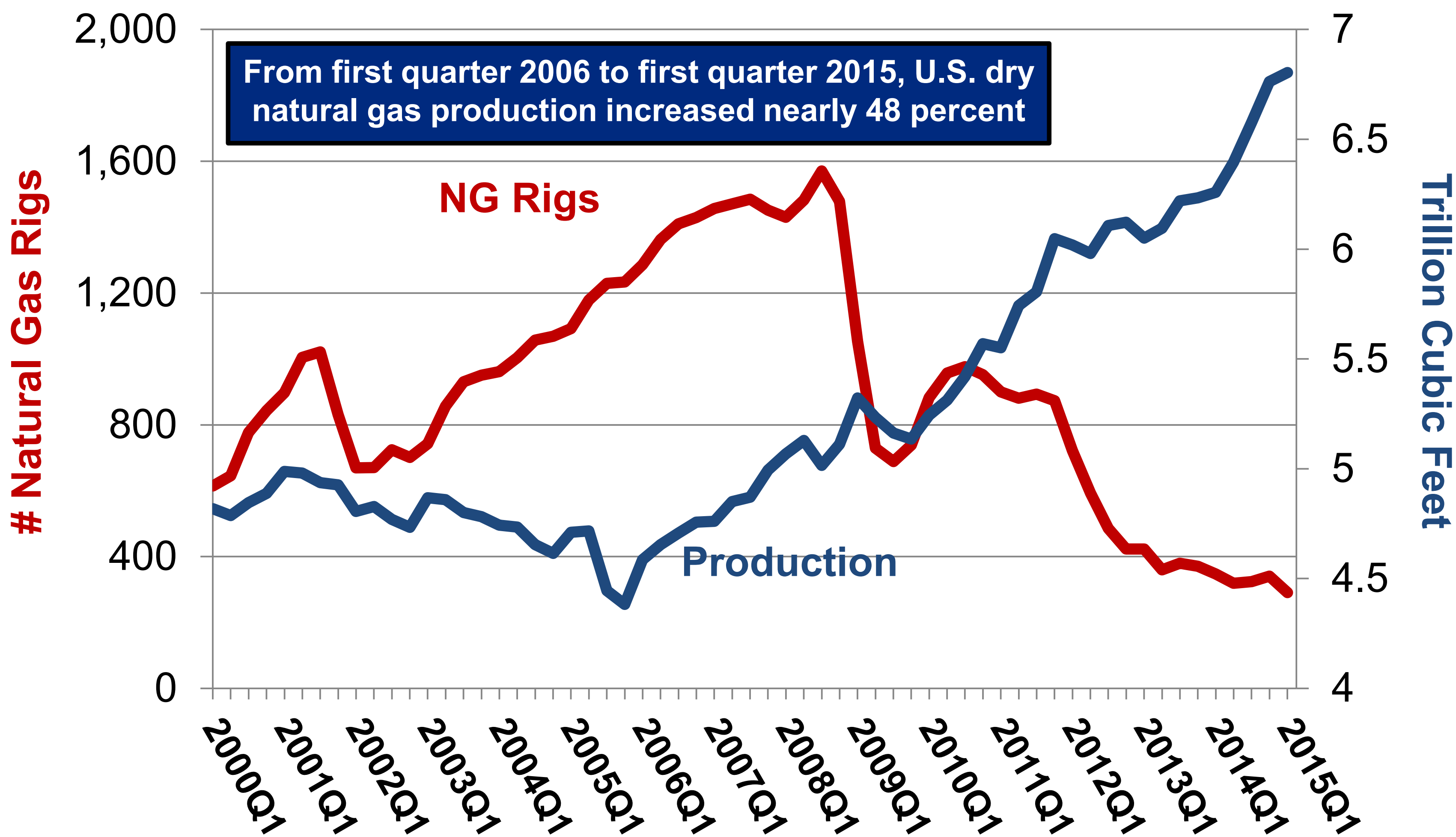





*Source: Baker Hughes http://investor.shareholder.com/bhi/rig_counts/rc_index.cfm*

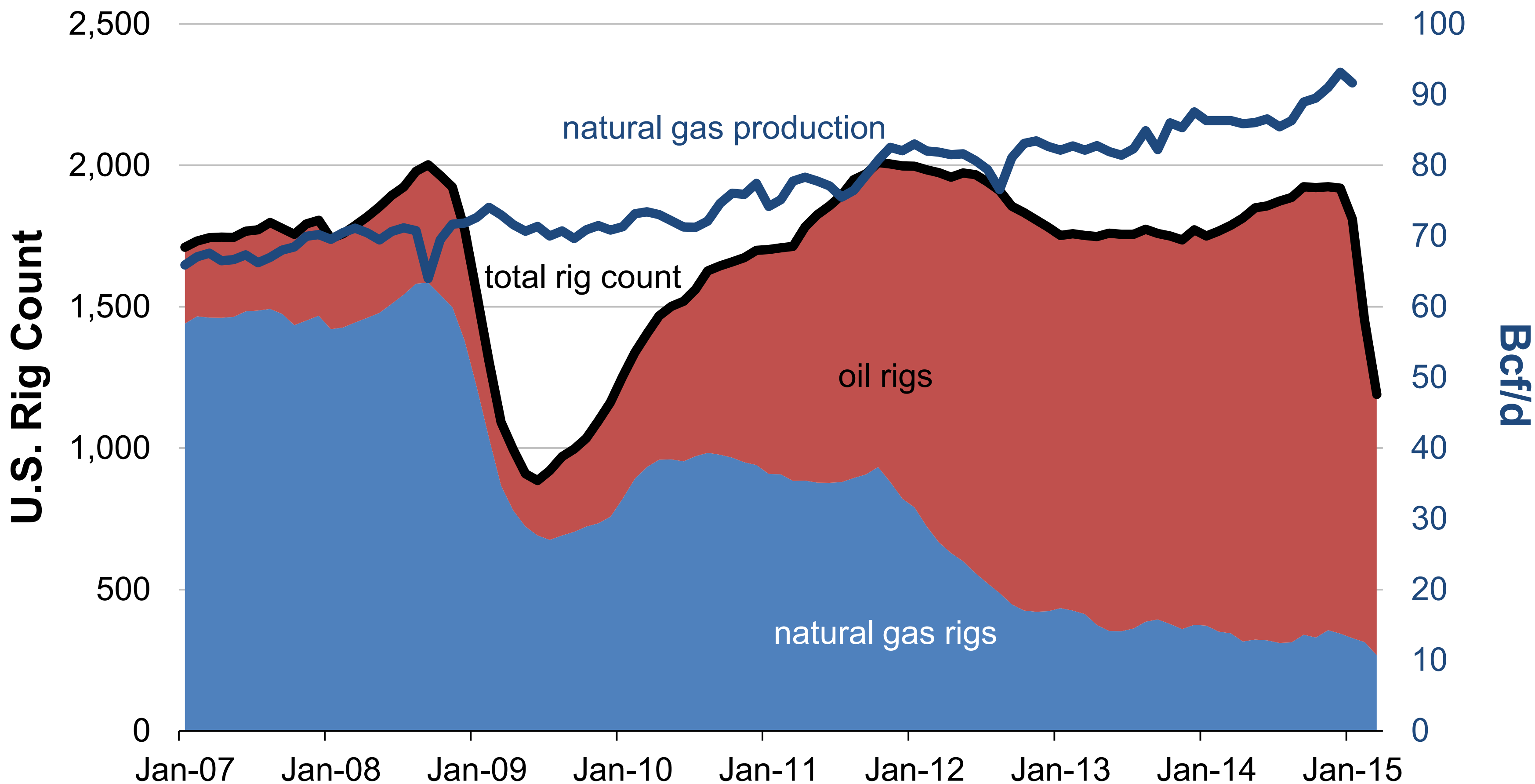
# Natural Gas Rig Count vs. Production

**Figure: Natural Gas Rigs vs. Dry Natural Gas Production, Quarterly**



# U.S. Rig Count and Production

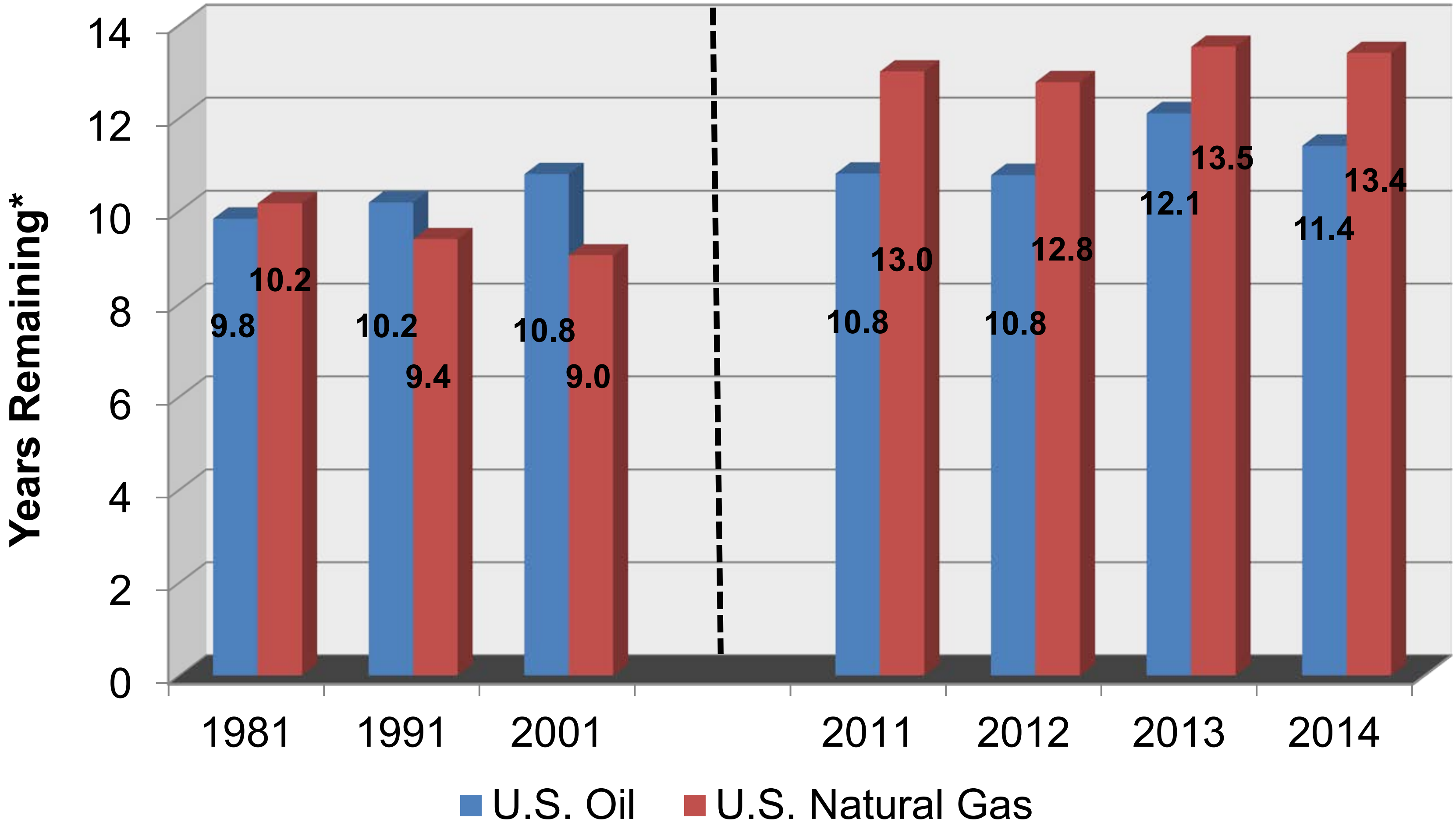
**Figure: Oil and Natural Gas Rig Count and Natural Gas Production**




Natural gas production increases despite fall in rig count

# U.S. Oil & Natural Gas Remaining Reserves

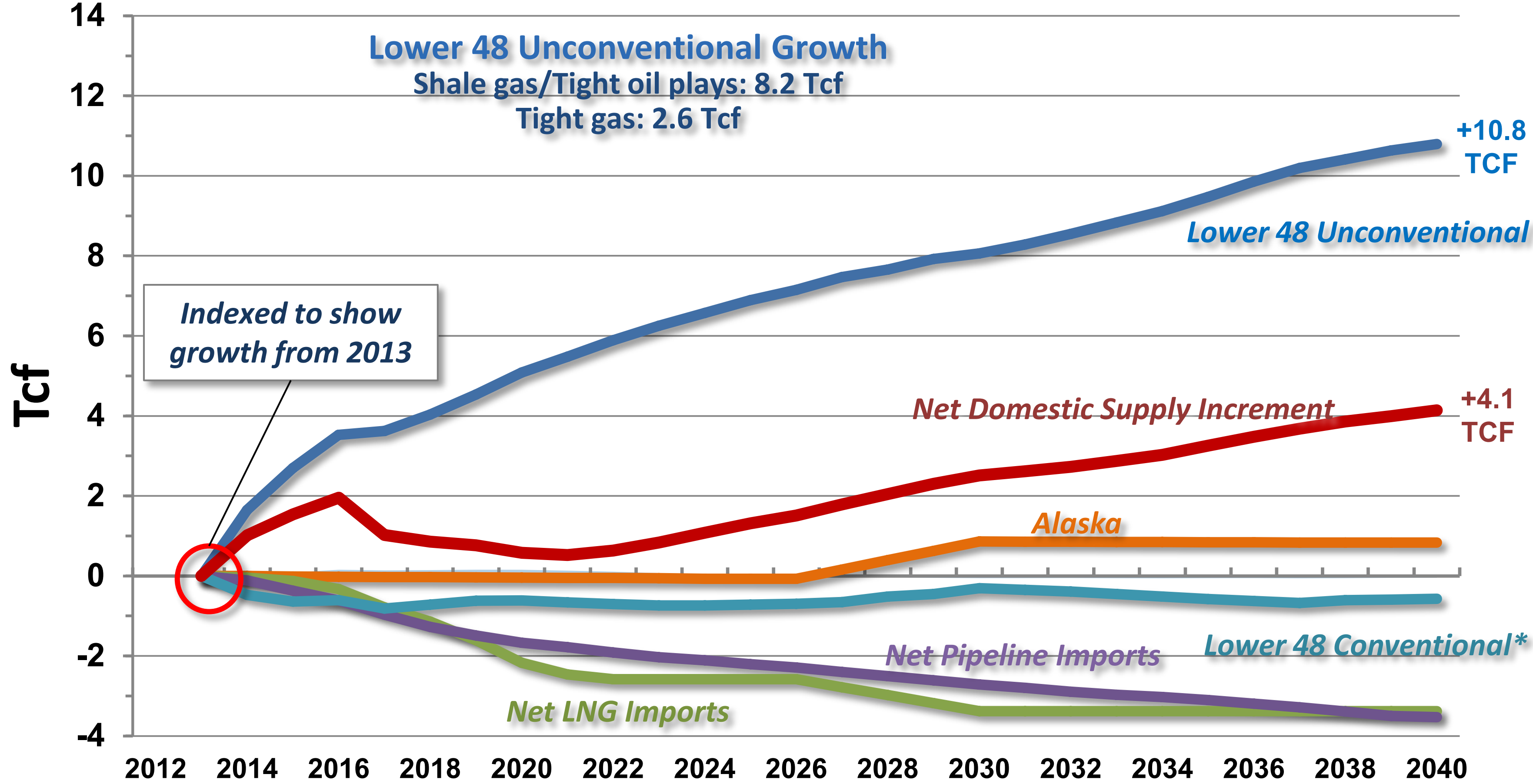
**Figure: U.S. Oil and Natural Gas Reserves/Production, 1981-2014**




* If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.

# Sources of Incremental Natural Gas Supply

**Figure: Sources of Incremental Natural Gas Supply** (AEO'15 Reference Case – Indexed to 2013)

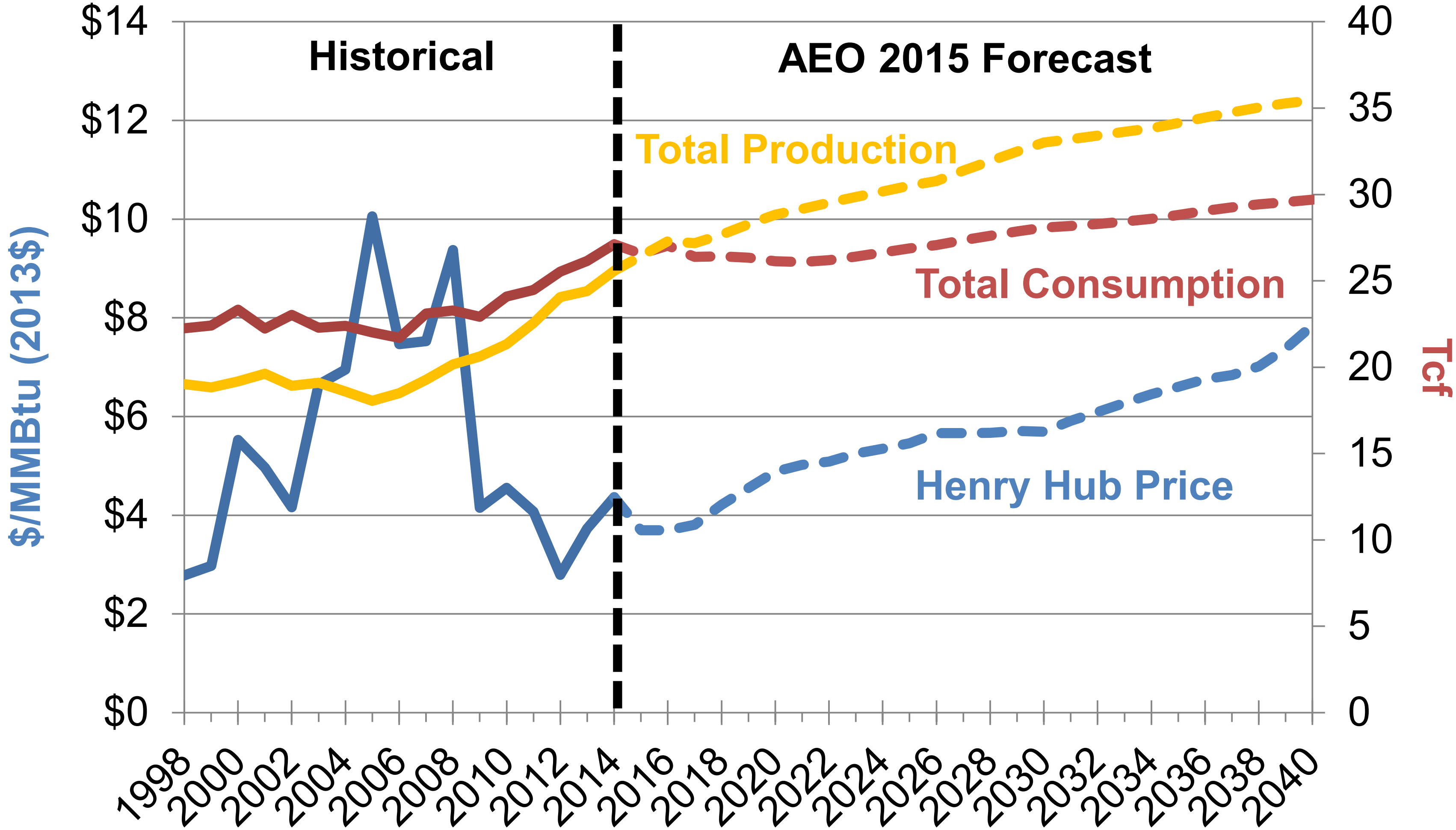



** Includes lower 48 offshore, and other production*

*Shale-gas production growth offset by conventional production declines and LNG and pipeline exports; 4.1 Tcf Incremental Supply by 2040 Available for New Markets*

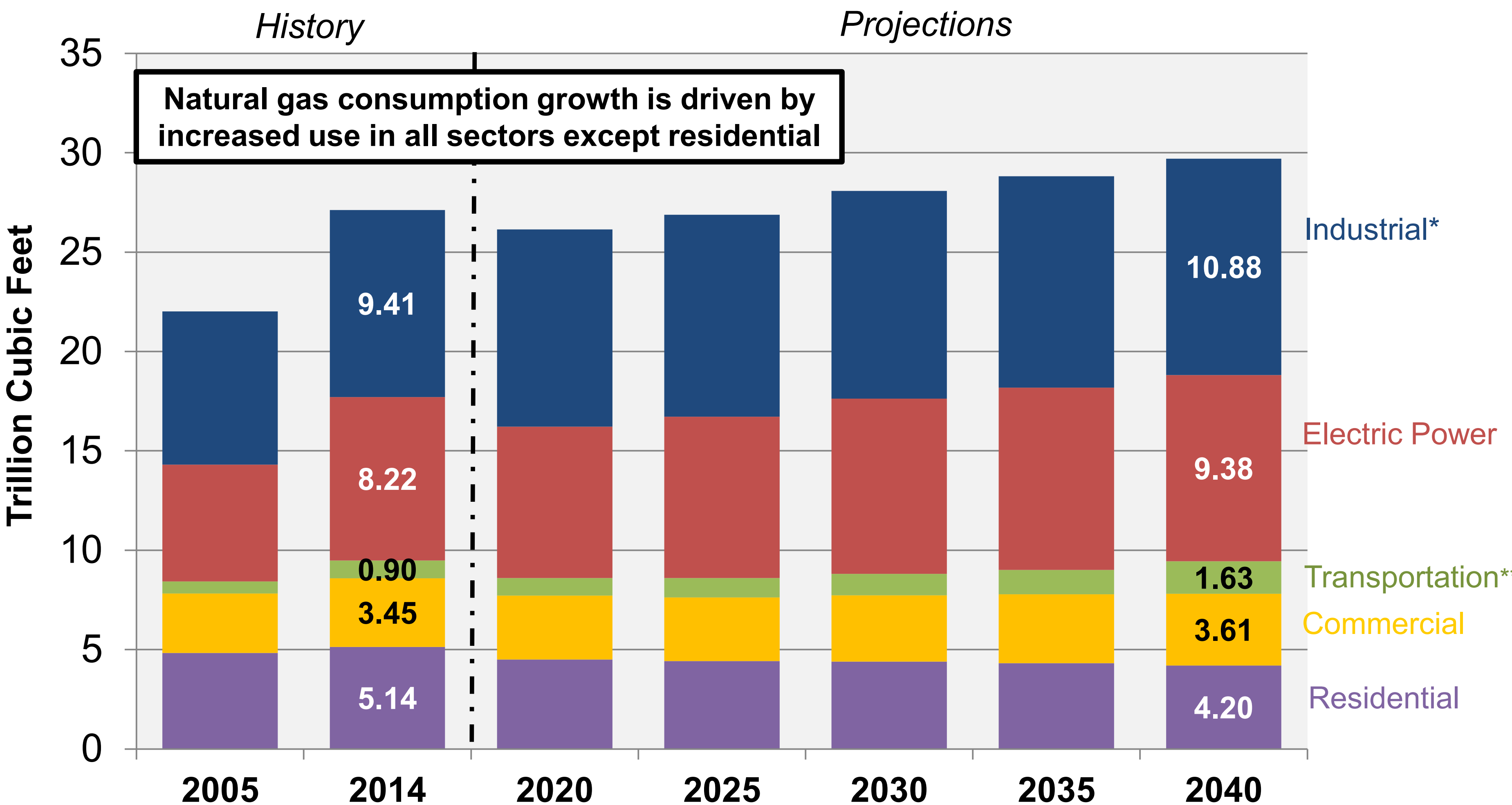
# Natural Gas Prices Versus Demand

**Figure: Henry Hub Spot Prices ($/MMBtu) vs. Total Consumption & Production (Tcf)**



# Natural Gas Consumption

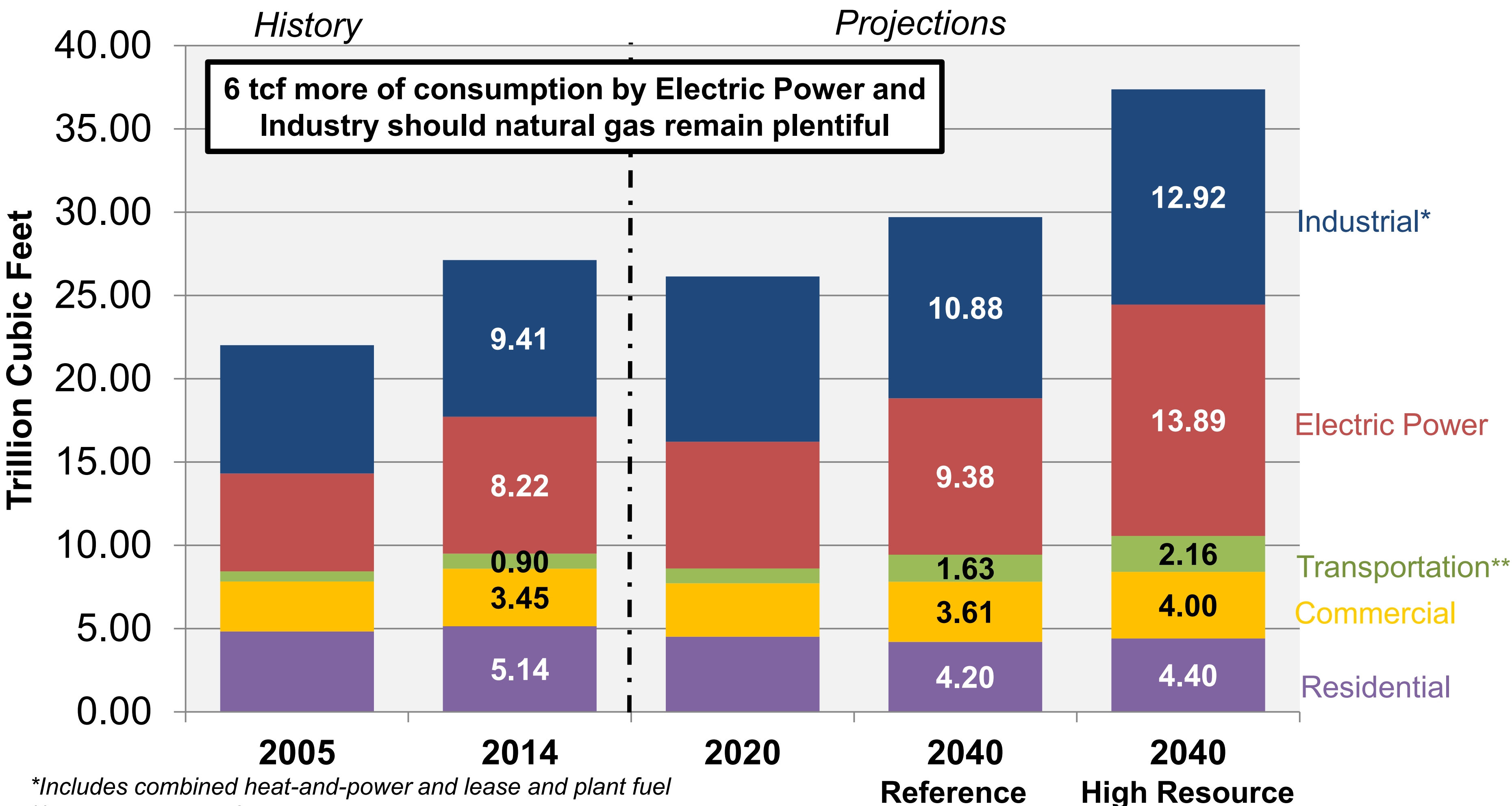
**Figure: U.S. Natural Gas Consumption by Sector through 2040 (Reference Case)**




*Includes combined heat-and-power and lease and plant fuel
**Includes pipeline fuel

# Natural Gas Consumption - High Case

**Figure: U.S. Natural Gas Consumption through 2040 (Reference vs. High Resource Case)**




*Includes combined heat-and-power and lease and plant fuel

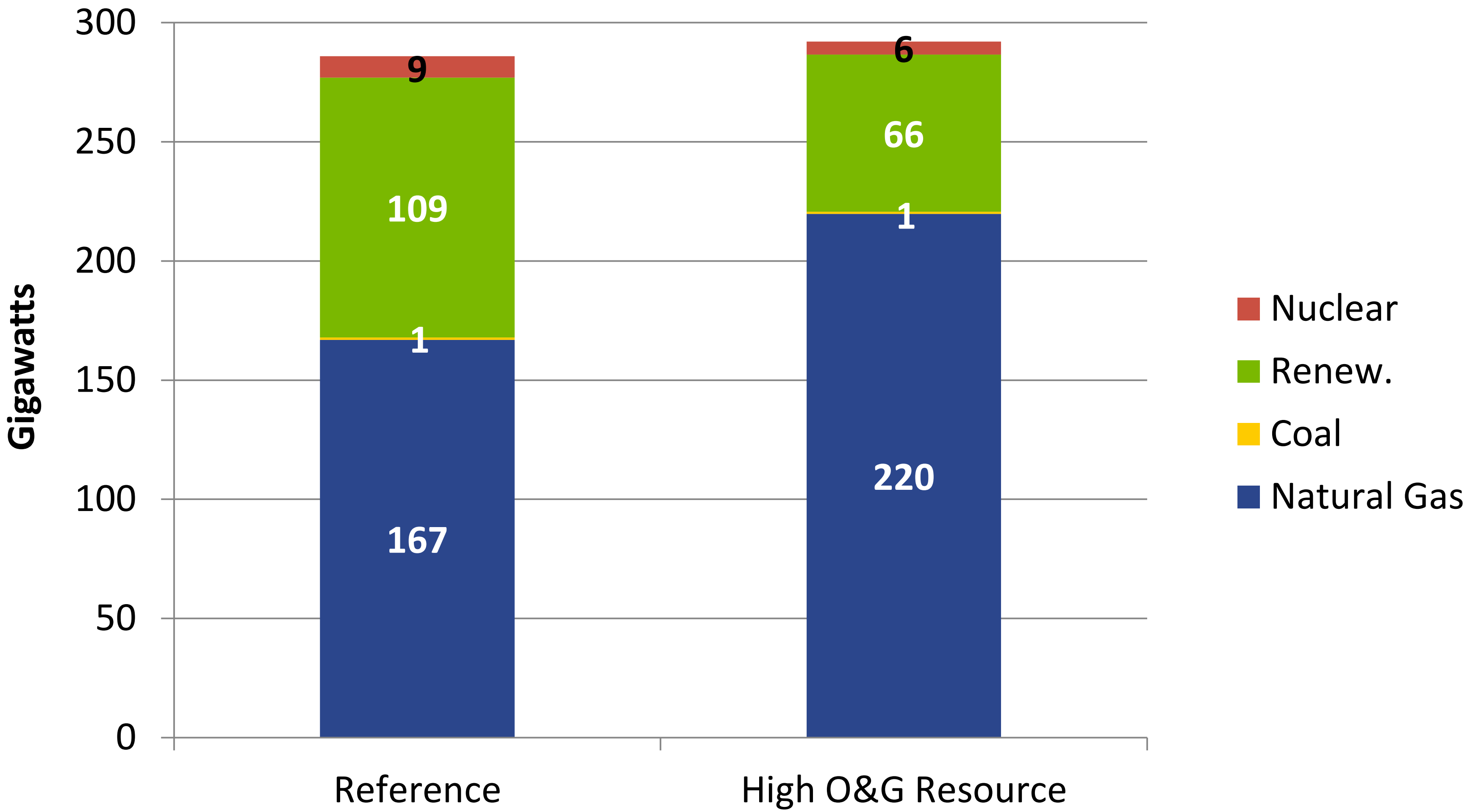
**Includes pipeline fuel



*Source: U.S. Energy Information Administration, http://www.eia.gov/naturalgas/data.cfm and Annual Energy Outlook 2015*

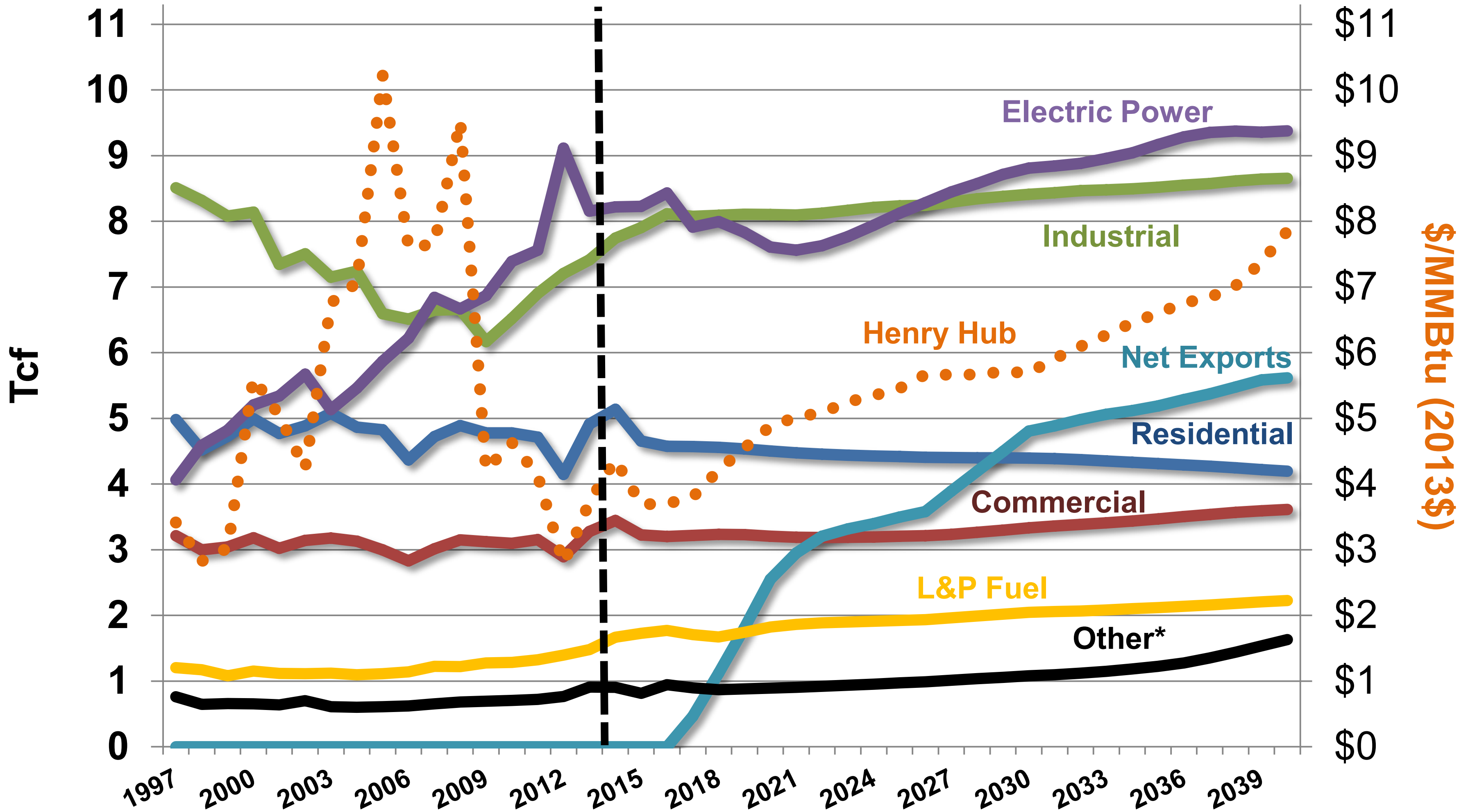
# Electricity Generating Capacity Additions

**Figure: Electricity Generating Capacity Additions, 2014-2040**



# Natural Gas Consumption vs. Price

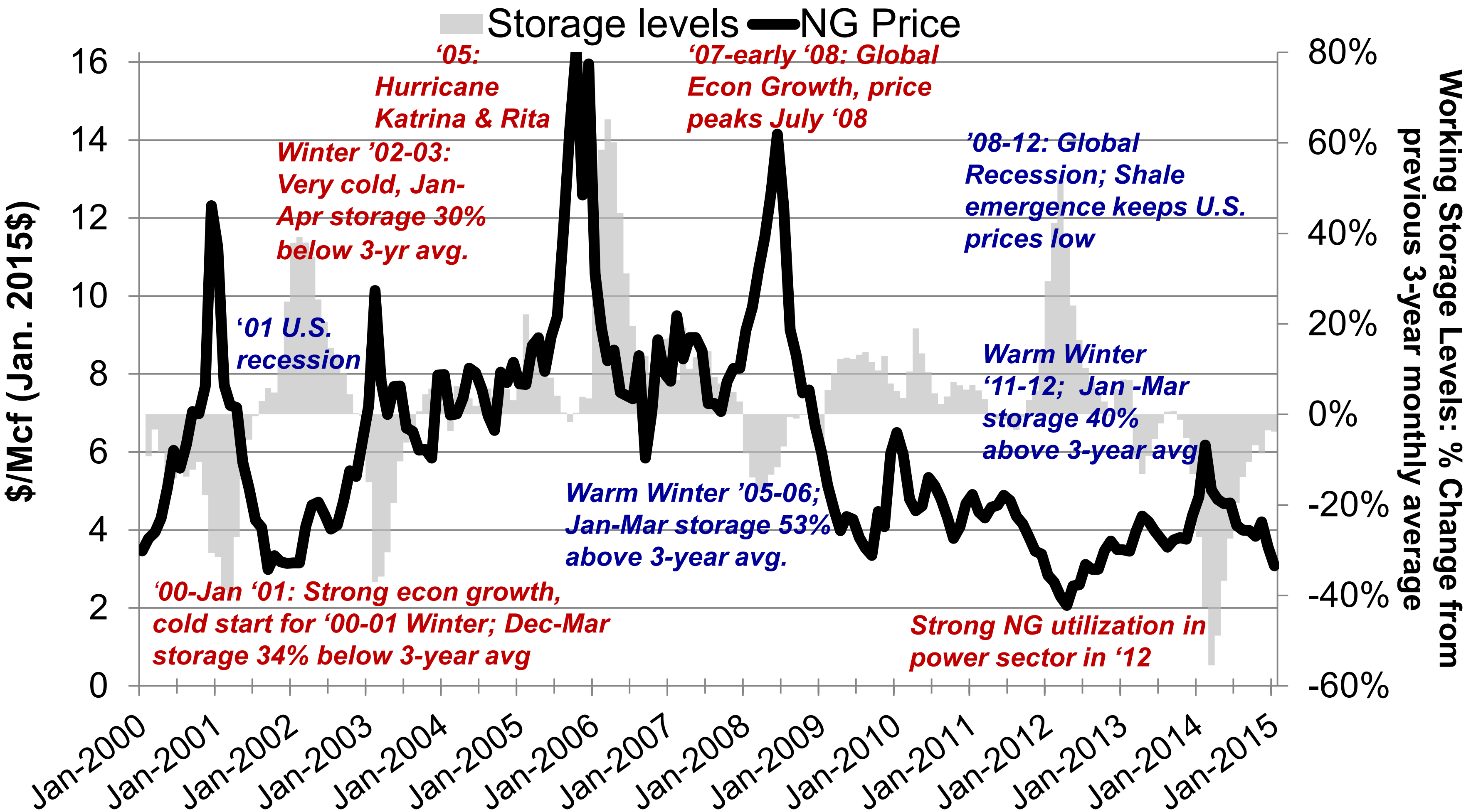
**Figure: Natural Gas Consumption (Tcf) versus Henry Hub Price ($/MMBtu)**




*Includes GTL, Pipeline Fuel, and Transportation

# Historic Natural Gas Price Movement

Figure: U.S. Natural Gas Henry Hub Price, January 2000 – January 2015




Upward price effect    Downward Price effect



*Sources: EIA: Natural Gas Navigator, Electric Power Annual, Short Term Energy Outlook (STEO); Consumer Price Index (taken from STEO)*

# Determinants of Natural Gas Prices

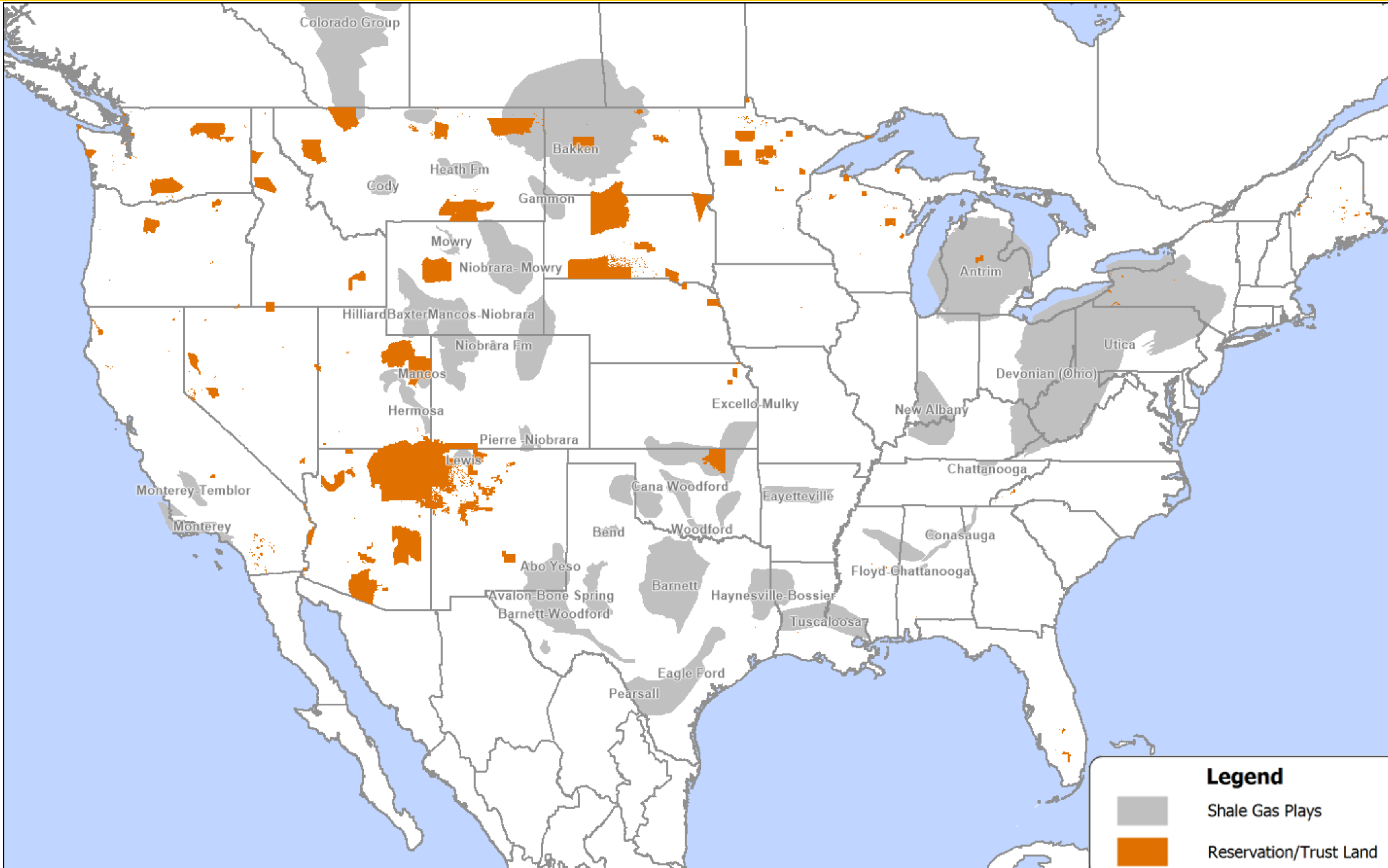
## Table: Direct and Indirect Determinants of Natural Gas Prices

| Direct Forces | Time Horizon | Likely Effect |
|---|---|---|
| Secular Demand | Long | Rising, thus prices rise; incentive for more supply |
| Cyclical Investment Behavior | Short to Medium | Pro-cyclical behavior increases amplitude of price fluctuations |
| Gas Storage | Short to Medium | If well behaved, counter-cyclical effect on price. Issue as to whether there will be enough storage |
| Pipeline Infrastructure | Medium to Long | Delays in permitting and constructing gathering lines and transmission projects moving gas from high supply areas to high demand areas |
| LNG Exports | Medium to Long | Foreign markets where natural gas prices are higher; thus putting upward pressure on domestic prices |
| Access to Resources | Medium to Long | Advanced technology and federal lands could increase supply. Low natural gas prices could hinder production |
| **Indirect Forces** | | |
| Industrial Use | Short to Long | Increased manufacturing adds structural element to gas demand |
| Transportation Use | Short to Long | NG and NGL Vehicles and fleets add structual element to gas demand |
| Coal Power | Short to Long | Environmental regulations reduce use; structural element added to gas demand |
| Nuclear Power | Short to Long | Cheapest marginal operating cost, retirements add structural element to gas demand if coal unavailable |

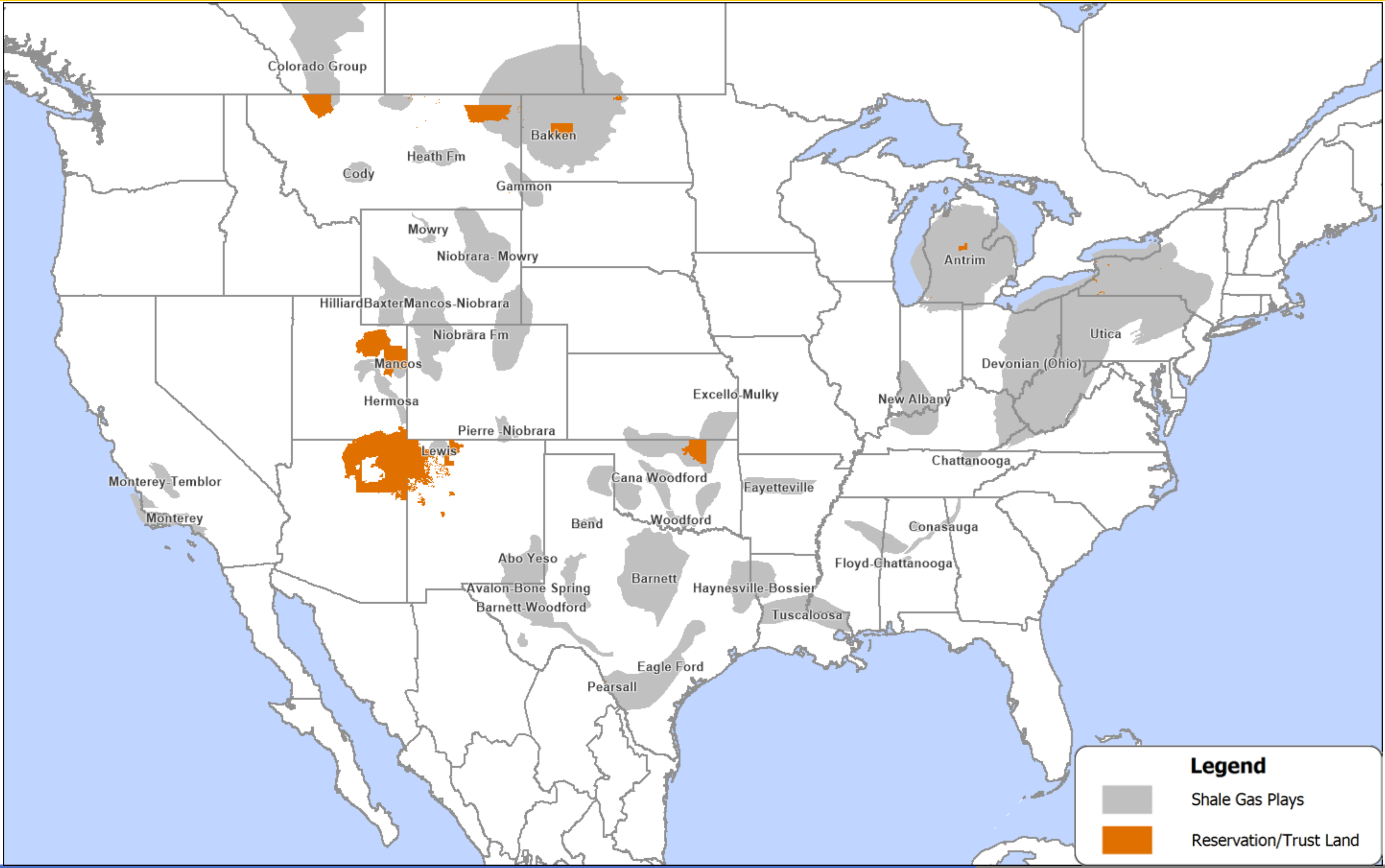
# OUTLINE

- Strategic Energy Analysis and Planning
- Natural Gas Supply and Demand
- **Tribal Areas and Natural Gas Reserves**
- SEAP Analysis of Natural Gas Issues
  - Dual Fuel
  - Electric Interdependencies
- SEAP Life Cycle Analysis

# 500 Reservations & 62 Shale Plays

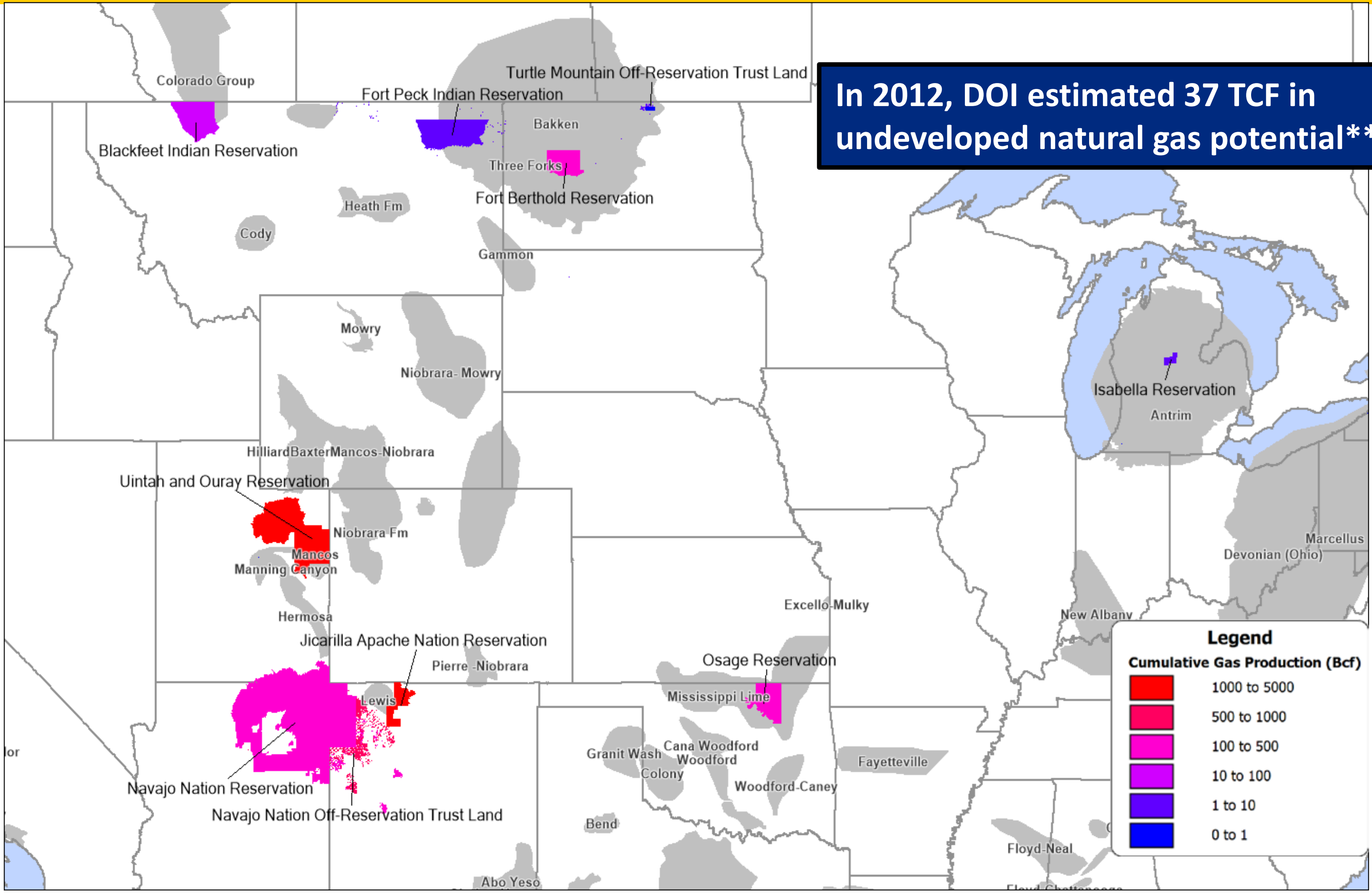


# 30 Tribes reside over known shale plays



# 8.2 Tcf produced on 10 reservations and trust lands since start of record keeping*

**In 2012, DOI estimated 37 TCF in undeveloped natural gas potential****



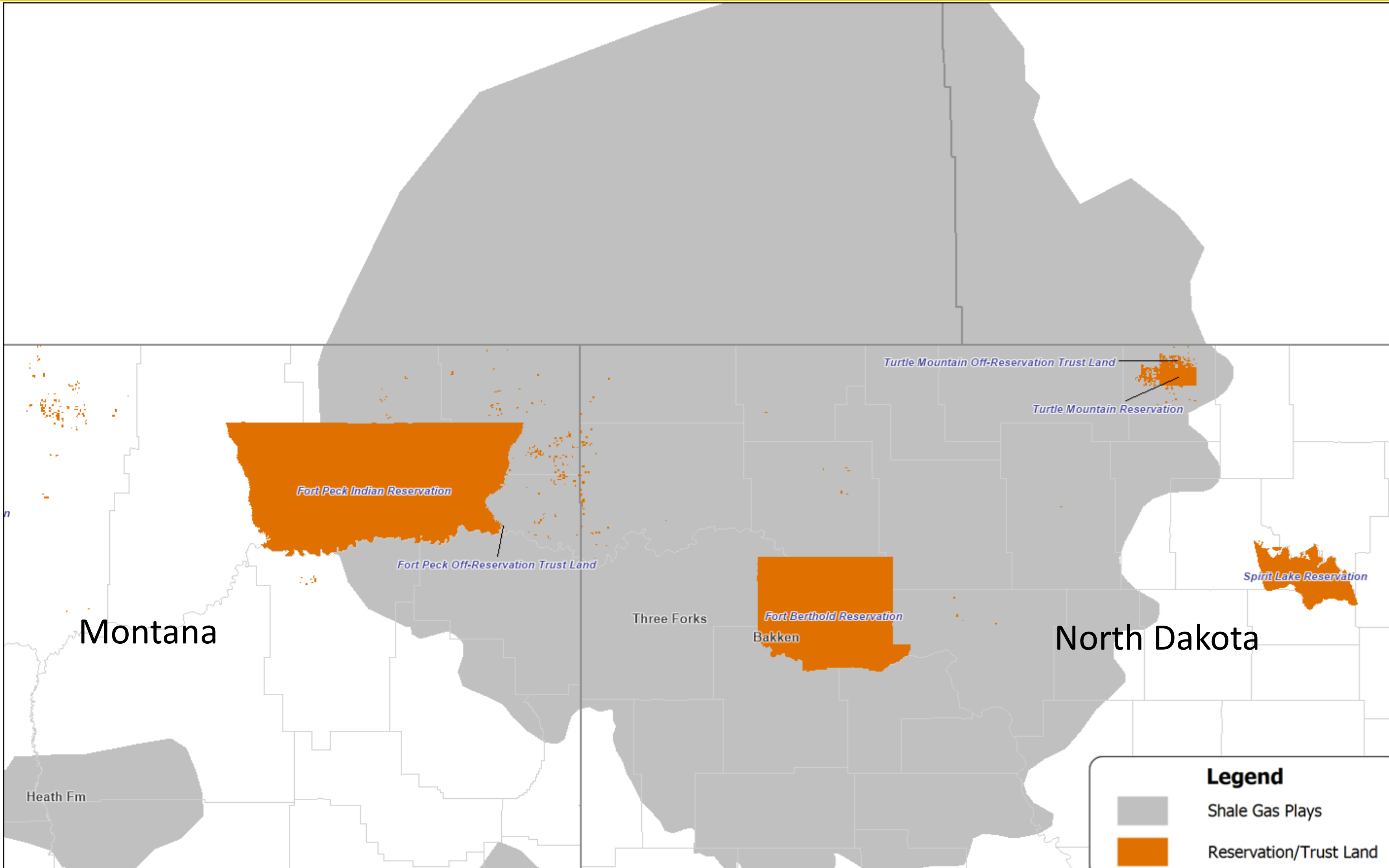

*Includes production from conventional, unconventional, oil, and coalbed methane wells. Record keeping varies by reservation/play (See slide 31 for dates)

*Generated using Ventyx Velocity Suite Federal Lands and Shale Plays Queries with production data from DrillingInfo*
***Regan, S. and Anderson, T. 2013. The Energy Wealth of Indian Nations. Available at http://www.bushcenter.org/sites/default/files/GWBI-EnergyWealthIndianNations.pdf.*

# Antrim Play
## Michigan Reservations

# Bakken/Three Forks Plays

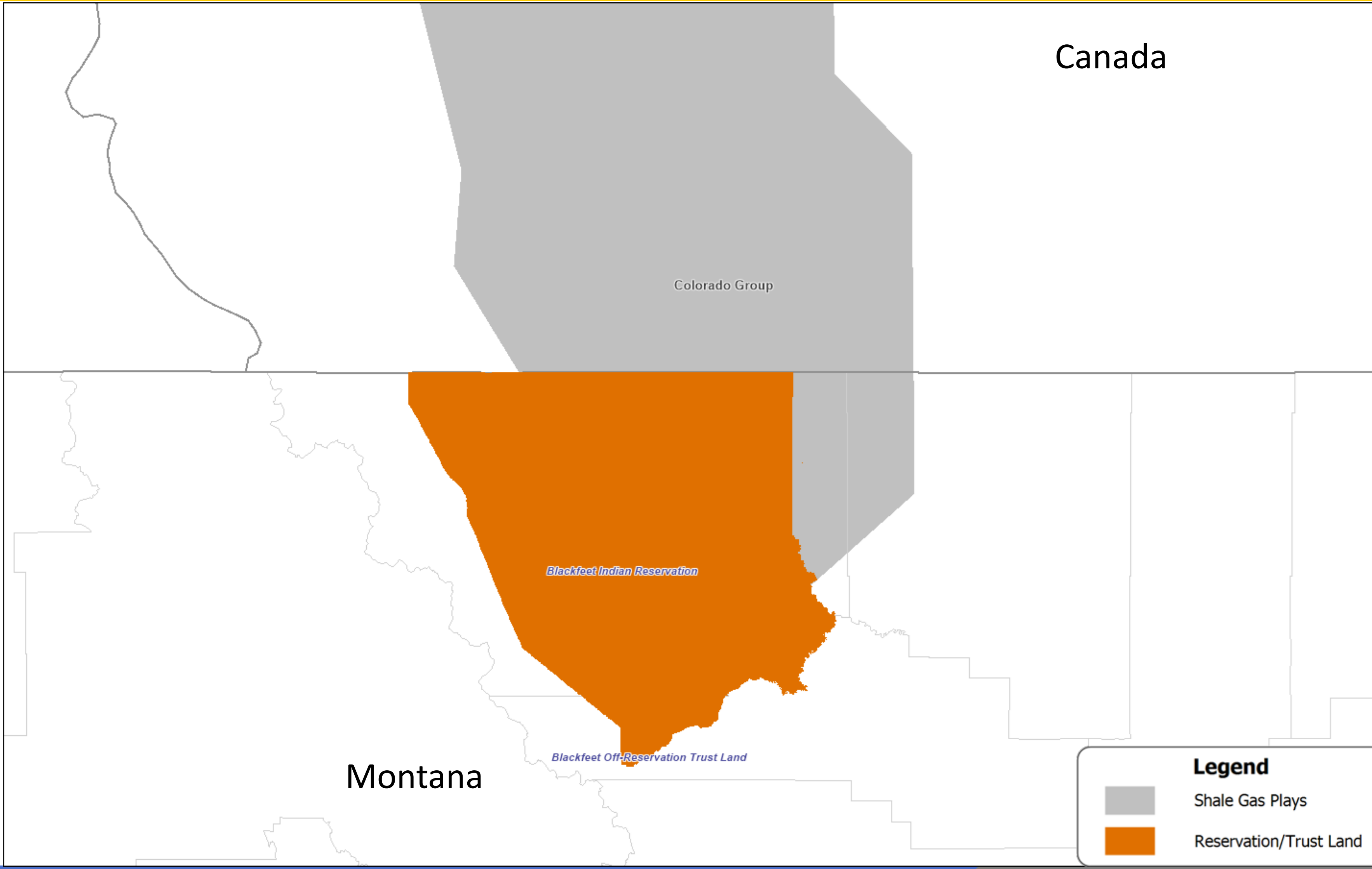
## Fort Peck/Fort Berthold/Turtle Mountain Reservations



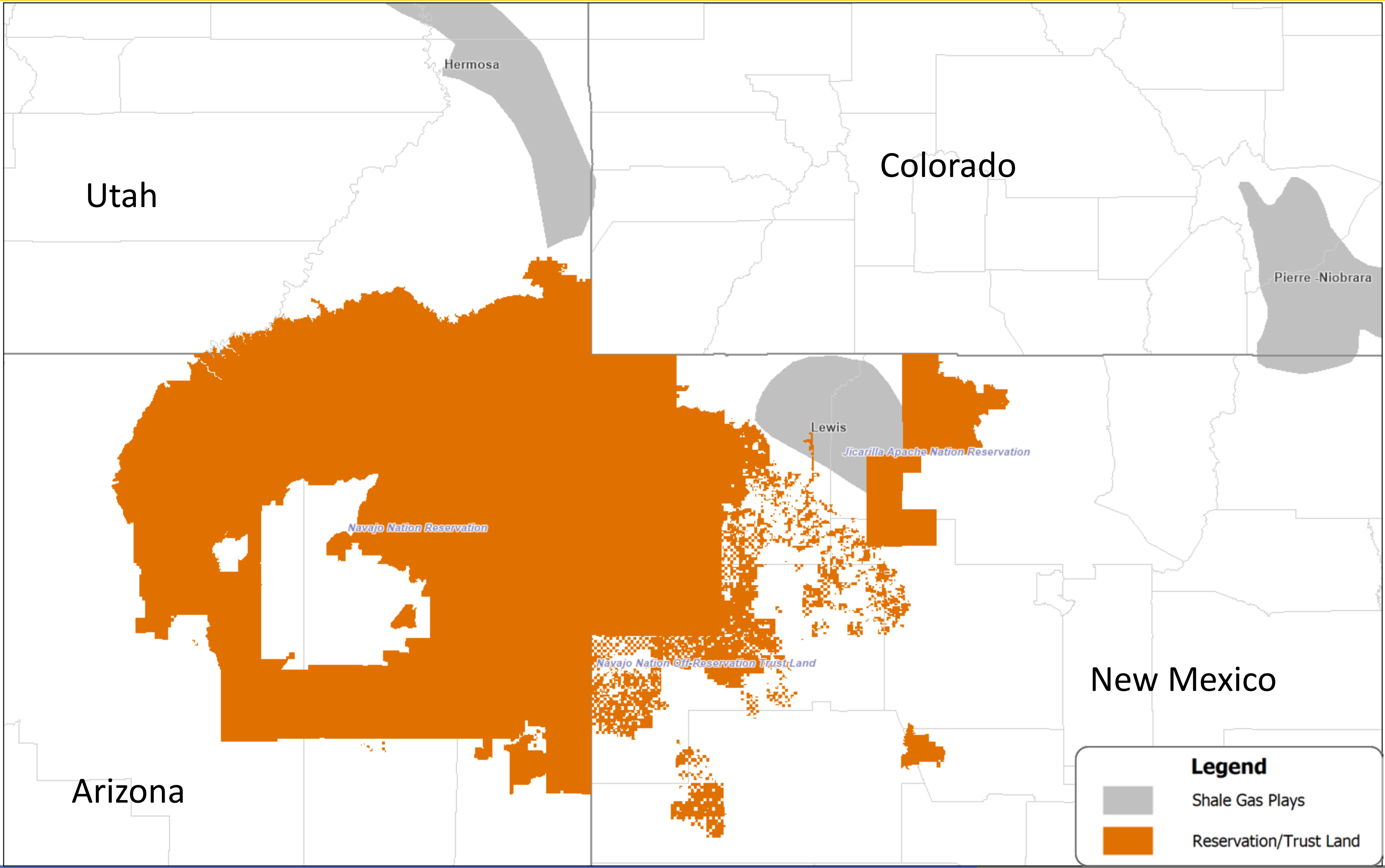

Generated using Ventyx Velocity Suite Federal Lands and Shale Plays Queries

# Colorado Group Plays

## Blackfeet Nation

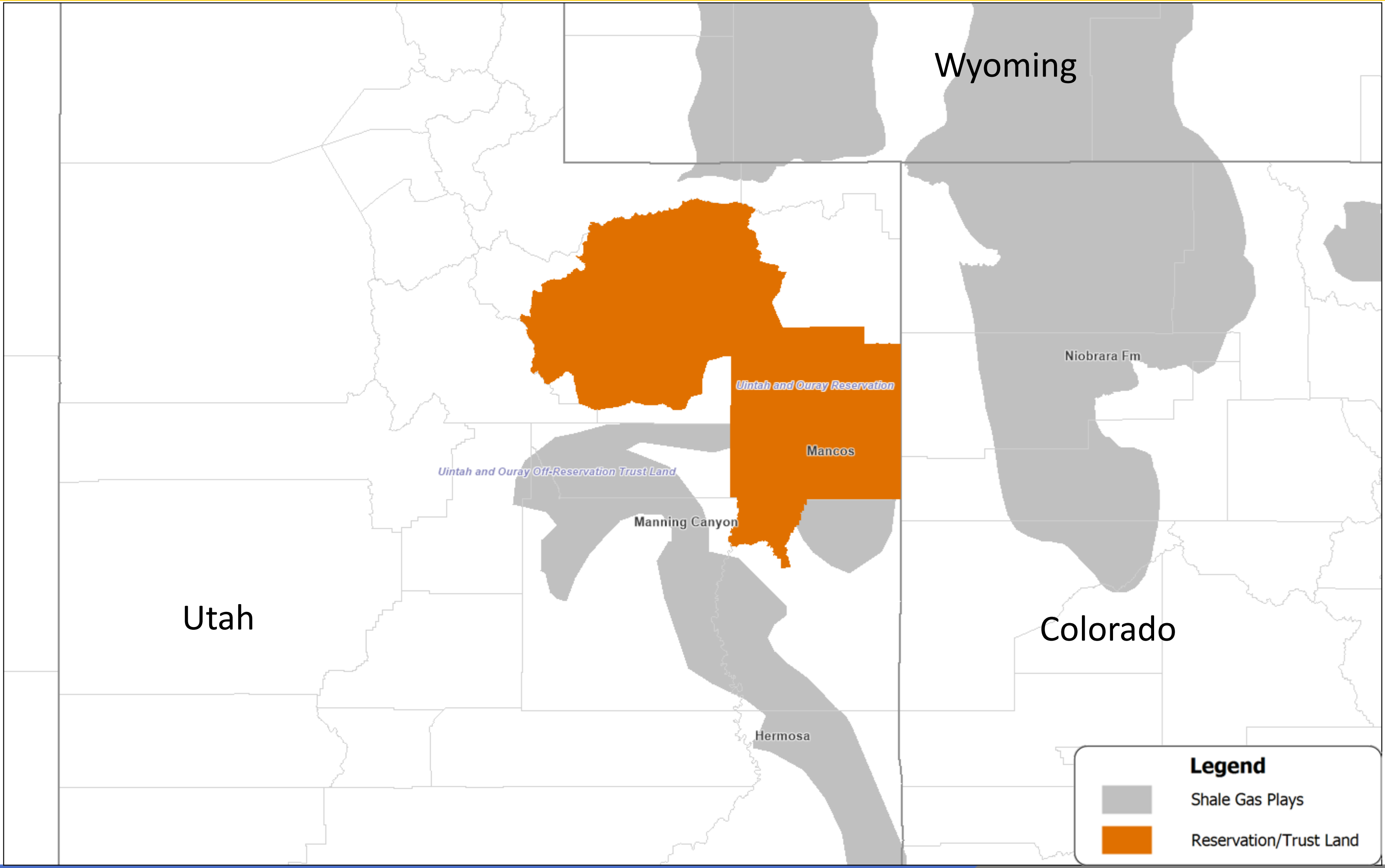


# Lewis Play
## Navajo & Jicarilla Apache Nations



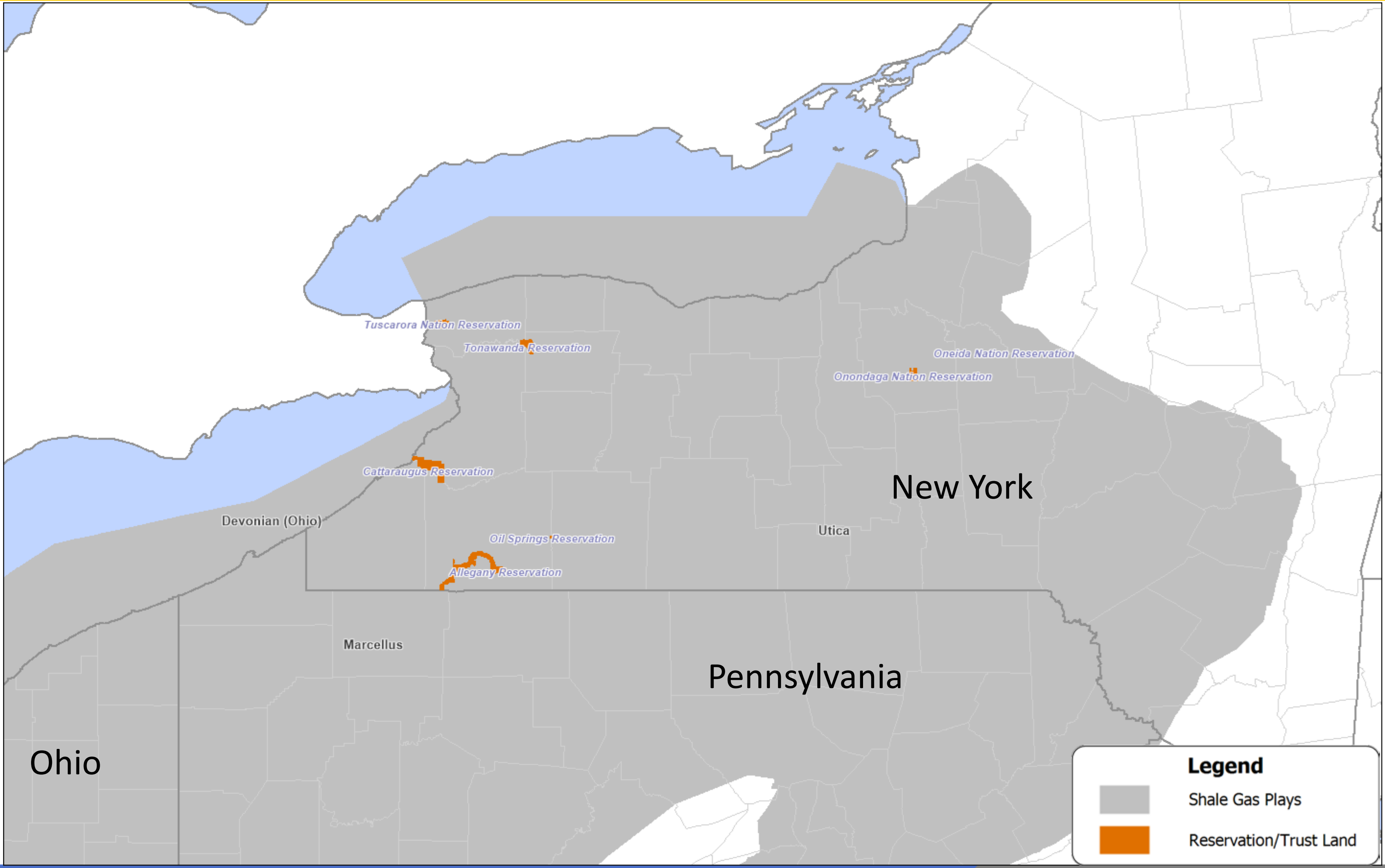
# Mancos/Manning Canyon/Hermosa Plays

## Uintah and Ouray Reservation

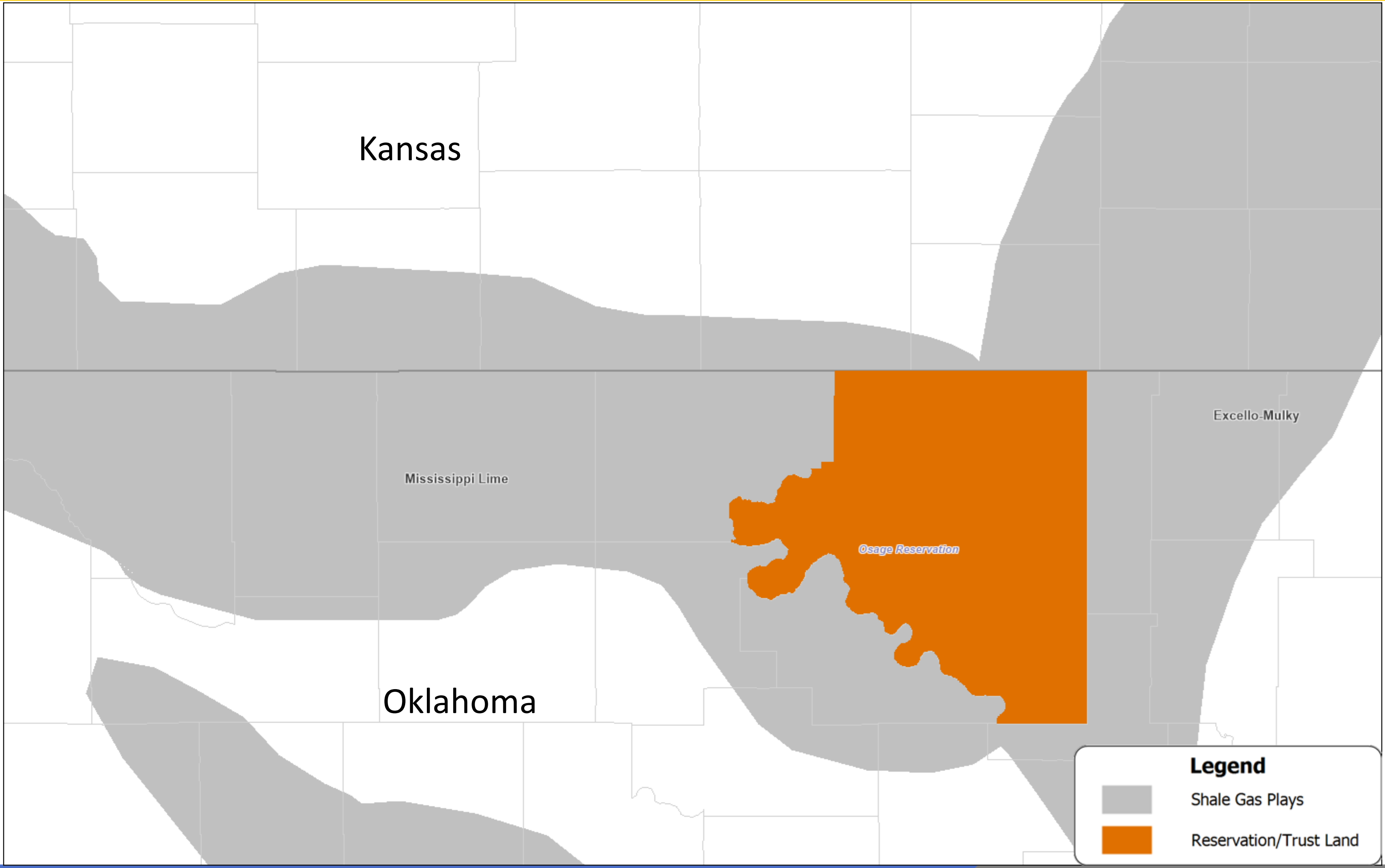


# Utica/Marcellus/Devonian Plays

## New York Reservations



# Mississippi Lime and Excello Mulky Plays Osage Reservation






*Generated using Ventyx Velocity Suite Federal Lands and Shale Plays Queries*

# 8.2 Tcf produced on 10 reservations and trust lands since start of record keeping

| Reservation/Trust | Cumulative Production (Bcf)* | Underlying Shale Formation(s) | State | First Record Date |
|---|---|---|---|---|
| Uintah and Ouray | 4,741.9 | Mancos, Manning Canyon, Hermosa | UT | 1963 |
| Jicarilla Apache Nation | 1,921.5 | Lewis | NM | 1918 |
| Navajo Nation Trust Land | 890.1 | Lewis | NM | 1948 |
| Navajo Nation | 277.4 | Lewis | UT/AZ/NM | 1924 |
| Fort Berthold | 192.6 | Bakken, Three Forks | ND | 1957 |
| Osage | 153.6 | Mississippi Lime, Excello Mulky | OK | 1901 |
| Blackfeet | 14.5 | Colorado Group | MT | 1932 |
| Fort Peck | 2.8 | Bakken, Three Forks | MT | 1943 |
| Turtle Mountain Trust Land | 2.2 | Bakken, Three Forks | ND | 1975 |
| Isabella | 1.3 | Antrim | MI | 1984 |

*Includes production from conventional, unconventional, oil, and coalbed methane wells



*Generated using Ventyx Velocity Suite Federal Lands and Shale Plays Queries with production data from DrillingInfo*

# OUTLINE

- Strategic Energy Analysis and Planning
- Natural Gas Supply and Demand
- Tribal areas and Natural Gas Reserves
- **SEAP Analysis of Natural Gas Issues**
  - Dual Fuel
  - Electric Interdependencies
- SEAP Life Cycle Analysis

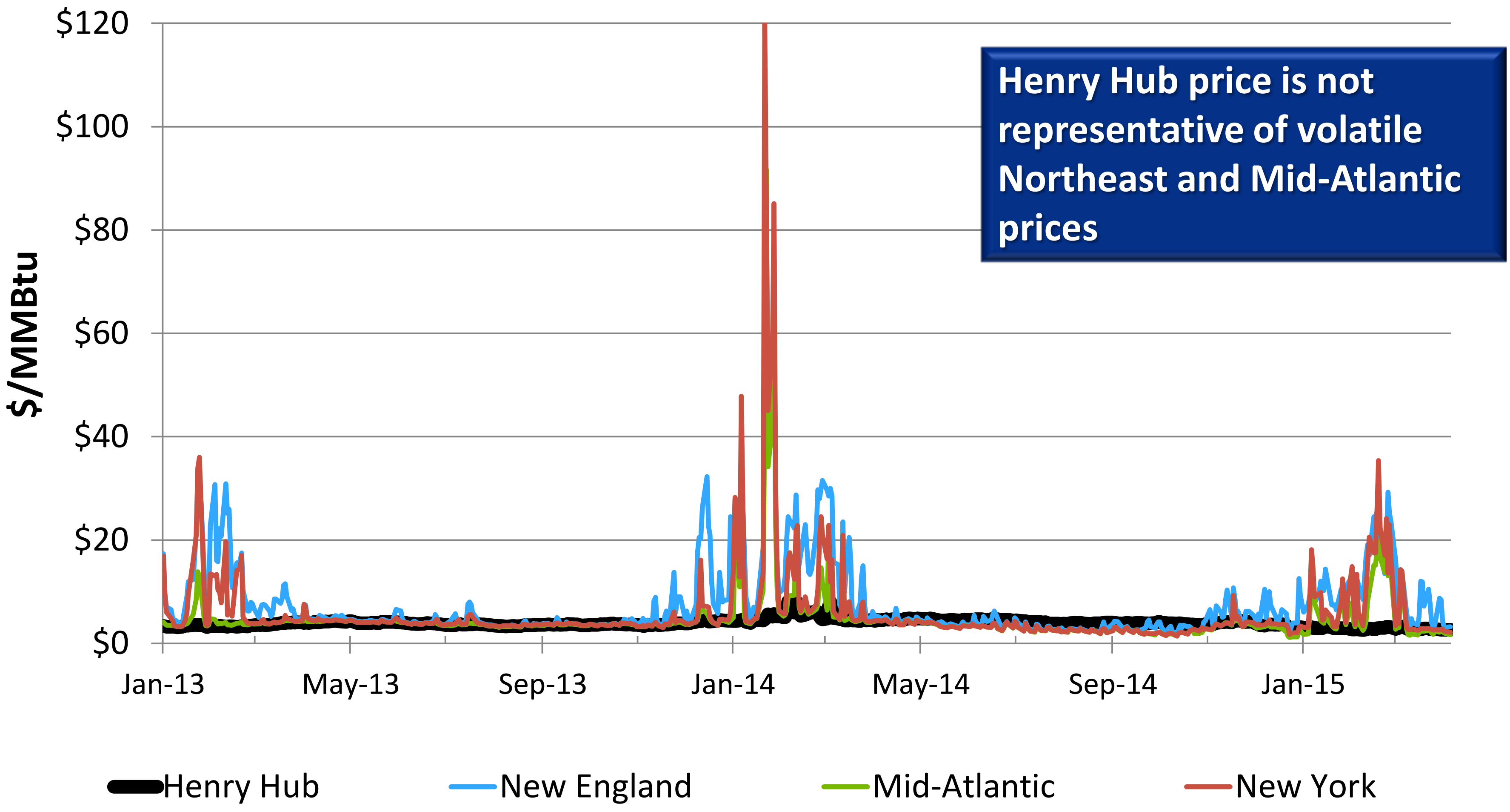
# Overview
## *Grid in Transition: Reliability & Other Implications*

### *Strategic Energy Analysis & Planning (SEAP) Mission Space*

- ***Situational Awareness***: Stay abreast of emerging issues and views
- ***Novel Work:*** Profile topics that others have not
- ***Critical Issues:*** Short- to Mid-Term Focus (Present to 2020/2025)
- ***Knowledge Transfer:*** Stakeholder Outreach & Education

# Regional Natural Gas Spot Prices

**Figure: Select Daily Spot Prices Since January 2013 ($/MMBtu)**



# Natural Gas & Electric Interdependencies

*Evaluating Dual-Fuel Capabilities of the Fleet*

- Natural gas differs as a fuel from traditional baseload power generation sources (coal, nuclear, and hydro) since fuel is generally delivered “just in time” as opposed to either having large on-site fuel stockpiles, or long periods between refueling.
- A portion of the natural gas fleet is either equipped for dual-fuel operation on liquid fuels in addition to natural gas, enabling them to hedge against high natural gas prices, take advantage of low liquid fuel prices, or utilize other fuels, stored on site, or otherwise.
- This report evaluates the dual-fuel capabilities of the natural gas-fired power generation fleet, the details of dual-fuel operation, and other related issues.

*Report Pending*

# Natural Gas & Electric Interdependencies
*Evaluating Dual-Fuel Capabilities of the Fleet*

- Examines impact on simple cycle gas turbines, combined cycle gas turbine with steam generator, subcritical steam turbine generator, and supercritical steam boiler generator
- Secondary fuel assumed to be No. 2 fuel oil for fuel requirement calculations
- Range of system sizes and heat rates from published information for each system type
- Reflects the natural gas fired-dual fueled capacity that will be available at the 2015 summer peak and where it is located
- Time to switch between fuels
  - Average unit takes 4 to 8 hours to switch
  - Switching time ranges from instantaneous to 72 hours depending on technology employed

*Report Pending*

# Natural Gas & Electric Interdependencies

*Evaluating Dual-Fuel Capabilities of the Fleet*

- **Dual fuel unit profile**
  - Most units are located in PJM, MISO, and SERC
    - Most units in PJM and MISO were built prior to deregulation
    - Newer dual fuel units have been built in SERC where cost recovery mechanisms are available
  - Average dual fuel unit in service today is 66 MW
  - If not co-firing with coal, dual fuel units spent less than 5% of the their operating time on their secondary fuel in 2013
  - Utilization of dual fuel capabilities at natural gas-distillate fuel oil units has increased nearly 20% across the U.S. since 2013

*Report Pending*

# Natural Gas & Electric Interdependencies
*Evaluating Dual-Fuel Capabilities of the Fleet*

## *Phase 2: Preliminary Analysis*

- **How much inventory is available at each site (Case Study: ISO-NE)**
  - Information will be compiled for plants with capacities greater than 100 MWs in the selected region
  - Pipeline capacity
- **Electricity market impacts**
  - Selected market area evaluated on a case study basis to determine if sufficient dual fuel generation is available to decrease the marginal bid price of electricity on a peak fuel cost hour/day
- Overview of regulatory/permitting issues for ISO-NE
- Evaluation of which plants could be converted to dual fuel (ISO-NE)
- Specific Plant Case Study

*Report Pending*

# Natural Gas & Electric Interdependencies
*Evaluating Dual-Fuel Capabilities of the Fleet*

## ***Phase 2: Evaluating which Natural Gas Plants can be Converted***

- **Assumptions**
  - The ability of a natural gas plant to convert to dual fuel (oil) is limited by the on-site space available for storage tanks
  - Space outside the plant's fence line is considered as unavailable due to unknown acquisition limitations
- **Methodology**
  - ISO-NE natural gas-fired power plants >100 MW were identified using the Ventyx VelocitySuite database
  - Dual fuel plants were identified using available databases and overhead imagery to identify potential fuel storage tanks
  - Overhead imagery was then used to evaluate remaining plants to determine if on-site space was available for storage tanks

*Report Pending*

# Natural Gas & Electric Interdependencies

*Case Study: Near-Term Infrastructure Needs in PJM*

The next five to ten years will be a period of transition as coal-plants retire and additional natural gas-fired generating capacity is added to meet new demand.

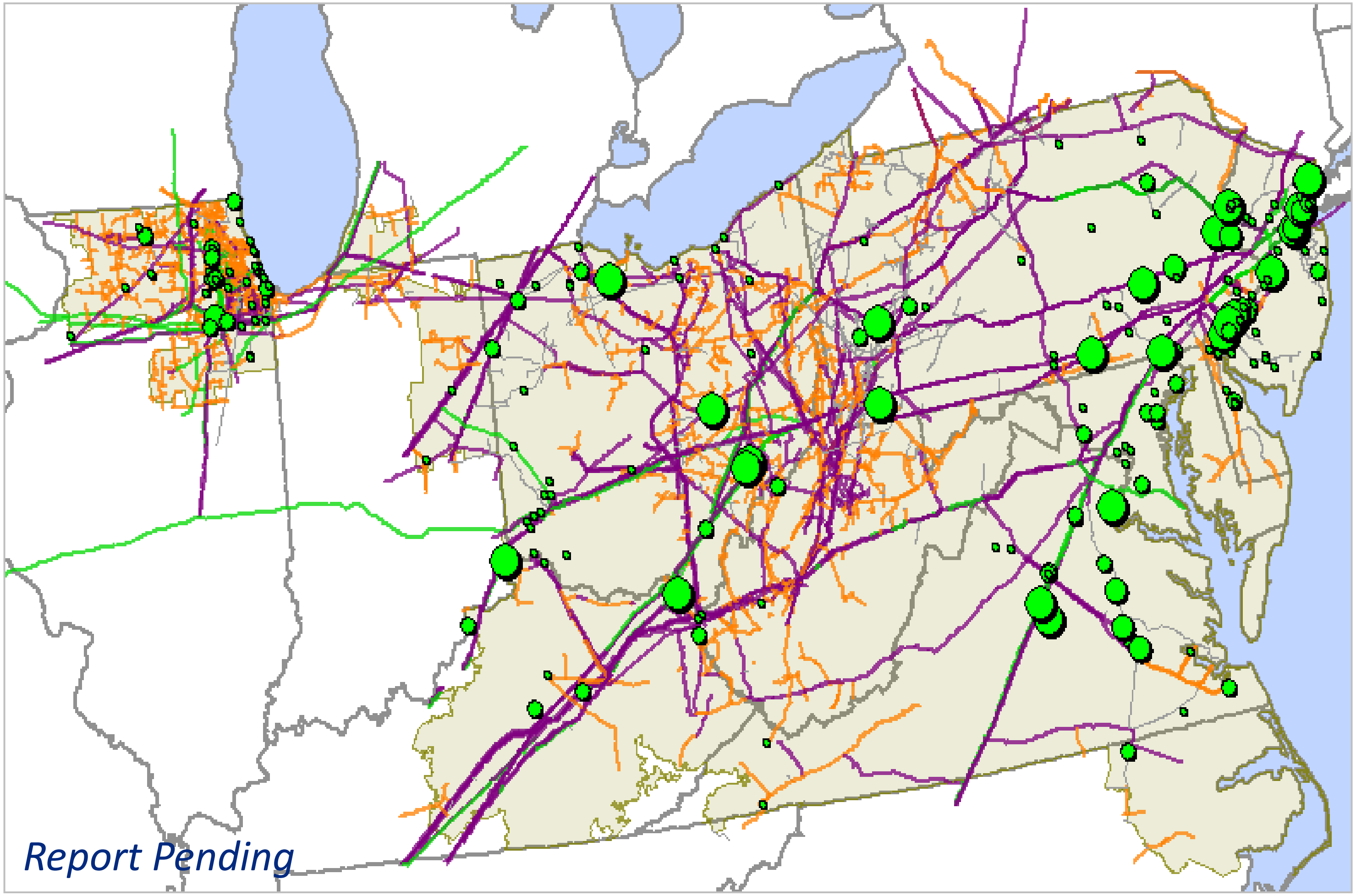
- Quantifies the scope and scale of that transition in terms of electrical generating capacity, increased demand for natural gas, and infrastructure needs.

- PJM was selected as a case study because of the relatively large number of coal plant retirements and increasing reliance on natural gas-fired power plants within PJM's footprint.

*Report Pending*

# Natural Gas & Electric Interdependencies
*Case Study: Near-Term Infrastructure Needs in PJM*

**Existing natural gas pipeline infrastructure feeds nearly 60 GW of natural gas-fired generating capacity throughout PJM as of May 2014**




**NG pipelines by diameter in inches**

- 32 to 44
- 16 to 32
- 0 to 16
- unknown

**NG generating units by size (MW)**

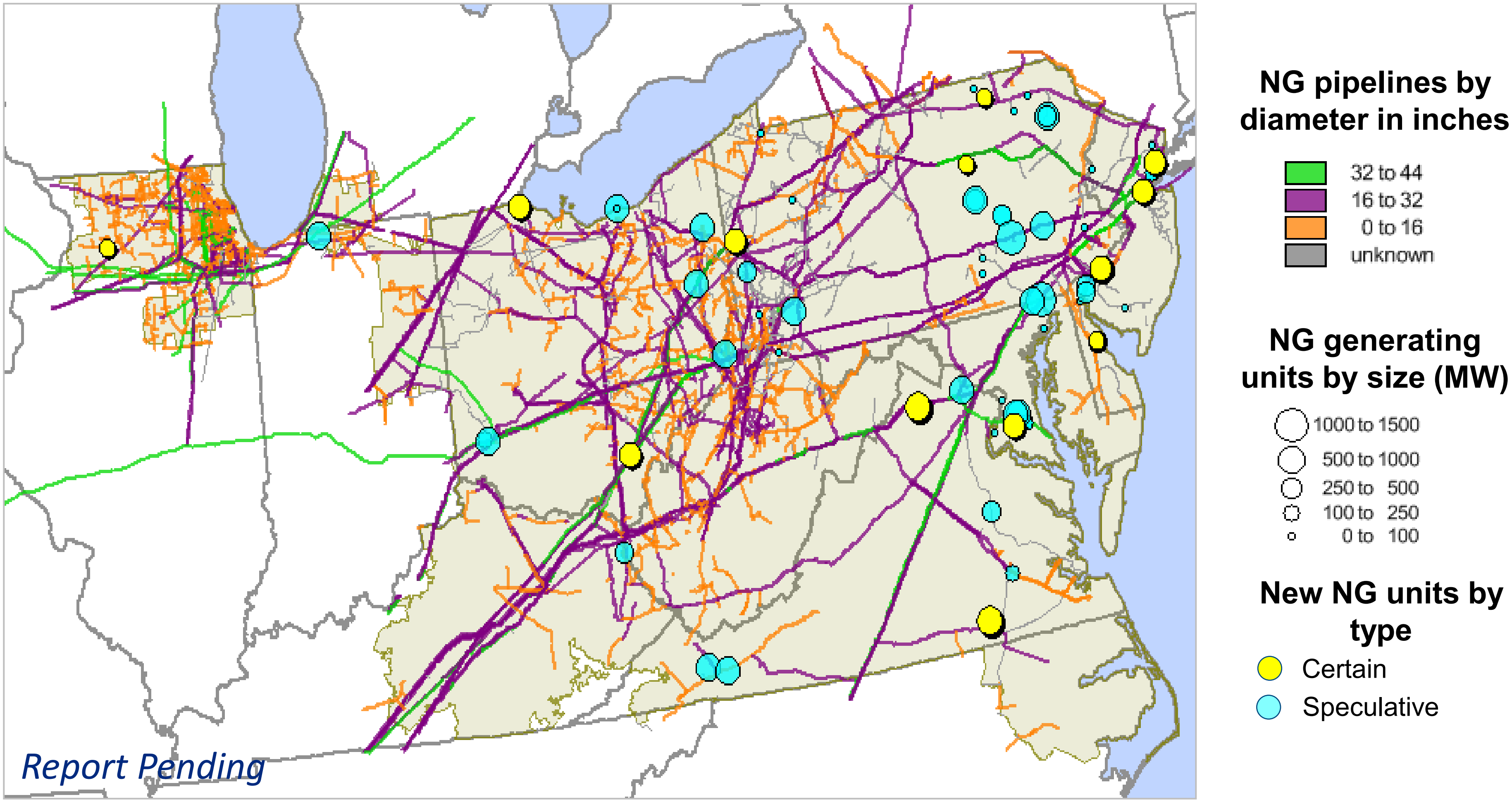
- 500 to 1000
- 250 to 500
- 100 to 250
- 0 to 100

- **The majority of the larger plants are aligned with large diameter pipelines**

# Natural Gas & Electric Interdependencies

*Case Study: Near-Term Infrastructure Needs in PJM*

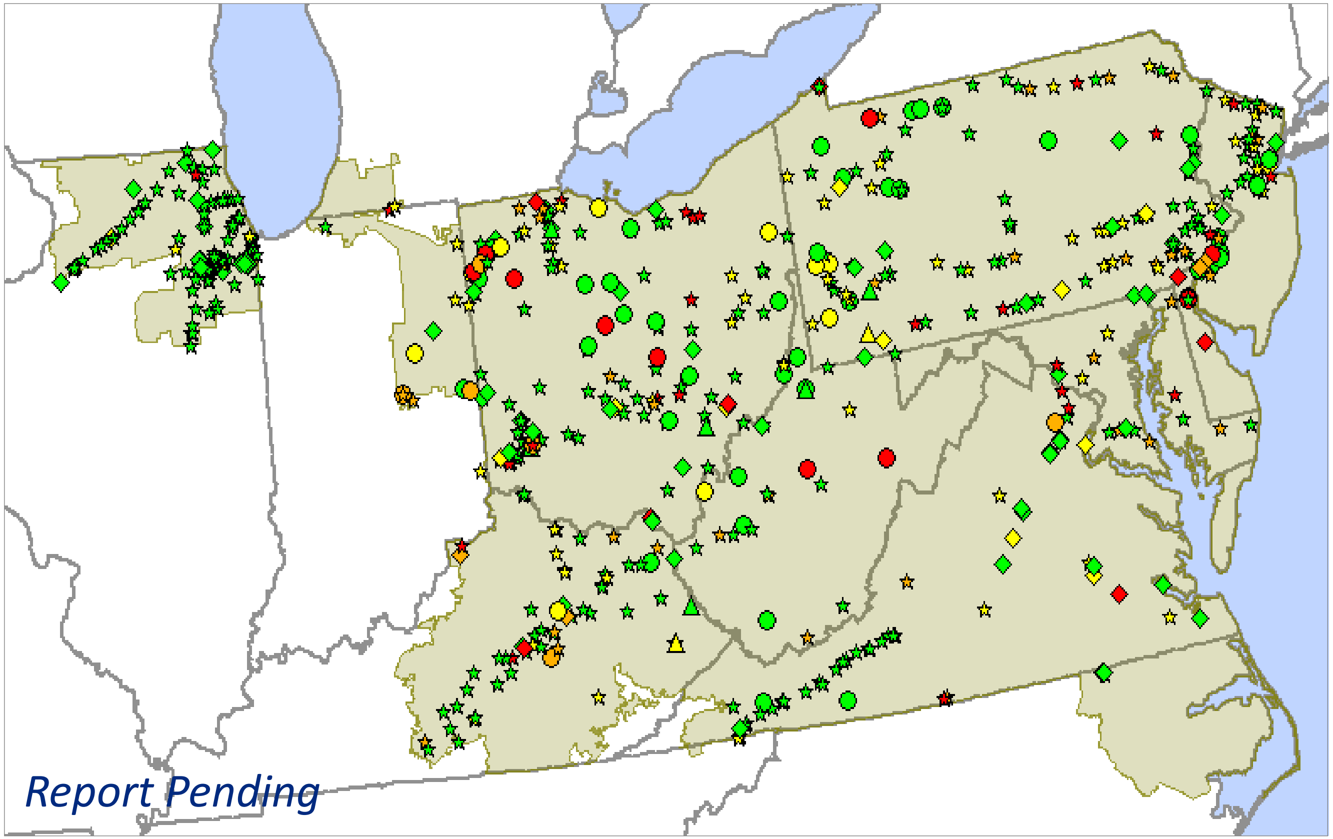
**About 30 GW of new natural gas-fired generating units are planned to be added in PJM area by 2020 near existing pipelines**



# Natural Gas & Electric Interdependencies

*Case Study: Near-Term Infrastructure Needs in PJM*

**Utilization of delivery points were between 0 percent and 100 percent on January 27, 2014 (max NG demand in 2014)**




**Style by point type**

- COMMERCIAL
- ELECTRIC PLANT
- INDUSTRIAL
- RESIDENTIAL

**Color by capacity utilization**

- 75 to 100
- 50 to 75
- 25 to 50
- 0 to 25

- **A few constrained industrial and electric plant points.**
- **Significant under-utilization throughout the region.**

- Residential – gas is delivered to a LDC or gas utility from a transmission pipeline for the main purpose of residential use
- Industrial – gas is delivered to a large industrial user, such as Cement Plants, Manufacturing, or Paper Mills
- Commercial – gas is delivered to a large commercial user such as Hospitals, Schools, Casinos, or Agriculture consumers
- Electric Plant – gas is delivered directly to an Electric Power plant

# Natural Gas & Electric Interdependencies

*Case Study: Near-Term Infrastructure Needs in PJM*

***Key Take-Aways***

- **Working natural gas storage is clustered in the central PJM & located near existing natural gas infrastructure**
  - Capacity has increased 4.2% since 2005, with daily capacity deliverable from storage increasing by 7.8%
  - Accomplished by upgrading existing storage sites and equipment
  - No new storage sites have been added or are planned
- **Only a few natural gas delivery points were at 75-100% utilization during the peak natural gas demand of 2014 but timing issues may cause congestion due to pipeline projects lagging power plant builds.**
  - Residential and electrical plant natural gas demand are 97 percent of the total natural gas demand in PJM region
  - Contracted natural gas for electric power generation is relatively consistent between 1 and 5 Bcf with peaks during summer high electrical demand periods

*Report Pending*

## *Additional Findings*

- **PJM can expect natural gas-fired capacity to increase from 60 GW to 90 GW between 2014 and 2025.**
  - Natural Gas delivery requirements will increase dramatically: 8 percent per year, declining to 5 percent after 2016.
- **After 2016, additional generating capacity is expected to be required to meet the NERC planning reserve requirements, and after 2020, additional capacity will be required to meet peak demand, potentially impacting reliability and cost.**
- **Significant (3,000 miles of new, mostly large) natural gas transmission pipelines planned for next 5 years.**

*Report Pending*

# Natural Gas & Electric Interdependencies
## *Issues in Focus* Series

***This series of papers profile different issues associated with natural gas/electricity interdependencies. Report summaries provided in Back up Slides***

- The Role of Natural Gas Storage in Maintaining Reliability on the Electric Power System
- Differences in Building Interstate Natural Gas Pipelines and Electric Transmission Lines
- Building Interstate Transmission Natural Gas Pipelines
- Natural Gas Volatility – A Historical Perspective
- Outages of Natural Gas Infrastructure – Historical Perspective
- Evaluating the Limitations to the Expansion of Natural Gas Generation

*Reports Pending*

# OUTLINE

- Strategic Energy Analysis and Planning
- Natural Gas Supply and Demand
- Tribal areas and Natural Gas Reserves
- SEAP Analysis of Natural gas Issues
  - Dual Fuel
  - Electric interdependencies
- **SEAP Life Cycle Analysis**

# Life Cycle Analysis (LCA)

## Life Cycle Analysis (LCA) at NETL meets both internal and external objectives

- **Produce LCAs of energy systems**
  - Inform and defend technology programs, and identify opportunities for R&D
  - Baseline different energy technologies
  - Understand technology strengths and weaknesses from a life cycle perspective
- **Improve LCA methods**
  - Expand environmental inventory
  - Characterize both variability and multiple types of uncertainty
  - Build flexible models
  - Enhance interpretation and comparability of inventory results without losing depth and transparency
- **Inform energy policy decision-makers**

# Life Cycle Analysis (LCA)

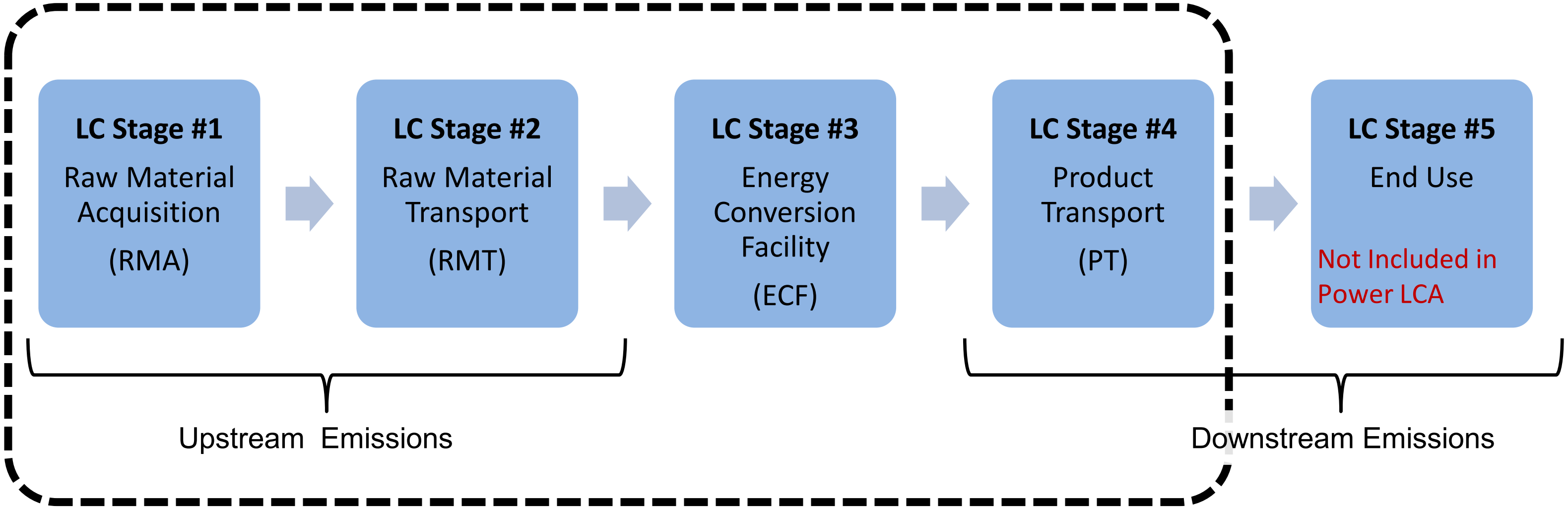
**NETL's Life Cycle Analysis (LCA) program has generated both high-profile results and productive collaborations**

- **Analysis**
  - Petroleum Baseline (2009)
  - Technology Assessment Reports (2012)
  - Enhanced Oil Recovery LCA (2013)
  - Coal and Biomass to Liquids LCA (2011-2015)
  - Natural Gas LCA (2011-2015)
  - Inventory Expansion (2013-2015)

- **Collaboration**
  - LCA of Alternative Jet Fuel
    *with DOD, FAA, EPA, academia*
  - DOE LCA Workgroup
    *with NREL, Argonne, LBNL, PNNL, BNL*
  - LCA Digital Commons, OpenLCA software
    *with EPA, USDA, USACE, academia*

# NETL Life Cycle Analysis Approach

**Compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product or service throughout its life cycle, from raw material acquisition to the final disposal**




**The ability to compare different technologies depends on the functional unit (denominator)**

- 1 MWh of electricity delivered to the end user
- 1 MJ of fuel combusted

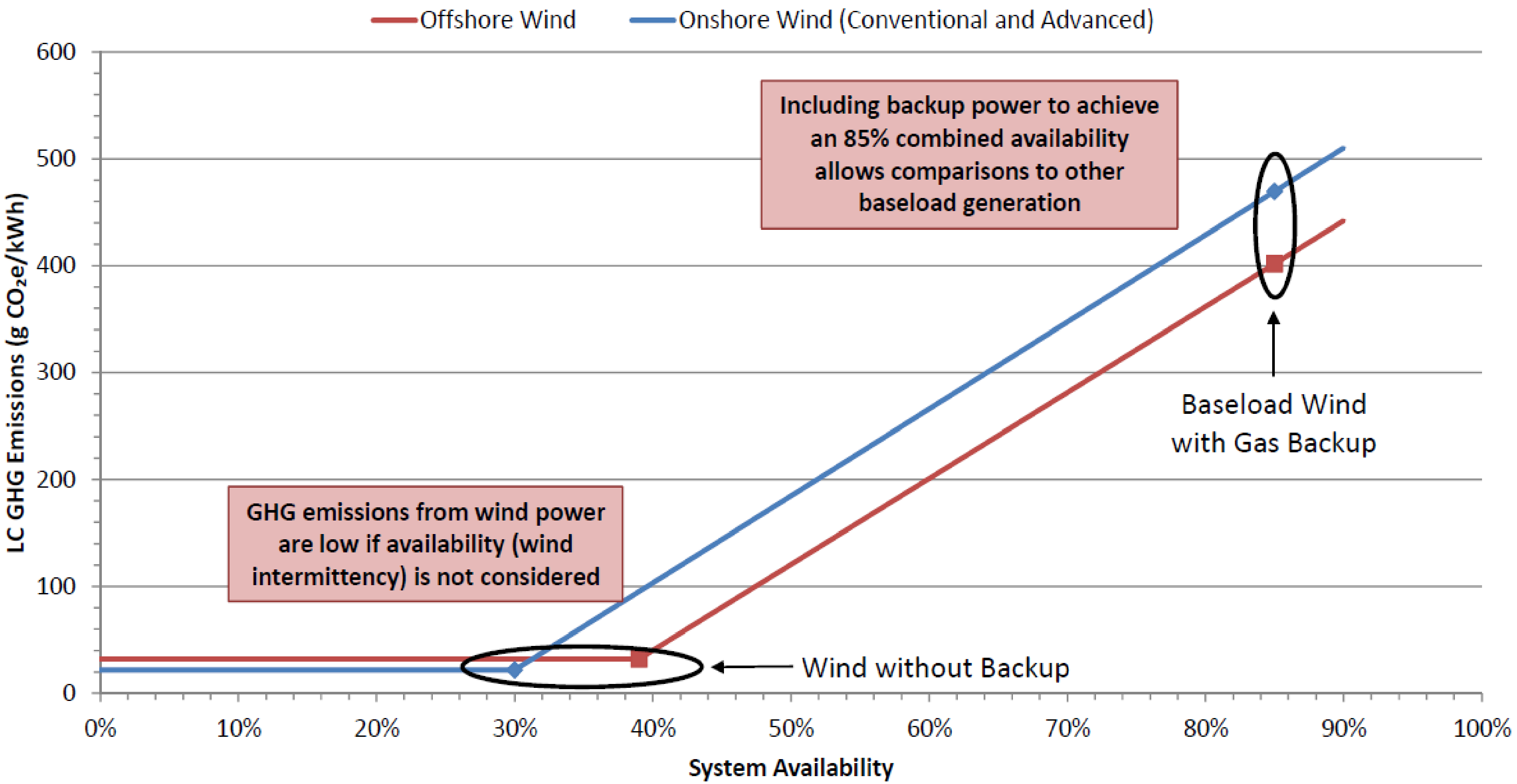
# NETL Life Cycle Study Metrics

- **Greenhouse Gases**
  - $CO_2$, $CH_4$, $N_2O$, $SF_6$
- **Criteria Air Pollutants**
  - $NO_X$, $SO_X$, CO, PM10, Pb
- **Air Emissions Species of Interest**
  - Hg, $NH_3$, radionuclides
- **Solid Waste**
- **Raw Materials**
  - Energy Return on Investment
- **Water Use**
  - Withdrawn water, consumption, water returned to source
  - Water Quality
- **Land Use**
  - Acres transformed, greenhouse gases
- **Life Cycle Cost**
  - Cost of Electricity (COE), Total Overnight Cost (TOC)

Converted to Global Warming Potential using IPCC 2013 (AR5) 100-year $CO_2$ equivalents

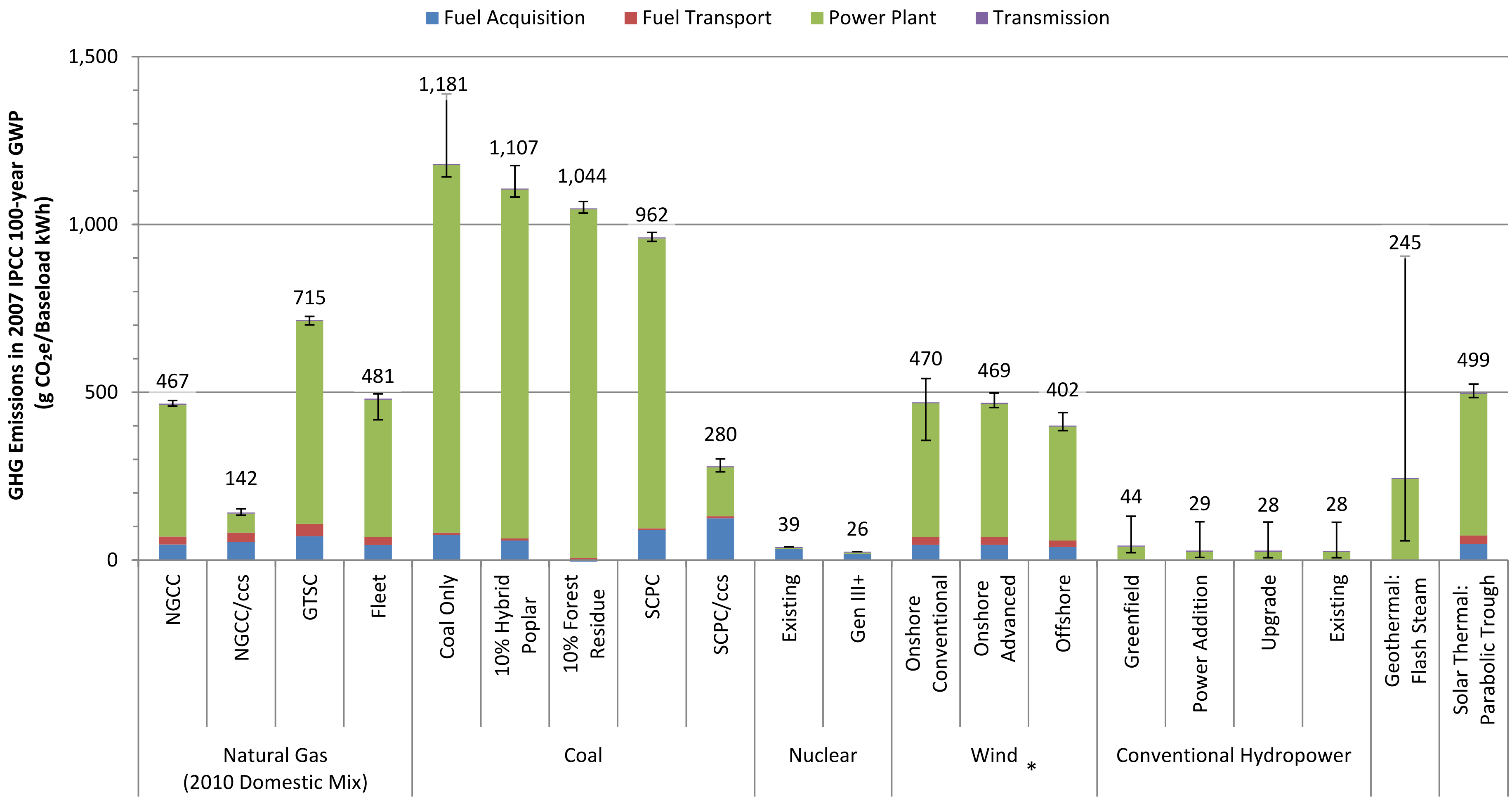
$CO_2$ = 1
$CH_4$ = 30
$N_2O$ = 265
$SF_6$ = 22,800

## Clear definition of function leads to appropriate boundary choices




**A "kWh-when-available" provides a different service than a baseload kWh**

# Comparisons among Disparate Technologies



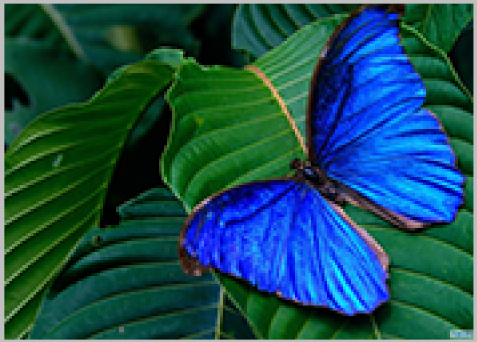
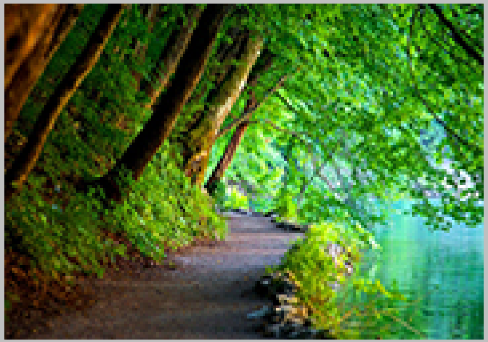

**A consistent LCA approach allows comparisons among disparate technologies**



* *Includes natural gas turbine simple cycle (GTSC) back-up*

# Back-up Slides
# Issues in Focus Summary

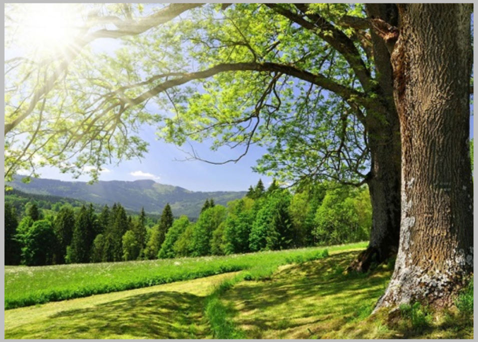


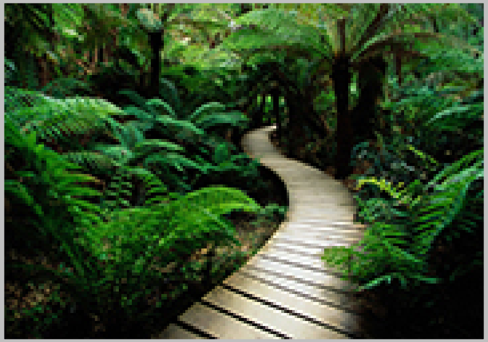



*For More Information, Contact NETL*

**the ENERGY lab**

*Delivering Yesterday and Preparing for Tomorrow*



## *The Role of Natural Gas Storage in Maintaining Reliability on the Electric Power System*

As natural gas provides an increasing percentage of the nation's electric power, the electric power system may become more vulnerable to certain types of reliability risks. Unlike other power generation sources – such as coal or nuclear – gas-fired power plants rely on just-in-time delivery of natural gas. Congestion and outages along the pipelines and/or compressor stations that supply gas-fired electric generating units can cause service interruptions. This Issue in Focus details the role of natural gas storage in maintaining reliability of the electric power system. This analysis is one of a series of *Issues in Focus* for natural gas/electricity interdependencies.

*Report Pending*

## *Differences in Building Interstate Natural Gas Pipelines and Electric Transmission Lines*

Changes in electricity generation asset types and locations, generator retirements, increased deployment of renewable energy, and geographic shifts in load centers have all contributed to a need for more interstate transmission lines in the U.S. Similarly, the development of new natural gas plays combined with a shift in demand centers has created a need for new natural gas pipelines. Differences in the process to site and permit each type of line – rather than a lack of demand for transmission - is widely considered to account for the disparity in transmission builds and are explored in this *Issue in Focus*.

*Report Pending*

## *Building Interstate Transmission Natural Gas Pipelines*

As the power sector's demand for natural gas increases and vies for pipeline capacity with demand from other end users, the construction of new natural gas pipelines will be necessary. However, because the timeline to plan, apply for and receive permits, and construct new interstate transmission natural gas pipelines may take several years, pipelines could experience constraints before new transmission/distribution capacity can be built. Pipeline operators will need to build sufficient time into their future capacity planning to meet expected demand growth; otherwise end users could experience gas delivery delays or shortages. Congestion along natural gas pipelines that supply gas-fired power plants can cause service interruptions to those plants, causing the electric power system to be more vulnerable to reliability issues.

*Report Pending*

## *Natural Gas Volatility – A Historical Perspective*

As the U.S. electric generation becomes more reliant on natural gas as a fuel, concerns have been raised about the availability of sufficient gas supplies and the impact of potential gas price swings during periods of high demand. One concern is that, in the past, there have been relatively large swings in the price of natural gas not associated with short term weather events. This *Issue in Focus* evaluates the factors which led to these past price swings and compares those factors against the current natural gas market.

*Report Pending*

## *Outages of Natural Gas Infrastructure – Historical Perspective*

This *Issue in Focus* examines outages of the natural gas infrastructure (pipelines/ compressors/etc) from a national perspective.  This analysis provides a brief background on the number of pipeline miles, size, age, material; a perspective of reporting requirements for outages and failures; the frequency of those outages; the trigger for those outages; details the outages relationship to age, location, size, material to determine if there is a correlation; and the impact, if any, on natural gas-fired generators.

*Report Pending*

## *Evaluating the Limitations to the Expansion of Natural Gas Generation*

The U.S. electric power industry is in the midst of a transition from a coal dominant feedstock to one where the bulk of power and heat will be produced from natural gas. Shifting predominant resources from coal to natural gas—when natural gas is also being utilized as the primary fuel for heating, with additional pressures from exports and refining, while providing a reasonable cost to the consumer—will be dependent on many factors, present and future, such as natural gas producer’s estimates, production rates, and the ability to replace the retiring coal fleet. Making such drastic changes to the electric power landscape will require answering some important questions. In essence, is there enough natural gas-fired generating capacity coming online to meet electricity demand, both in the near-term (to 2020) and long-term (through 2040)?

*Report Pending*