

Natural Gas Markets: Leveraging the Production Revolution into an Industrial Renaissance

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Center for Energy Studies

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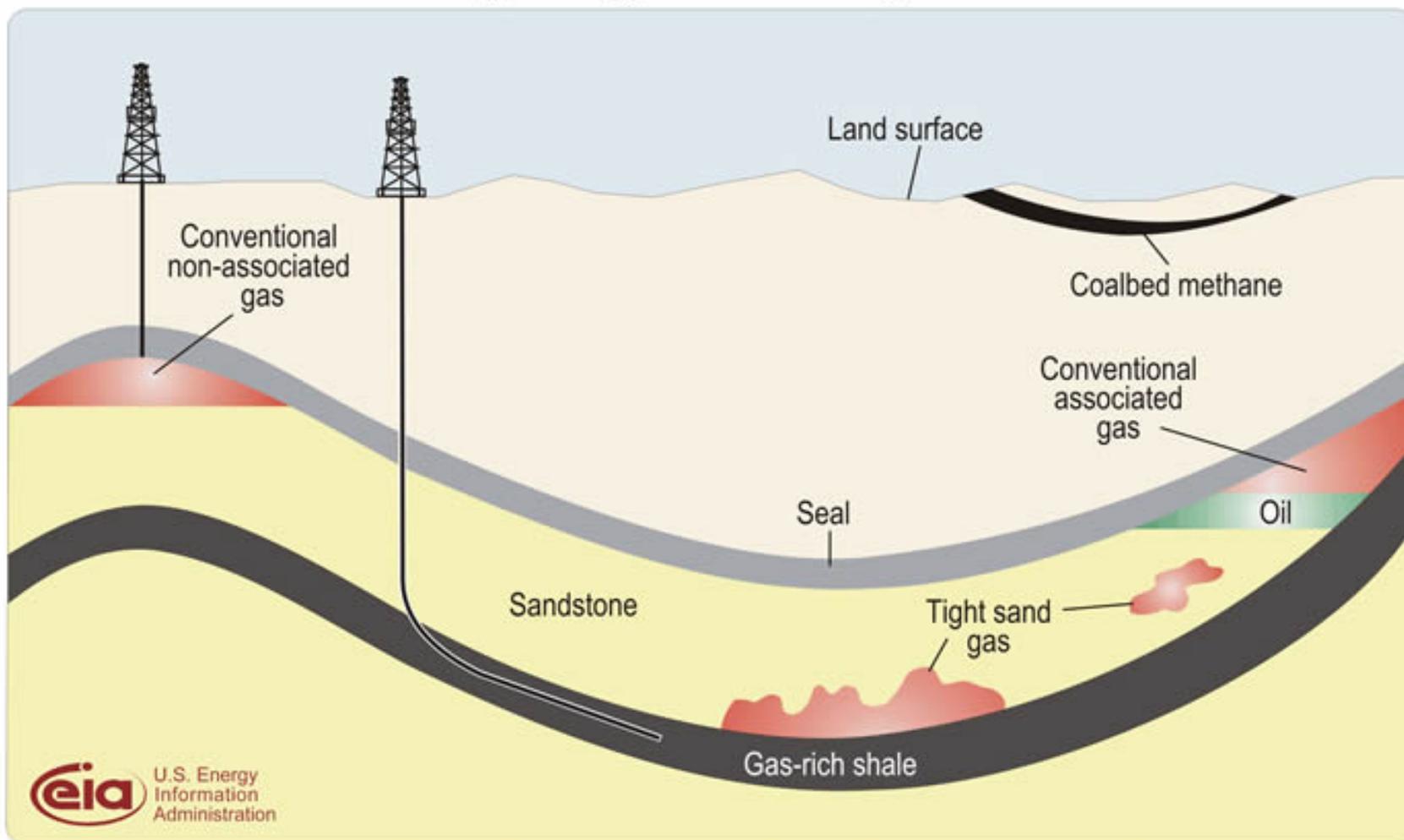
Summary and Take Away

- New **natural gas supply availability** is having considerable impacts on all energy markets today and on a longer term basis.
- Shale revolution is now **migrating into liquids and crude oil production**. Facilitating additional natural gas production despite low prices and some “dry” gas well shut-ins and decreased natural gas well drilling.
- **Considerable economic development opportunities** are starting to arise leading to a burst in considerable capital investment.
- All industry stakeholders (labor, management, regulators, customers, interest groups) need to be aware of **diversity sensitivities** and **continued natural gas resource development concerns and opposition**.

Recent Trends in Natural Gas Markets

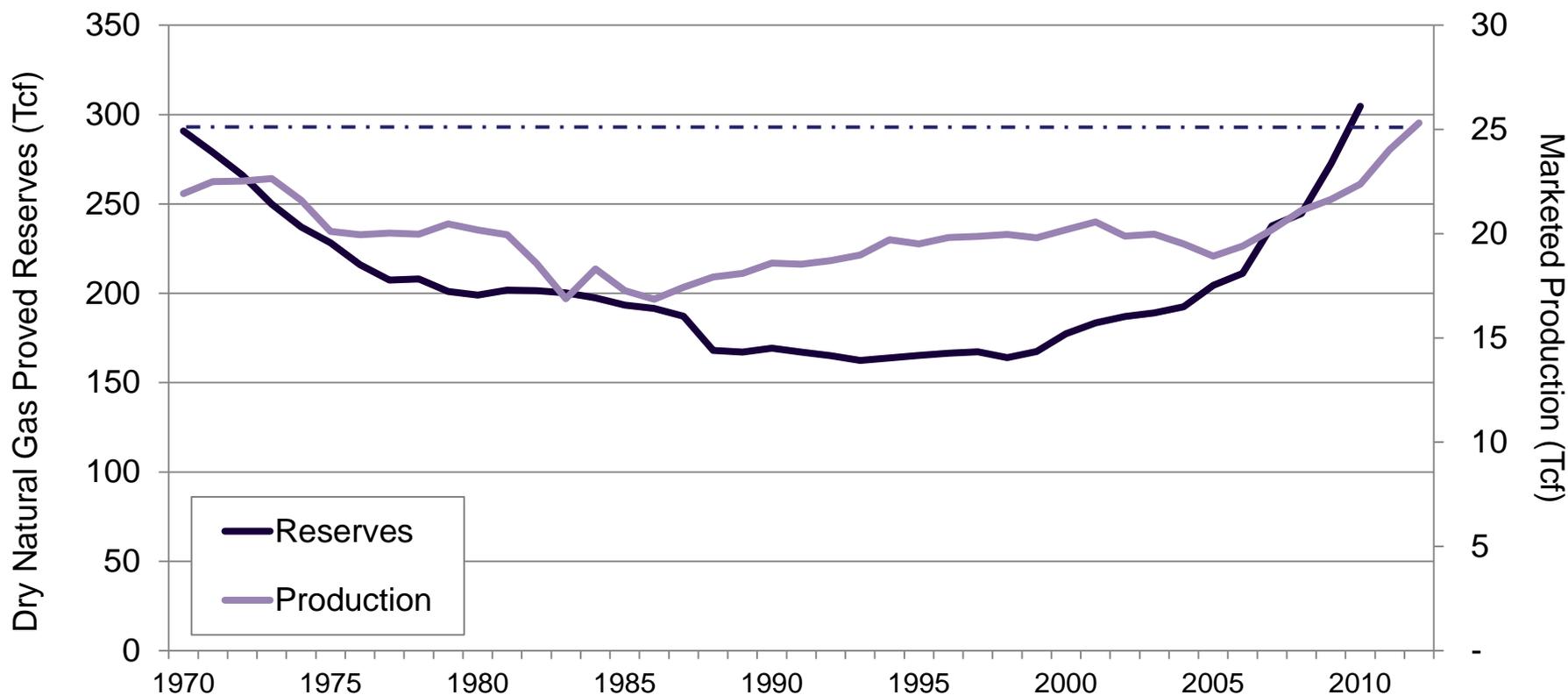
Unconventional vs. Conventional Geological Formations

Schematic geology of natural gas resources



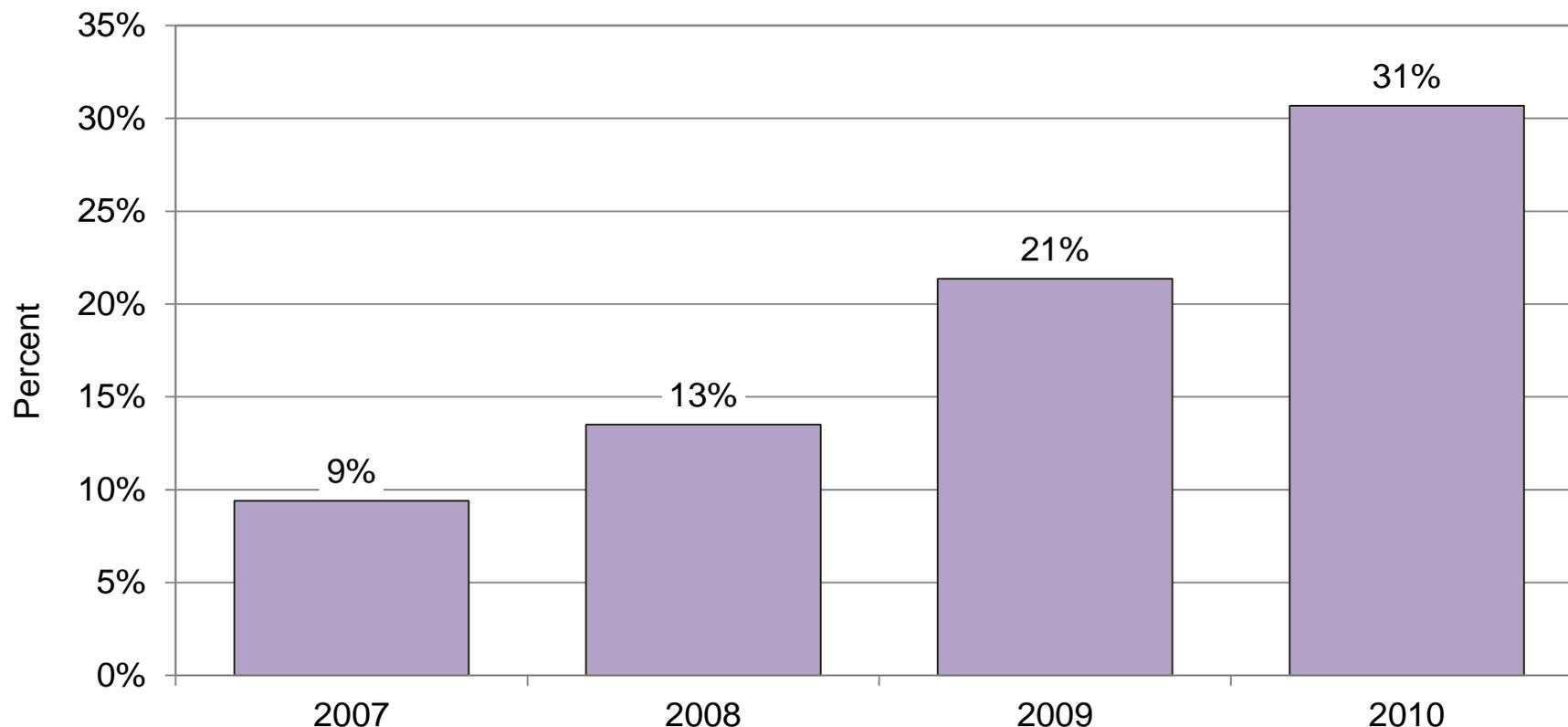
Natural Gas Proved Reserves and Production

Current U.S. natural gas reserves are approaching record levels not seen since 1970. Natural gas production is at levels that surpass historic peaks.



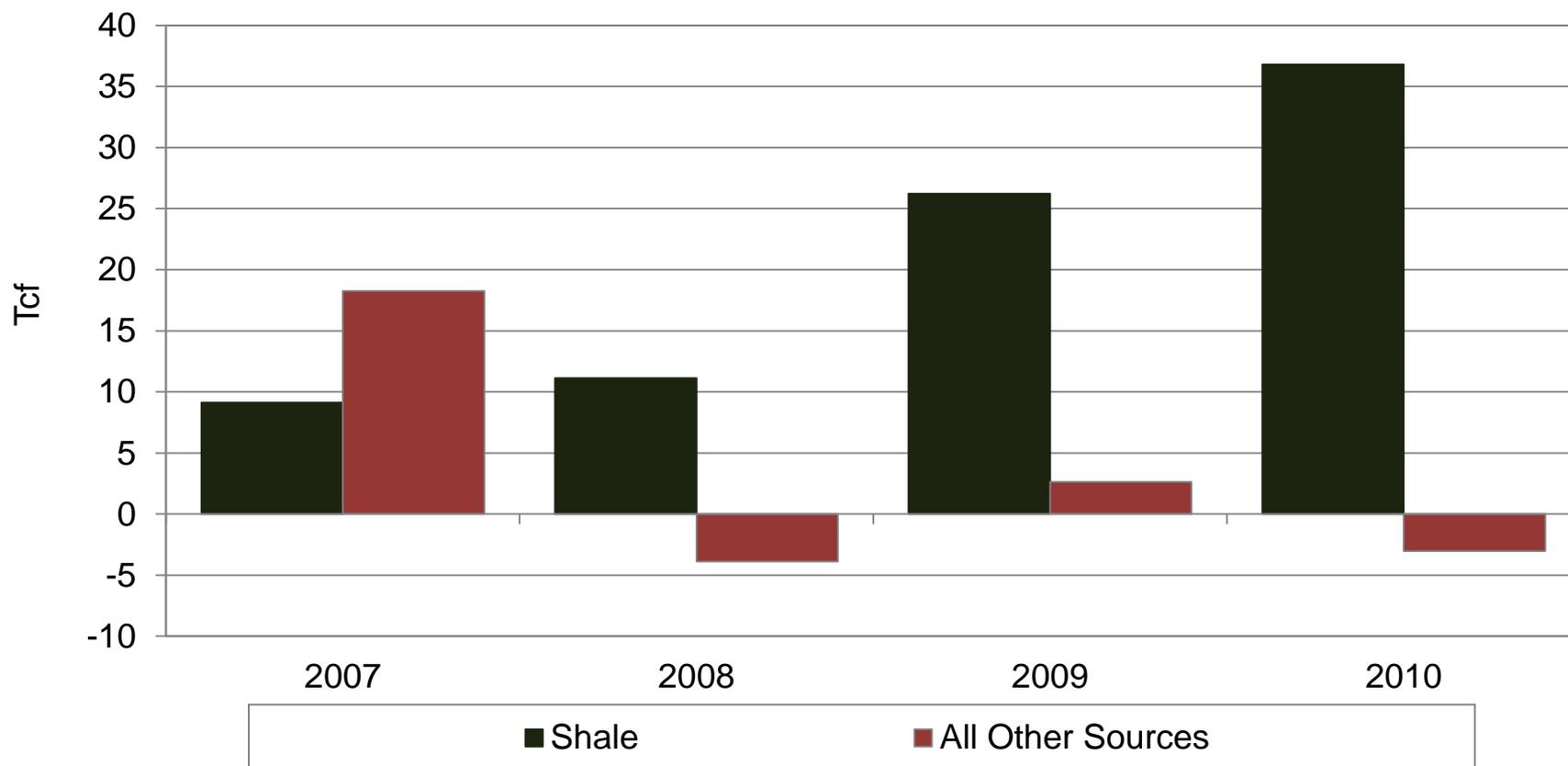
Shale's Share of Natural Gas Reserves

The share of shale gas relative to total U.S. natural gas proved reserves has been increasing significantly, from less than 10 percent in 2007 to over 30 percent in 2010.



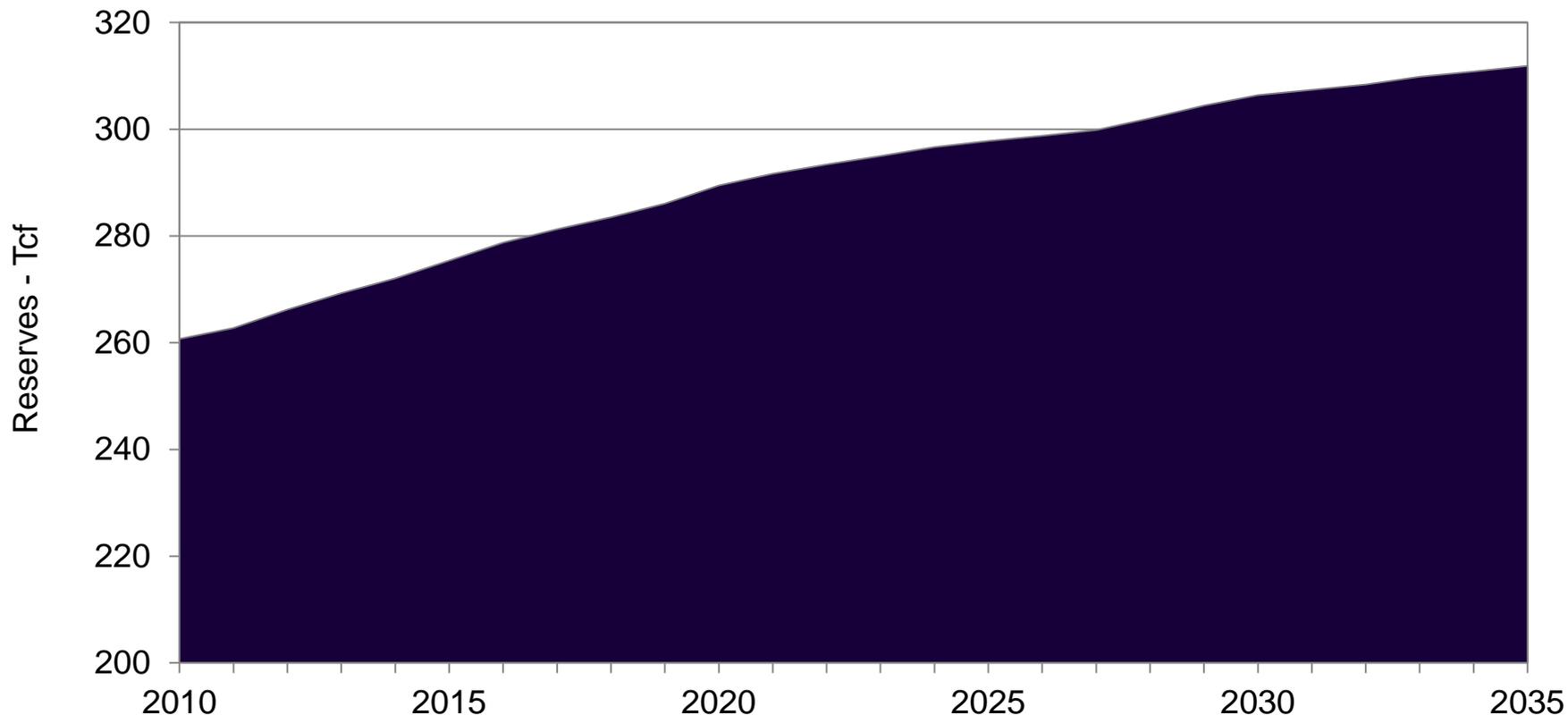
U.S. Dry Natural Gas Reserve Adjustments

U.S. shale gas reserves are increasing, enough to more than offset the decrease in net reserves from all other sources in both 2008 and 2010.



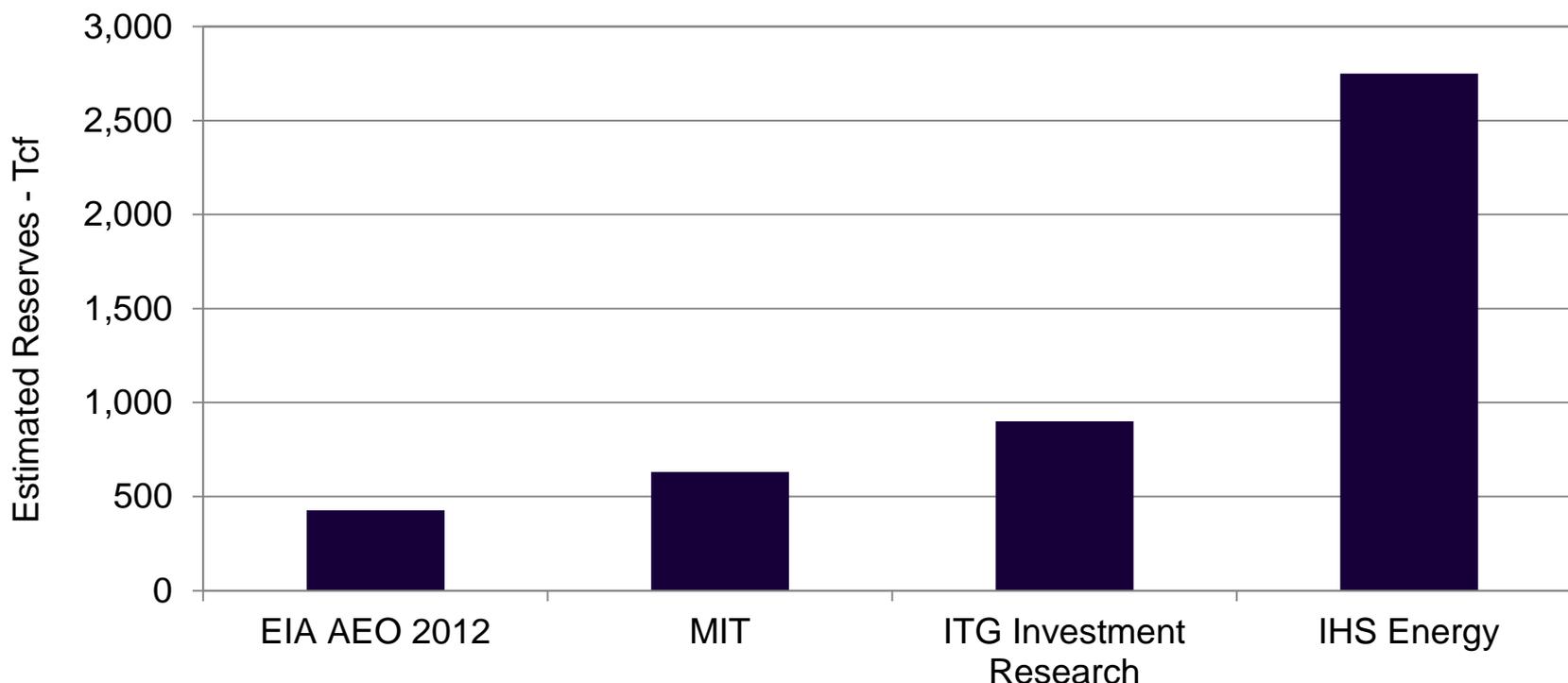
Annual Energy Outlook, Natural Gas Reserves

Unconventional resources are not a “flash in the pan” and are anticipated to continue to increase over the next two decades or more.



Alternative Natural Gas Reserve Forecasts

There are a wide range of unconventional shale gas reserve estimates that are as low as 436 Tcf to as high as 2,750 Tcf. This represents a range of between 18 years and over 100 years of available natural gas resources based upon current consumption levels.*

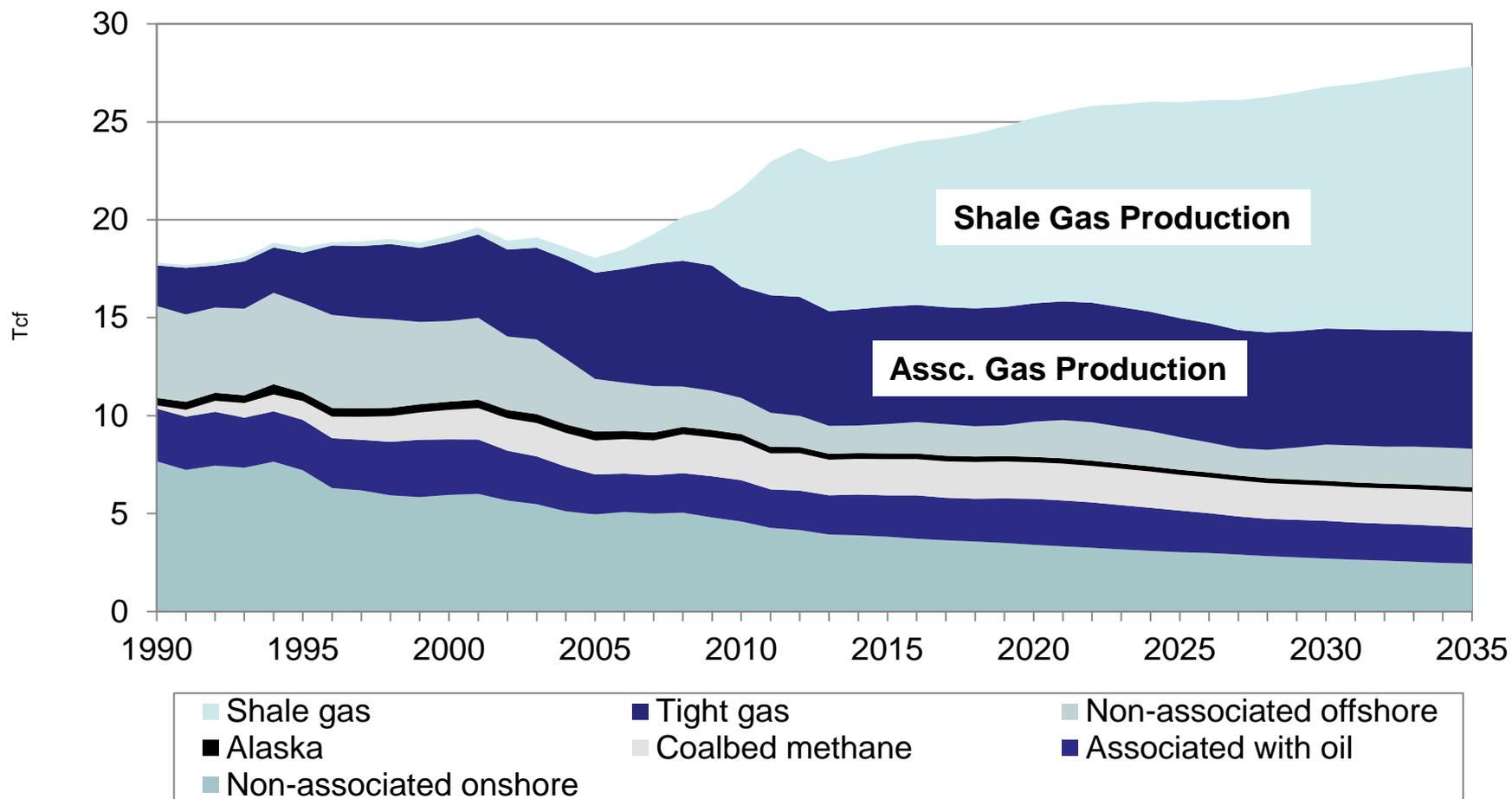


Note: *Assumes an annual consumption level of 24.3 Tcf.

The MIT study reached a mean estimate of technically recoverable resources of 631 Tcf with an 80 percent confidence interval of 418 to 871 Tcf. The ITG estimates of recoverable resources is for 10 overlapping plays, totaling 900 Tcf. These are the same 10 plays as estimated by the EIA's AEO (resulting in 426 Tcf). IHS Energy estimates show that total recoverable shale in the U.S. could be as high as 2,750 Tcf, significantly higher than their estimate of 1,268 in 2010.

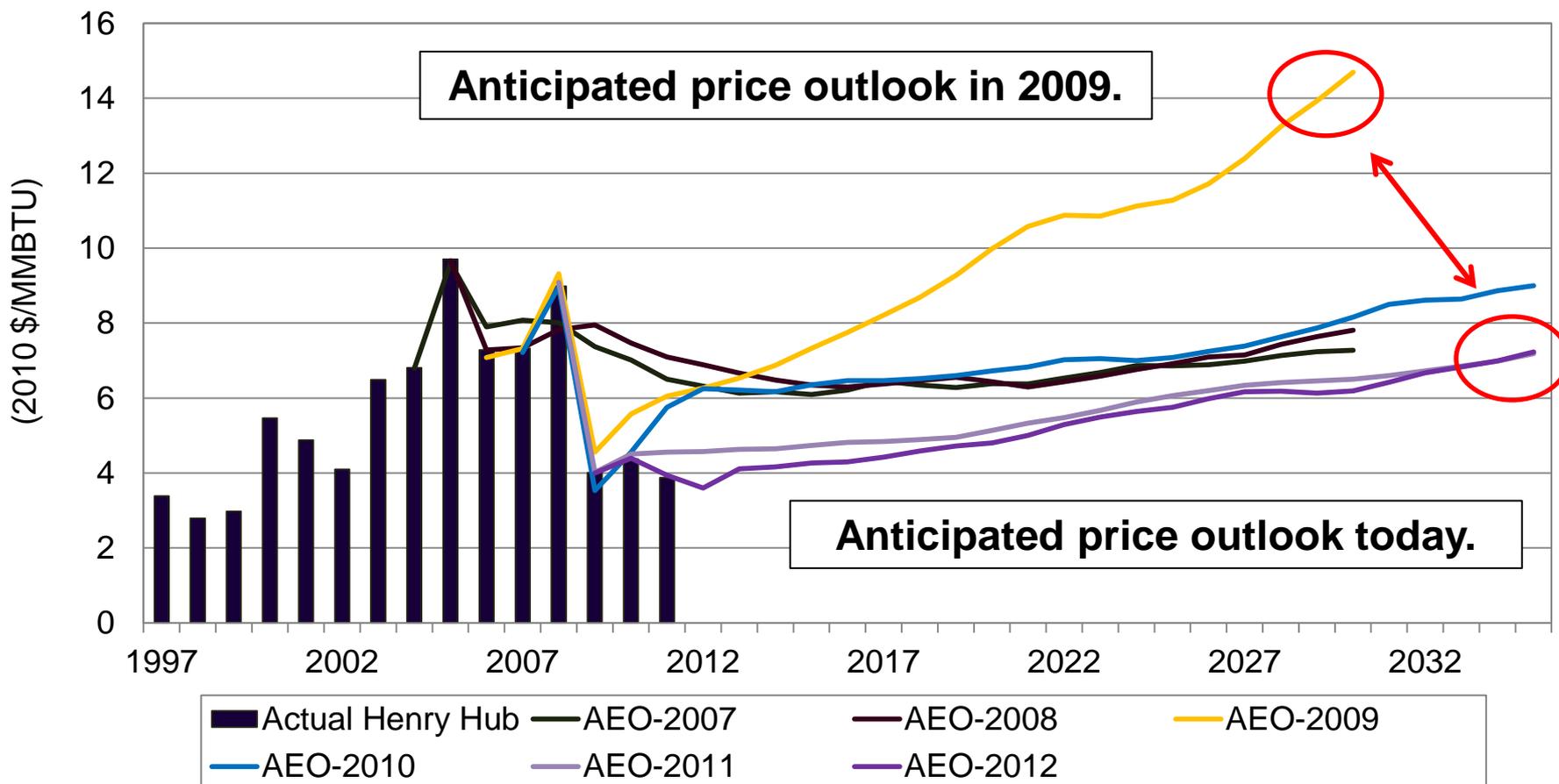
Forecast U.S. Natural Gas Production

Shale availability will drive U.S. natural gas supply.



Changes in AEO Natural Gas Price Forecasts

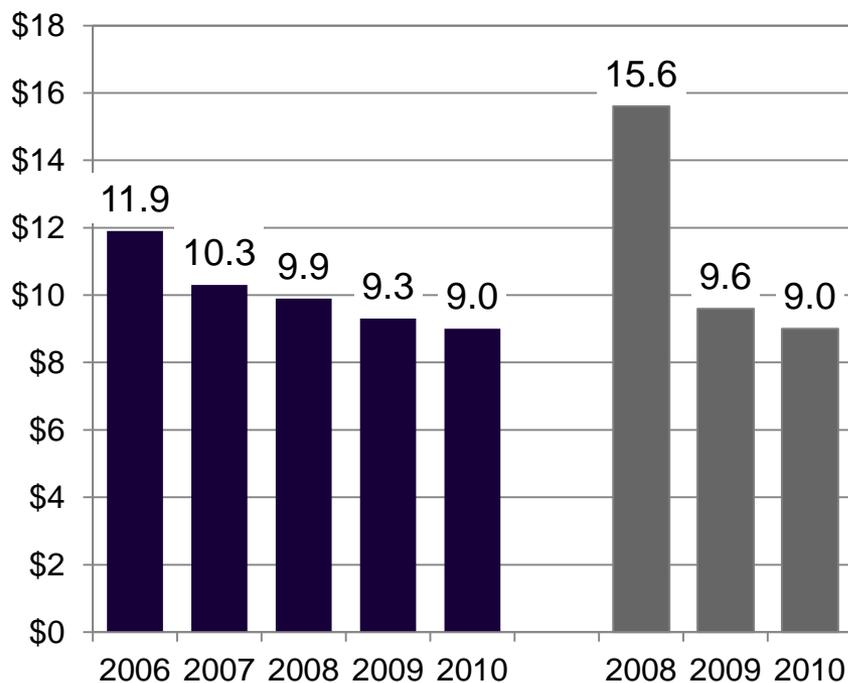
Shale availability has significant impact on future price outlook.



Changes in Well Costs and Productivity

Encana reports a reduction in well costs of 15-30% through use of multi-pad drilling, improved rig efficiencies, and lower hydraulic fracturing costs. The use of higher water volumes, increased frac stages, and enhanced pay selection have resulted in 100-150% increases IP rates.

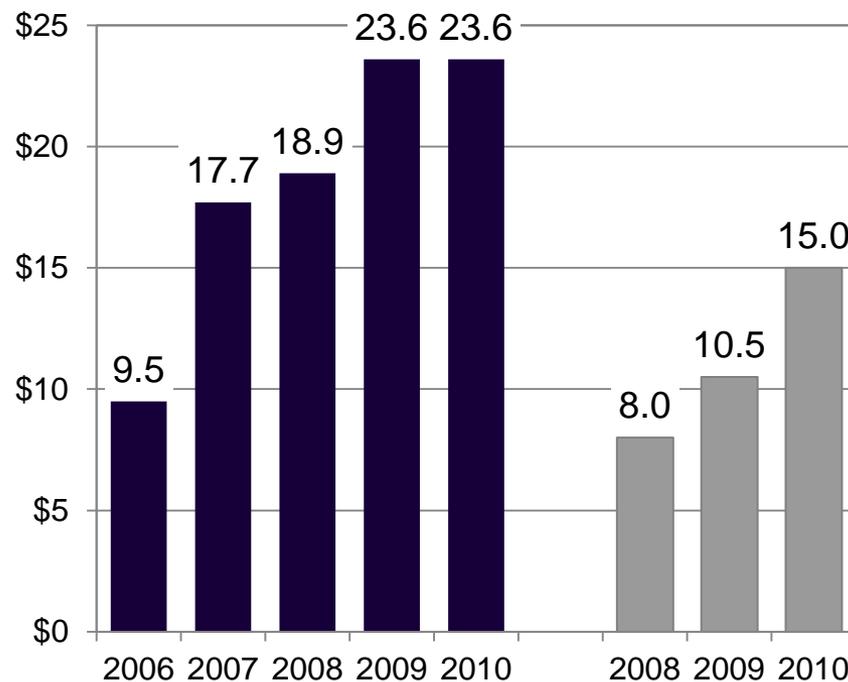
Well Cost (million \$)



East Texas Deep Bossier

Haynesville

Well Performance (MMcfe/d)



East Texas Deep Bossier

Haynesville

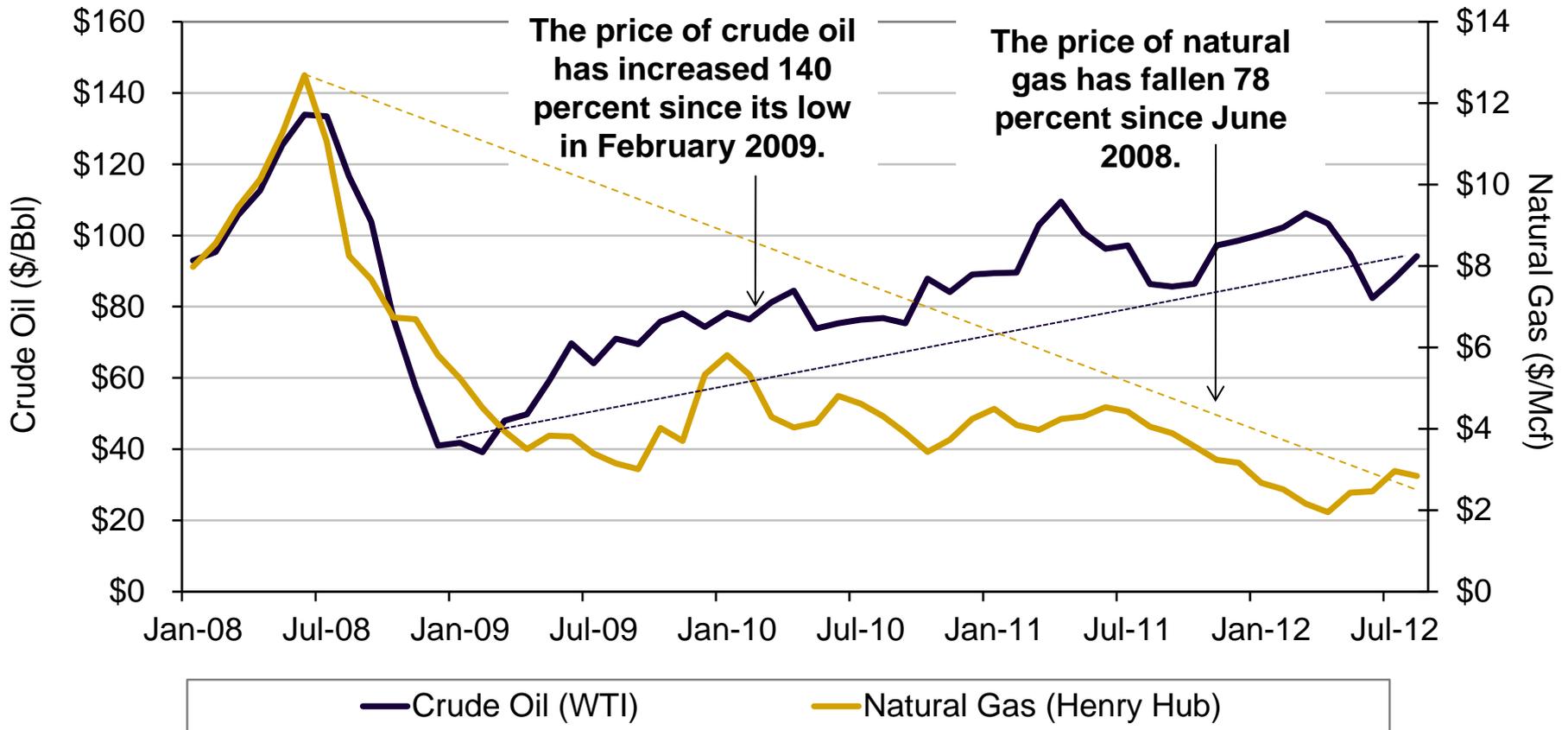


Liquids and Crude Oil Development



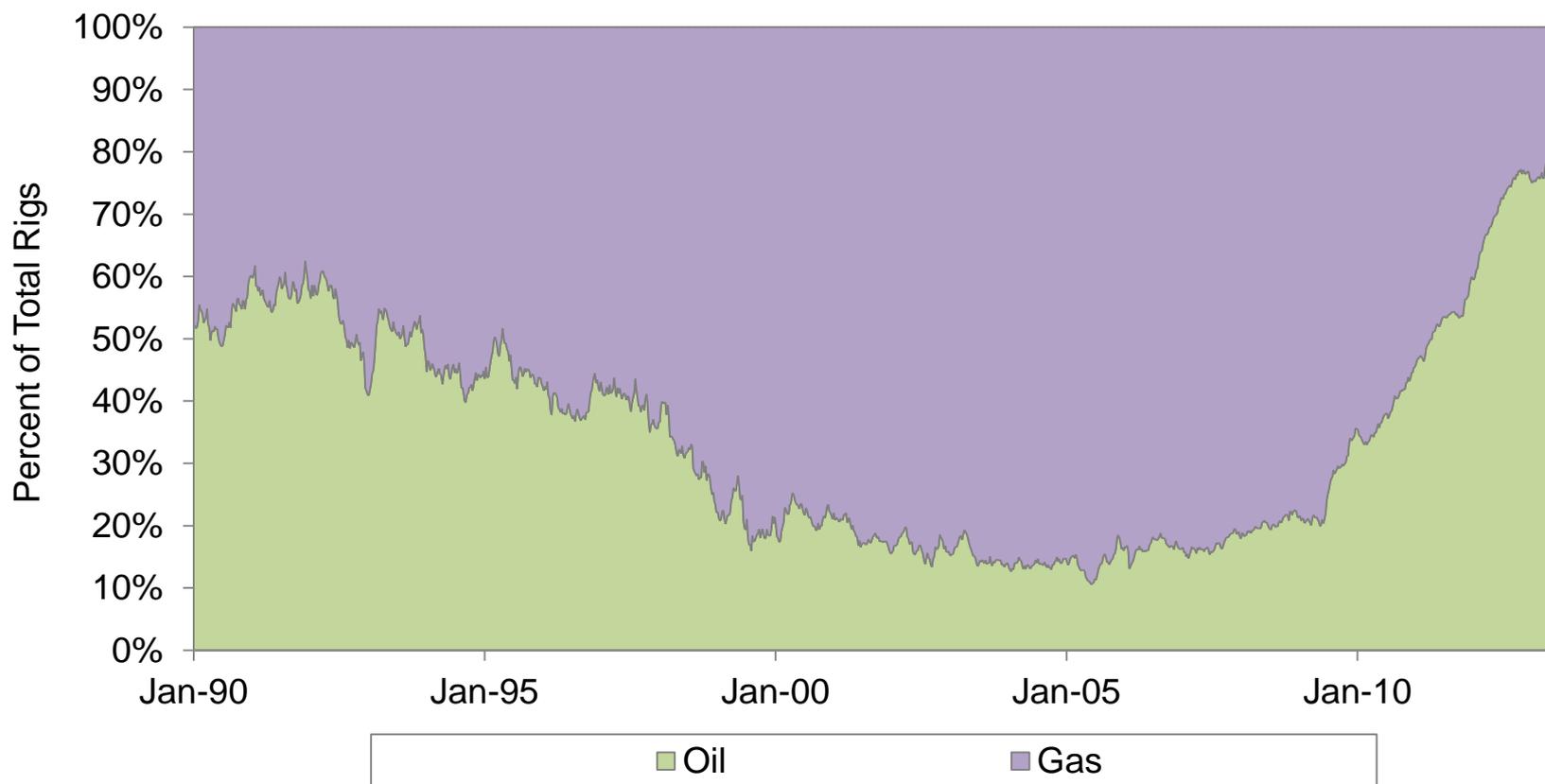
Crude Oil and Natural Gas Price Decoupling

Crude oil prices have doubled in the aftermath of the recession but natural gas prices have remained stable.



US Oil and Natural Gas Rig Count

The increase in crude oil prices has resulted in a revised emphasis in unconventional drilling. Developers are shifting rigs into basins that are expected to yield crude and liquids rather than those with dry gas .

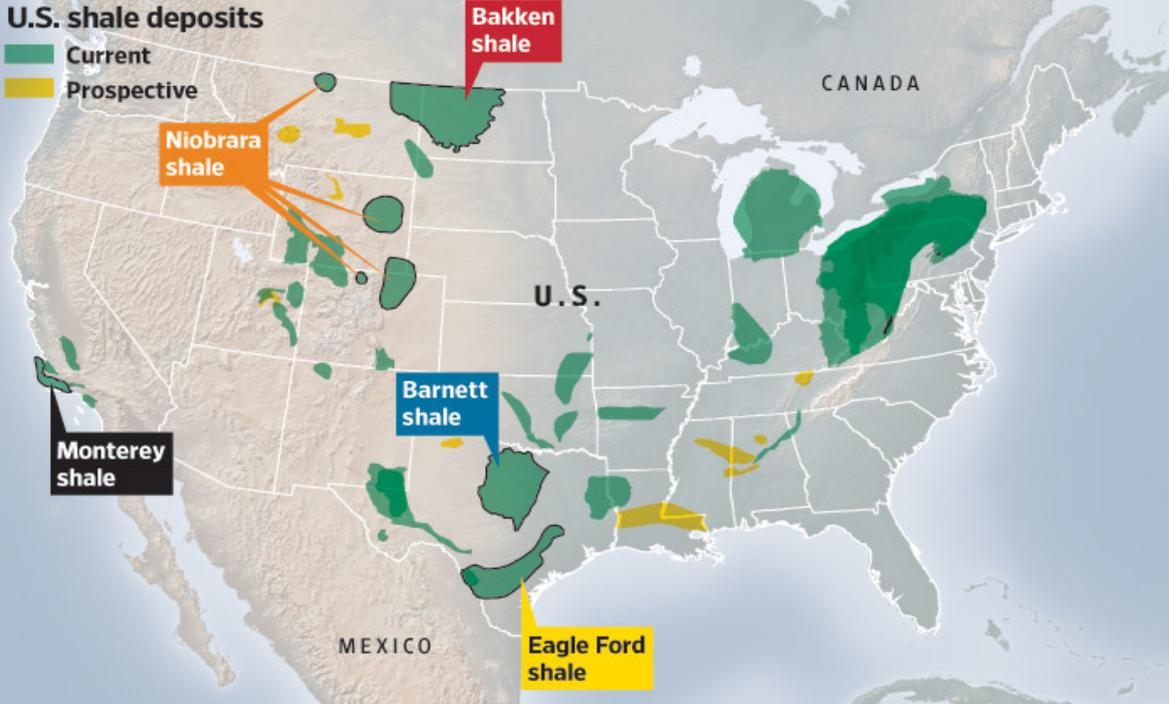




Crude Awakening | Fracking has helped ignite a rise in U.S. oil production

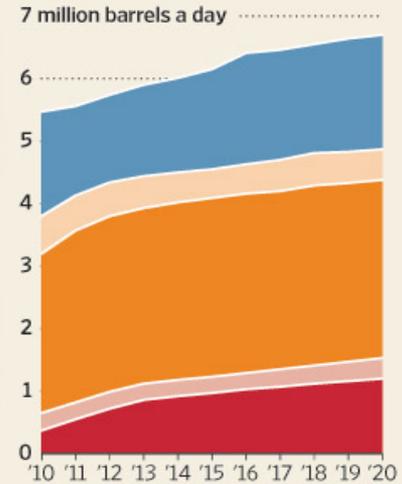
U.S. shale deposits

- Current
- Prospective

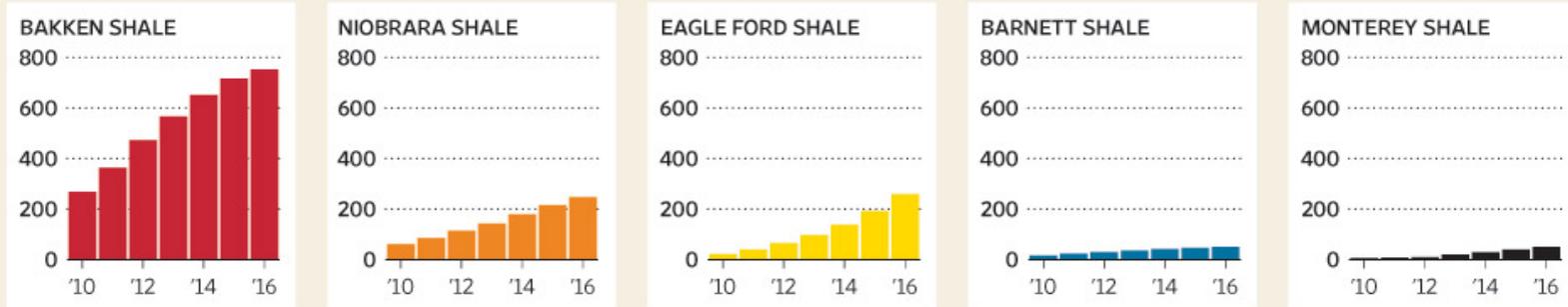


U.S. oil-production forecast

- Gulf of Mexico
- Alaska
- Other onshore oil
- CO2-enhanced oil recovery
- Oil from fracking**



Light crude oil supplies from U.S. shale fields, in thousands of barrels a day



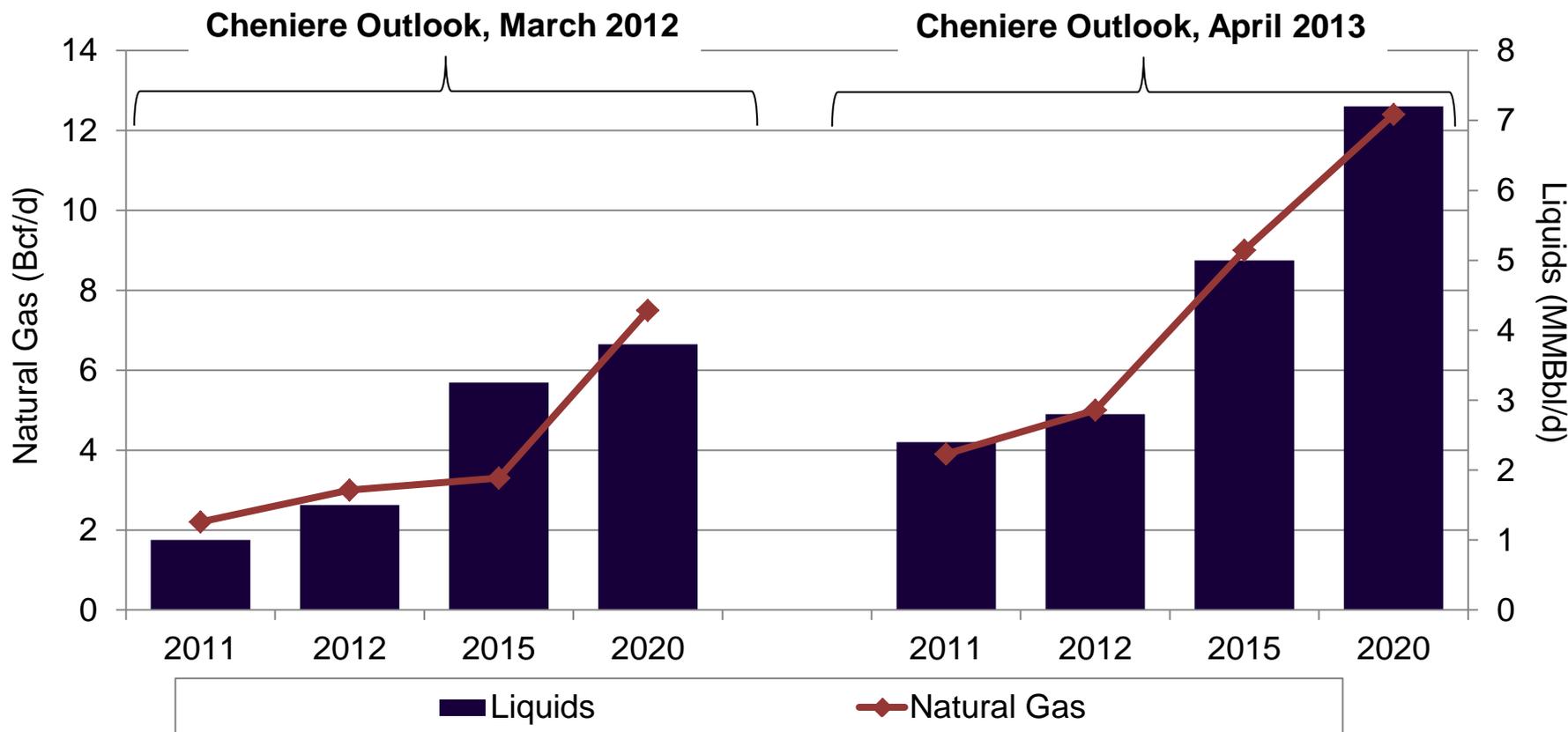
Note: Projections begin in 2011 for all data.

Sources: U.S. Energy Information Administration; International Energy Agency (individual shale production)

The Wall Street Journal

Annual Production from Unconventional Reservoirs

In just one year, Cheniere has revised its forecasted natural gas production in 2020 from slightly less than 8 Bcf per day to more than 12 Bcf per day; and liquids production from 6 MMBbls per day to 7 MMBbls per day.

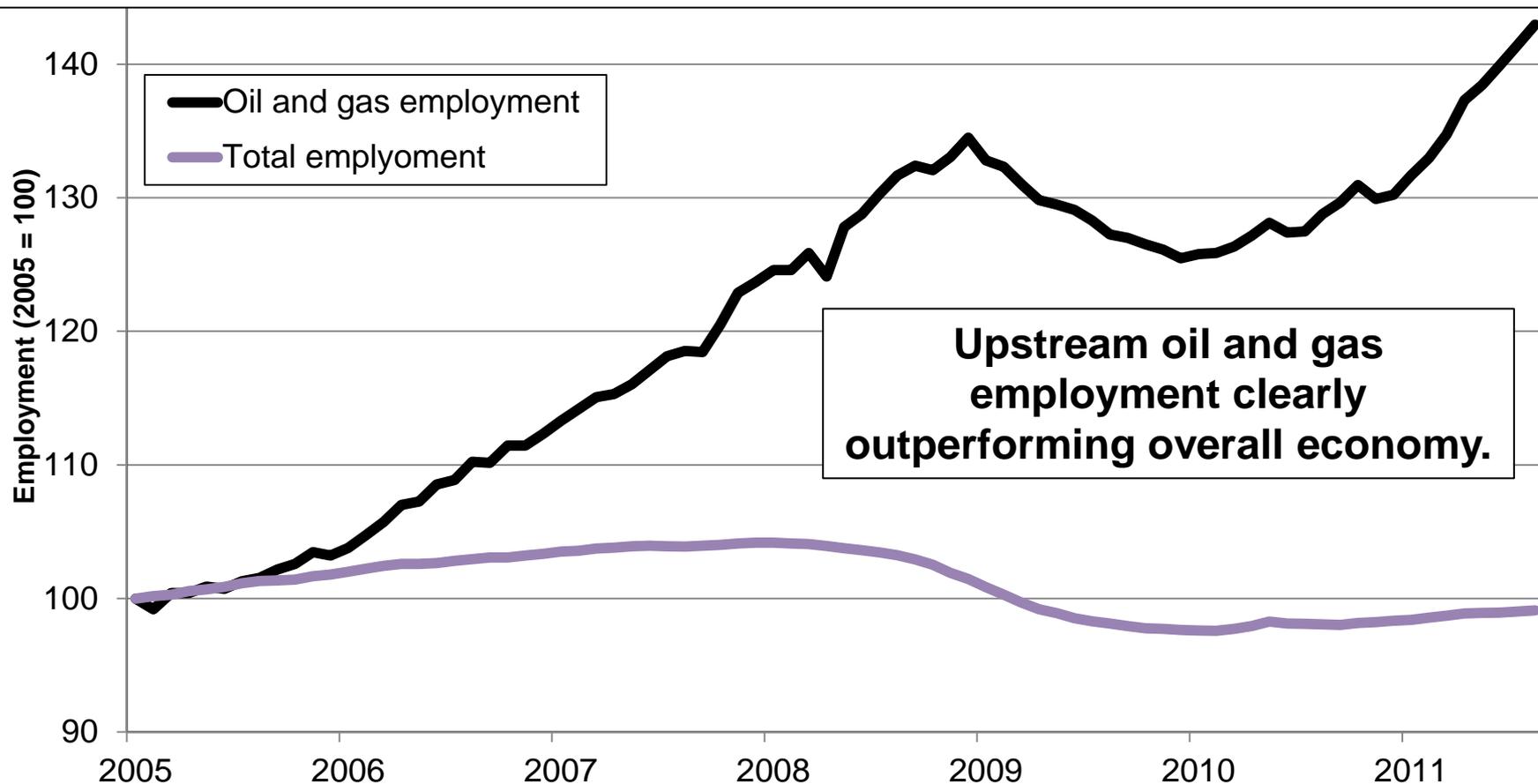


**Natural Gas and Economic
Development: Moving from
“Revolution” to “Renaissance”**



U.S. Oil and Gas Employment v. Economy-wide Trends (2005 = 100)

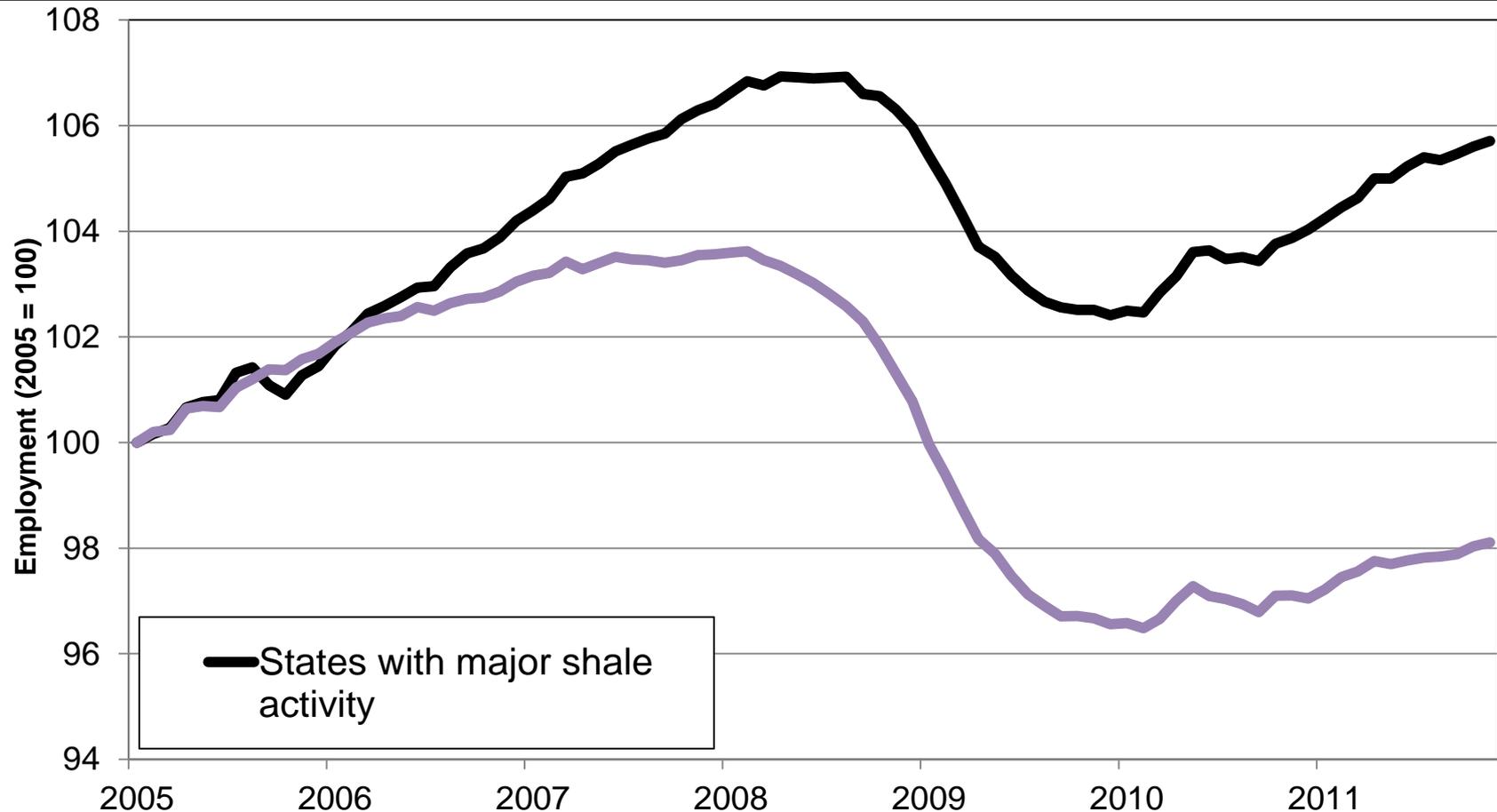
Oil and gas employment is almost 40 percent above its 2005 level while total U.S. employment struggles to regain four years of losses.





U.S. Employment Trends (2005=100): Total Employment, Select States

The “multiplier” effects of upstream development have likely had significant beneficial impacts on shale-producing states.

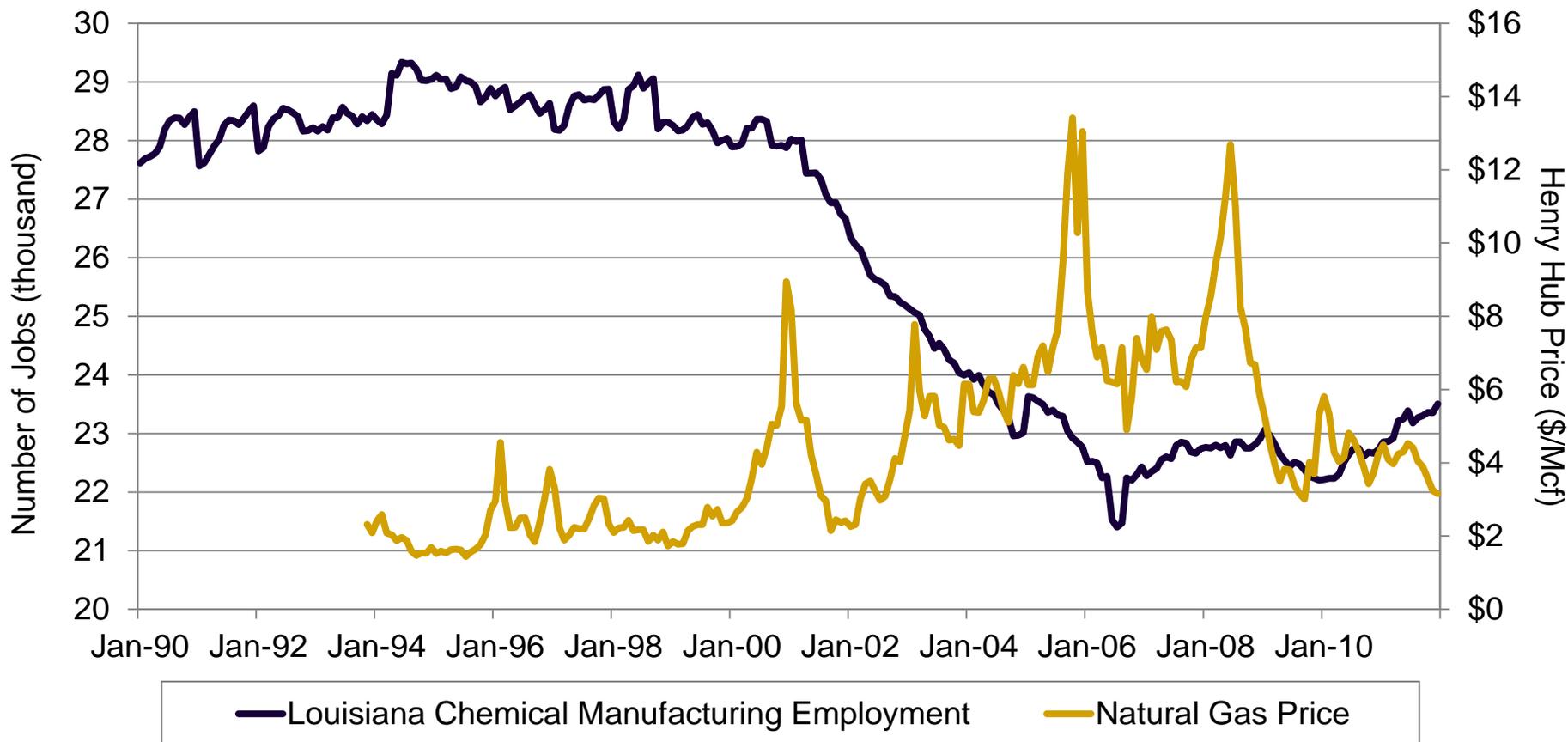


Shale states: LA, TX, AR, ND, UT, CO, & PA
Source: Bureau of Labor Statistics



Louisiana Chemical Industry Employment and Henry Hub Spot Price

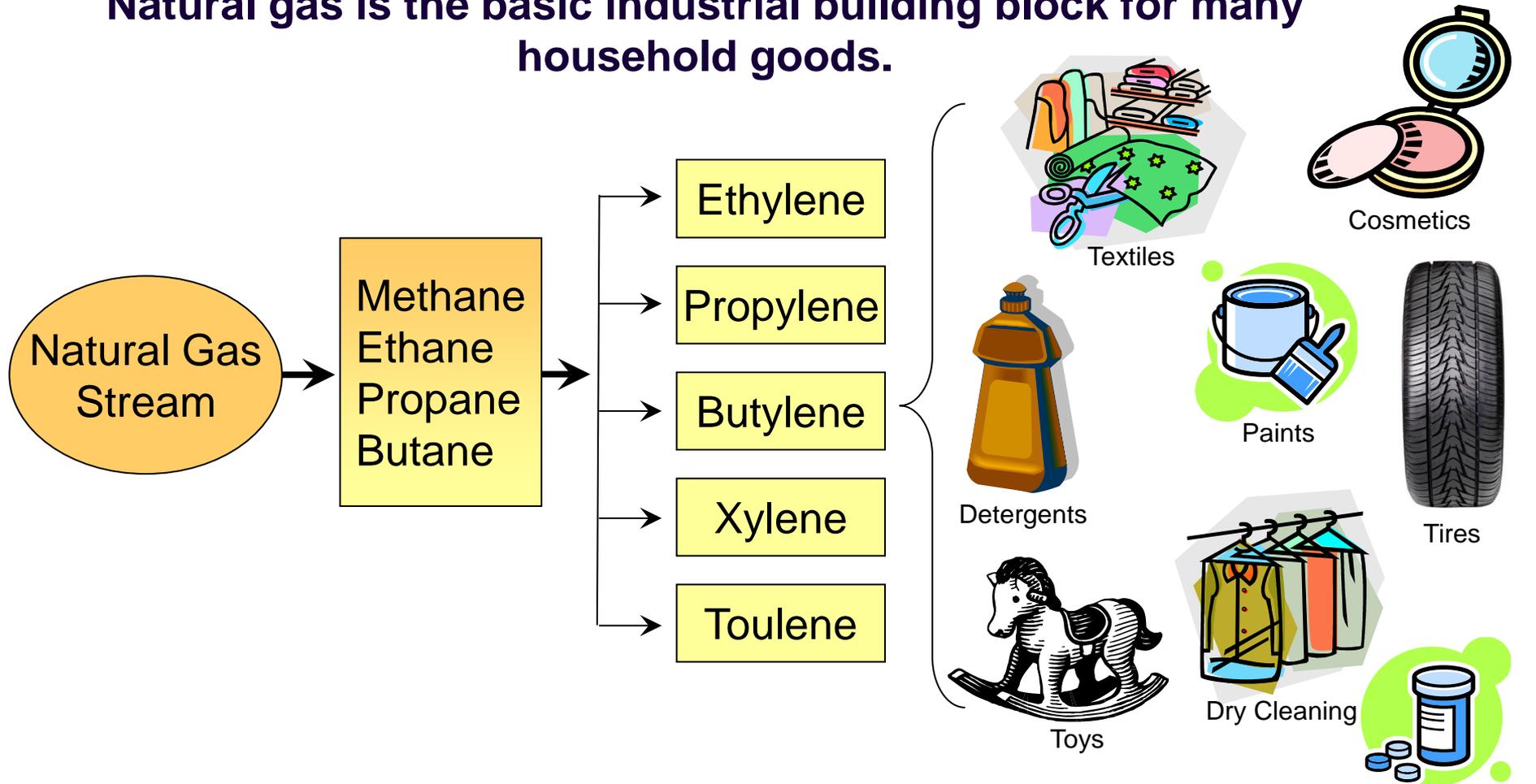
The chemical industry is particularly sensitive to natural gas prices. As natural gas prices increase, chemical industry employment decreases.





Natural Gas Composition and Modern Chemistry

Natural gas is the basic industrial building block for many household goods.

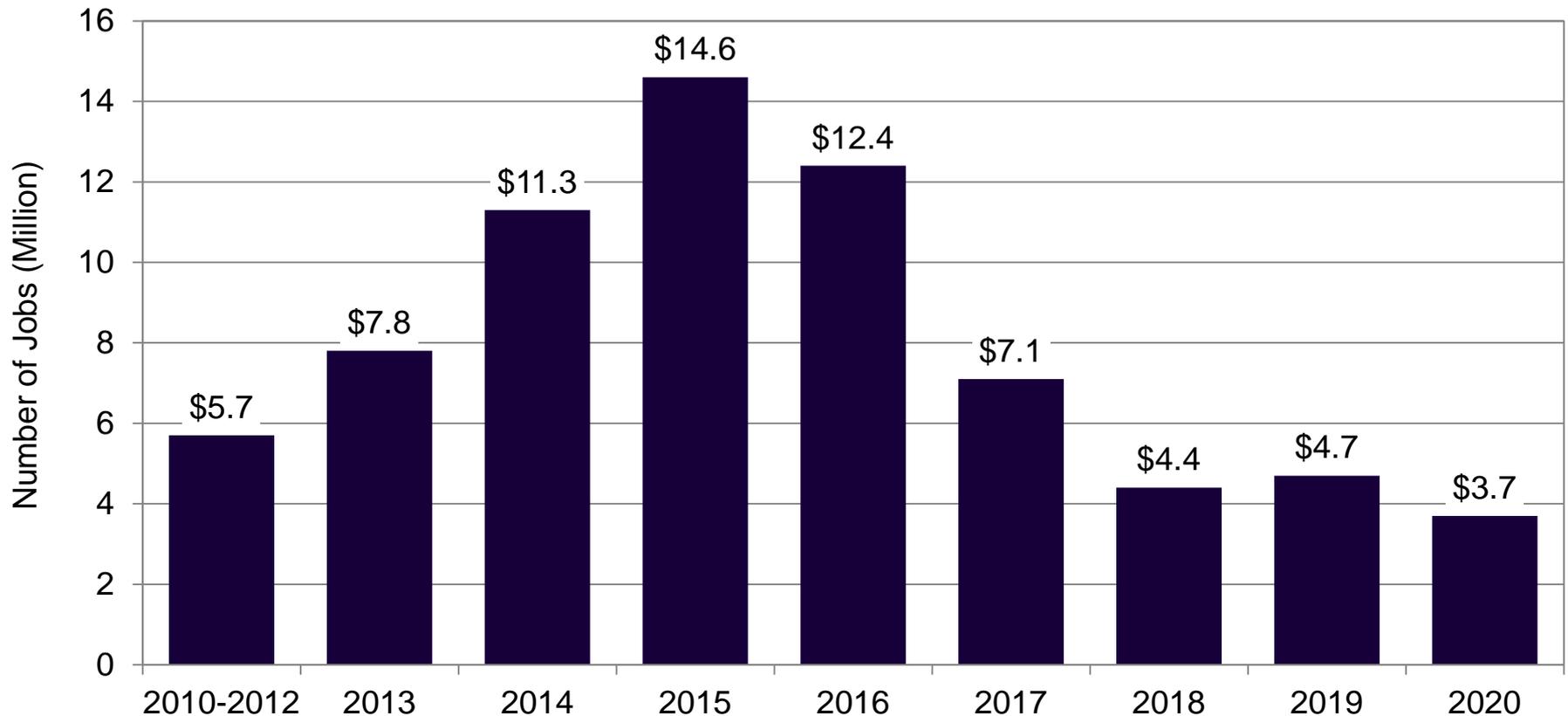


Pharmaceuticals



Incremental U.S. Chemical Industry Capital Expenditures

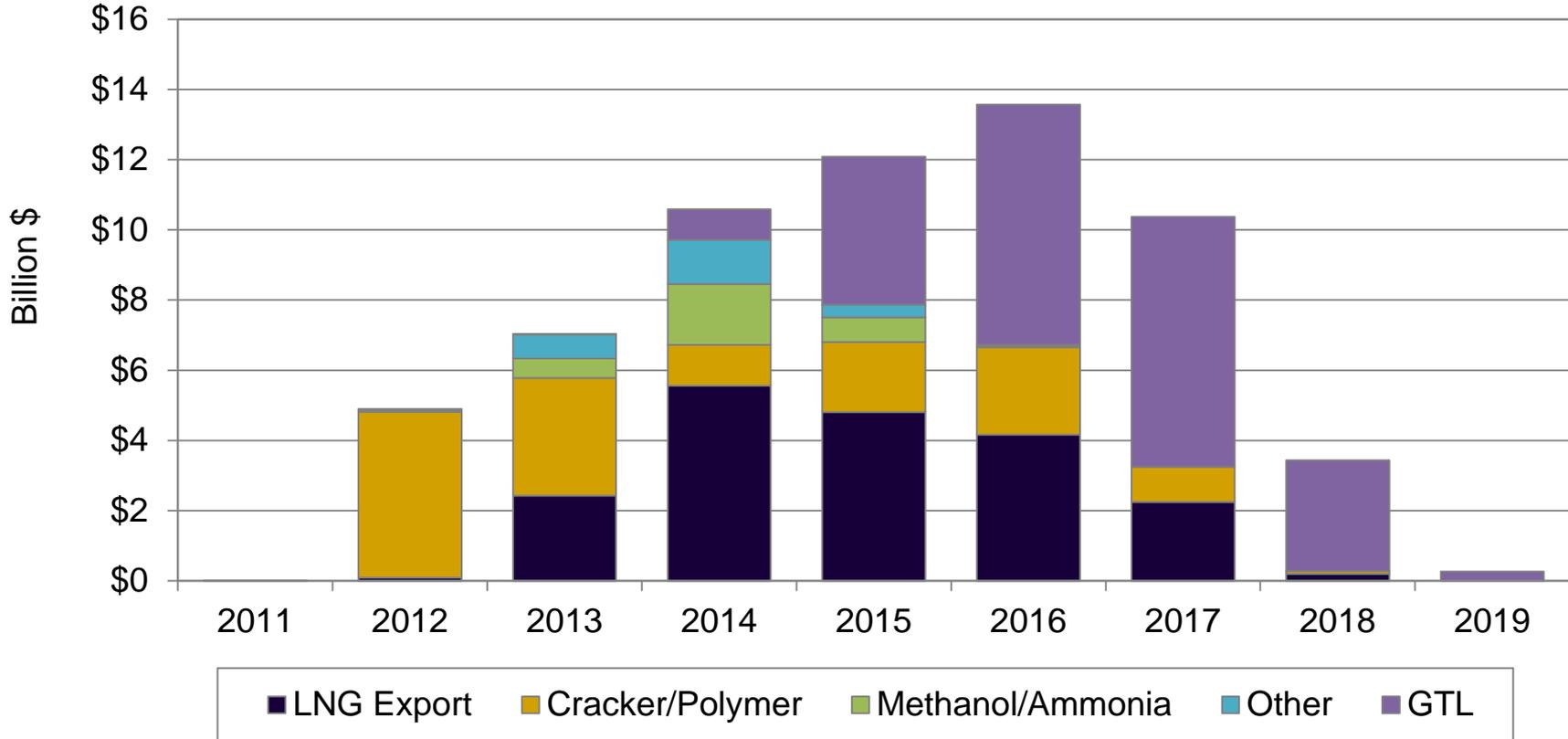
The American Chemical Council estimates that U.S. chemical industry capital investments will total \$71.7 billion through 2020. These investments are based on a “renewed competitiveness from shale gas.”





Louisiana Total Capital Expenditures by Sector

Recent LSU-CES Study found that the total capital investment associated with all announced natural gas-driven manufacturing investments in Louisiana totals over \$62 billion. Most of the investment is anticipated to occur between 2014 and 2017.



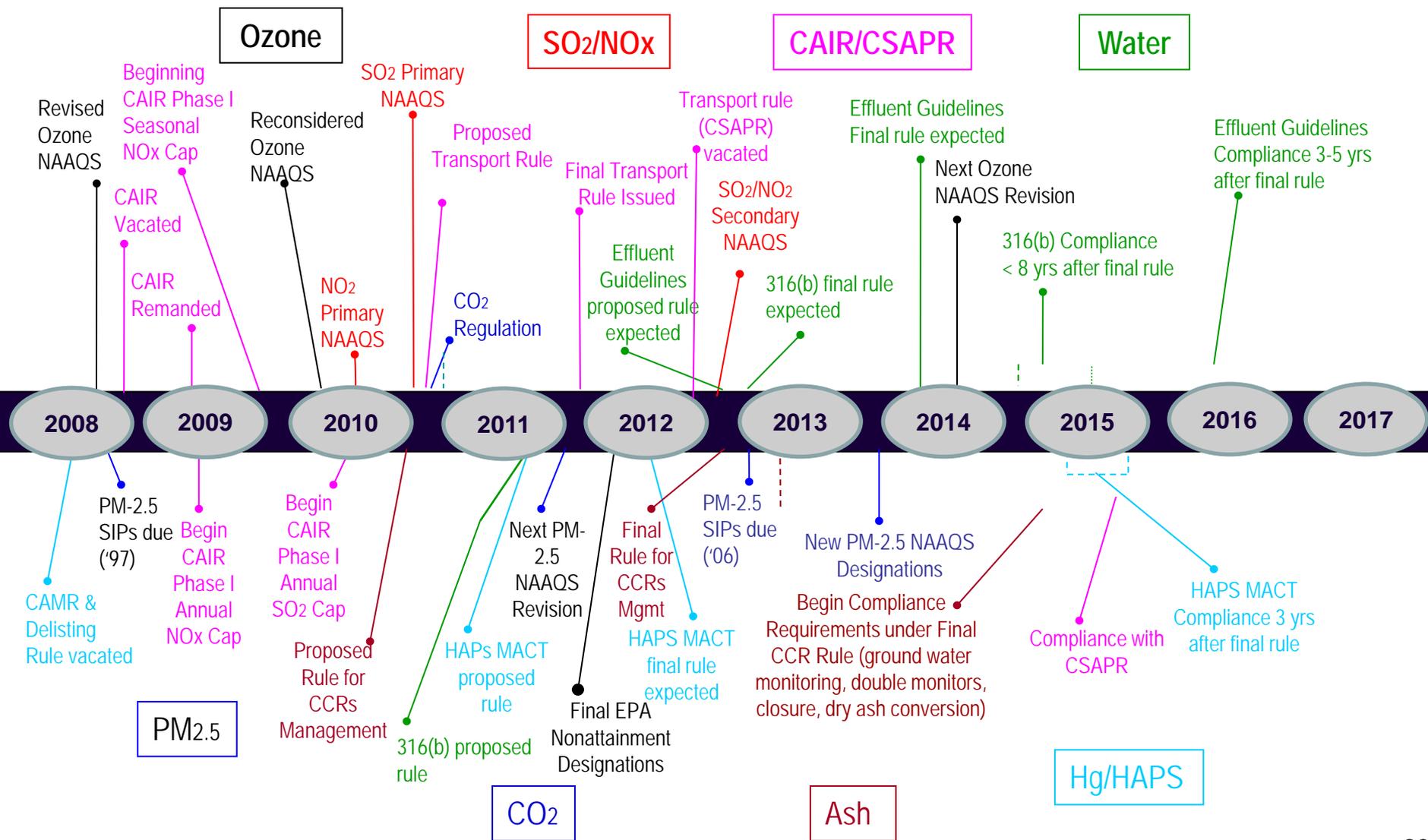
Source: David E. Dismukes (2013). *Unconventional Resources and Louisiana's Manufacturing Development Renaissance*. Baton Rouge, LA: Louisiana State University, Center for Energy Studies.

Potential Changes in Power Generation

New Natural Gas End Uses and Fuel Diversity Concerns

- As noted earlier, the industrial “renaissance” is likely to lead to the first increase in industrial natural gas demand in decades. The extent and degree of this is indeterminate. Consider that a new GTL plant or a new LNG facility, use roughly 2/Bcfd alone at full capacity (730 Bcf of annual load each).
- However, power generation has been – and will continue to be – a significant natural gas end use.
- Environmental regulations are having a considerable impact on developers’ capacity development decisions.
- The low cost of natural gas is clearly provides a preference to new gas over new coal.

Electric Industry Environmental Regulations Create Uncertainty for Coal



Coal-Fired Capacity Share by Age Category

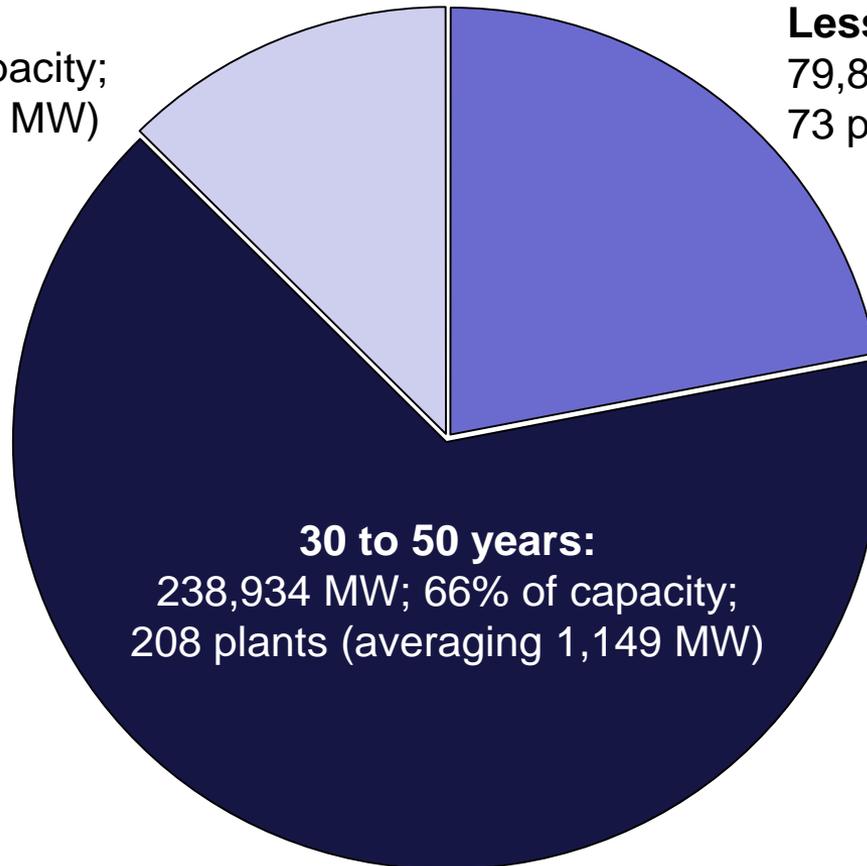
There is a considerable amount of legacy coal capacity (45 GWs) that is relatively old, and in some instances, has few to little controls to meet anticipated standards.

Greater than 50 years:

45,382 MW; 12% of capacity;
72 units (averaging 630 MW)

Less than 30 years:

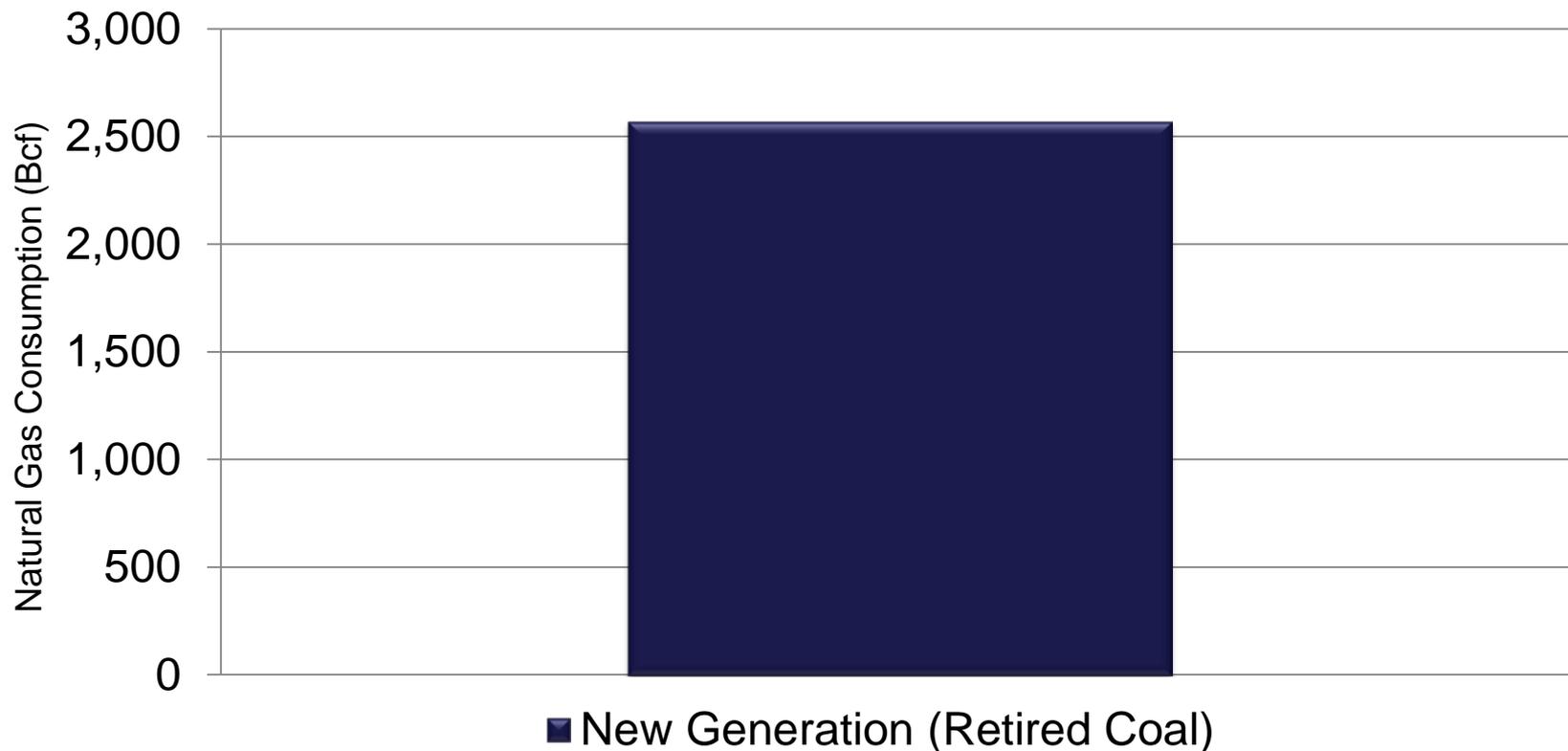
79,876 MW; 22% of capacity;
73 plants (averaging 1,094 MW)



30 to 50 years:
238,934 MW; 66% of capacity;
208 plants (averaging 1,149 MW)

Increased Natural Gas Use from CSAPR-Induced Coal Plant Retirements

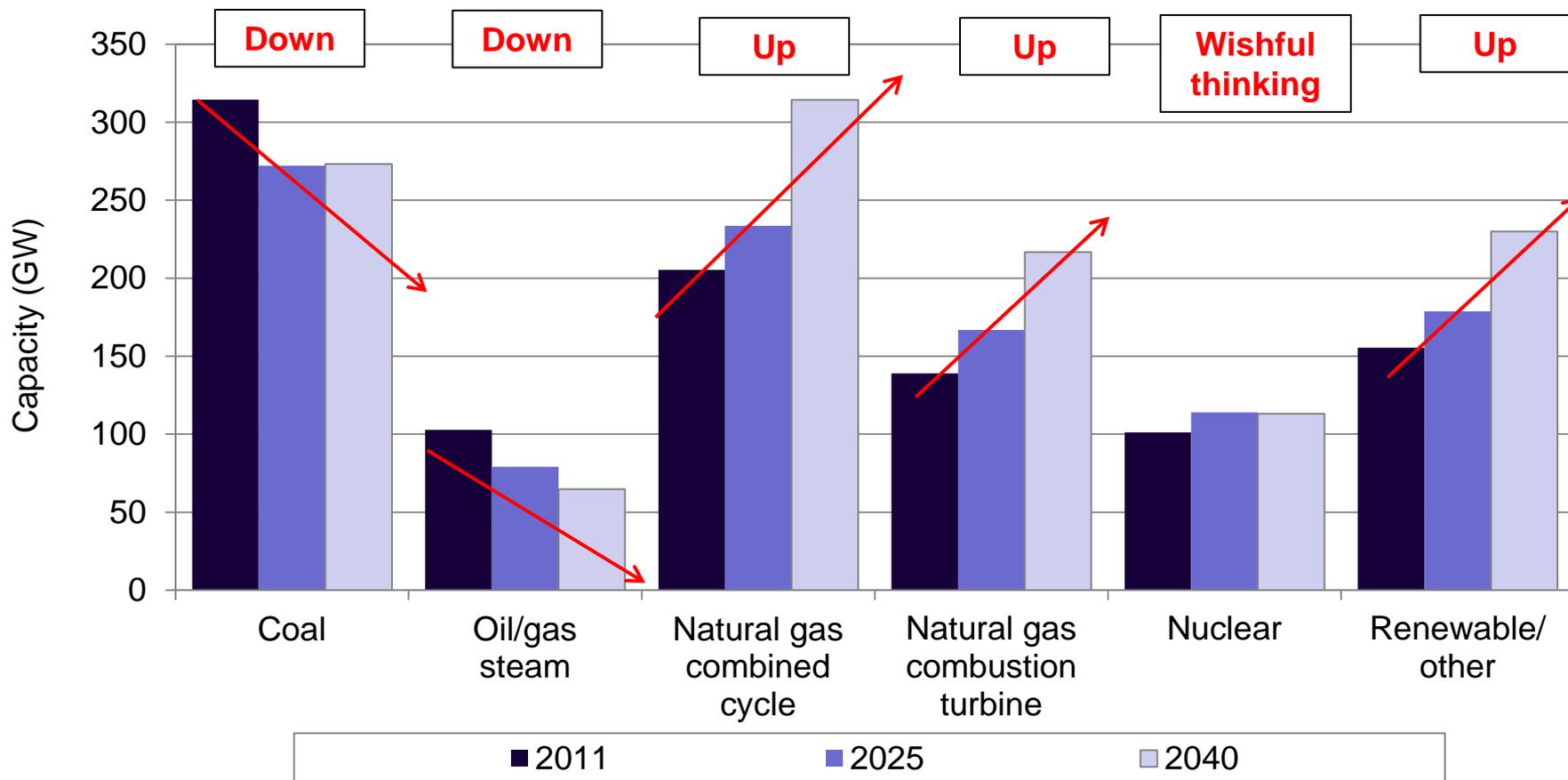
The retirement of 45 gigawatts of capacity would likely have an impact on overall natural gas usage (potentially 2 TCF).



Note: Assumes 160 Bcf of NGV natural gas use. Also assumes retirement of 45 GW of coal-fired capacity, replaced with new natural gas generation with an 85 percent capacity factor and a 7,600 Btu/kWh heat rate.

U.S. Generation Capacity by Fuel Type: 2011, 2025 and 2040

EIA estimates the growth in new generation to come primarily from natural gas (~170 GWs) and renewables (~75 GWs).



What About Gas Exports?

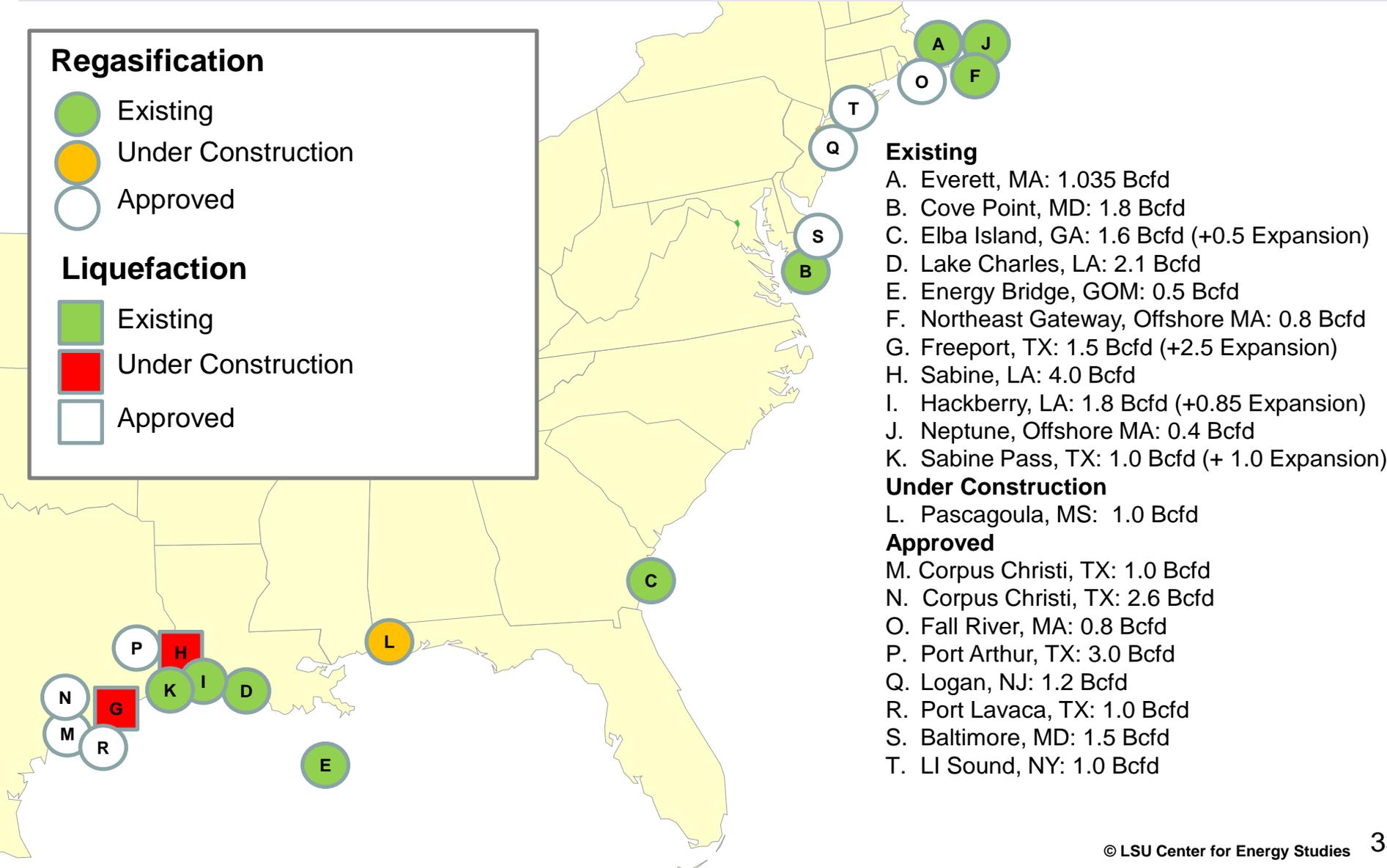
Considerable Underutilized LNG Regasification Capacity along GOM

Regasification

- Existing
- Under Construction
- Approved

Liquefaction

- Existing
- Under Construction
- Approved



Existing

- A. Everett, MA: 1.035 Bcfd
- B. Cove Point, MD: 1.8 Bcfd
- C. Elba Island, GA: 1.6 Bcfd (+0.5 Expansion)
- D. Lake Charles, LA: 2.1 Bcfd
- E. Energy Bridge, GOM: 0.5 Bcfd
- F. Northeast Gateway, Offshore MA: 0.8 Bcfd
- G. Freeport, TX: 1.5 Bcfd (+2.5 Expansion)
- H. Sabine, LA: 4.0 Bcfd
- I. Hackberry, LA: 1.8 Bcfd (+0.85 Expansion)
- J. Neptune, Offshore MA: 0.4 Bcfd
- K. Sabine Pass, TX: 1.0 Bcfd (+ 1.0 Expansion)

Under Construction

- L. Pascagoula, MS: 1.0 Bcfd

Approved

- M. Corpus Christi, TX: 1.0 Bcfd
- N. Corpus Christi, TX: 2.6 Bcfd
- O. Fall River, MA: 0.8 Bcfd
- P. Port Arthur, TX: 3.0 Bcfd
- Q. Logan, NJ: 1.2 Bcfd
- R. Port Lavaca, TX: 1.0 Bcfd
- S. Baltimore, MD: 1.5 Bcfd
- T. LI Sound, NY: 1.0 Bcfd

LNG Value Chain

Feedstock (production) costs will be critical in determining the location of basin-specific production along the global LNG supply curve.



	Feedgas 56% (\$/MMBtu)	Liquefaction 11%-17% (\$/MMBtu)	Shipping & Fuel 20%-29% (\$/MMBtu)	Regas 4%-7% (\$/MMBtu)	Delivered Cost (\$/MMBtu)	Equivalent Oil Price* (\$/BOE)
Europe:						
Low	\$4.00	\$1.25	\$1.40	\$0.50	\$7.15	\$41.47
High	\$6.50	\$1.25	\$1.65	\$0.50	\$9.90	\$57.42
Asia:						
Low	\$4.00	\$1.25	\$2.90	\$0.50	\$8.95	\$51.91
High	\$6.50	\$1.25	\$3.45	\$0.50	\$11.70	\$67.86

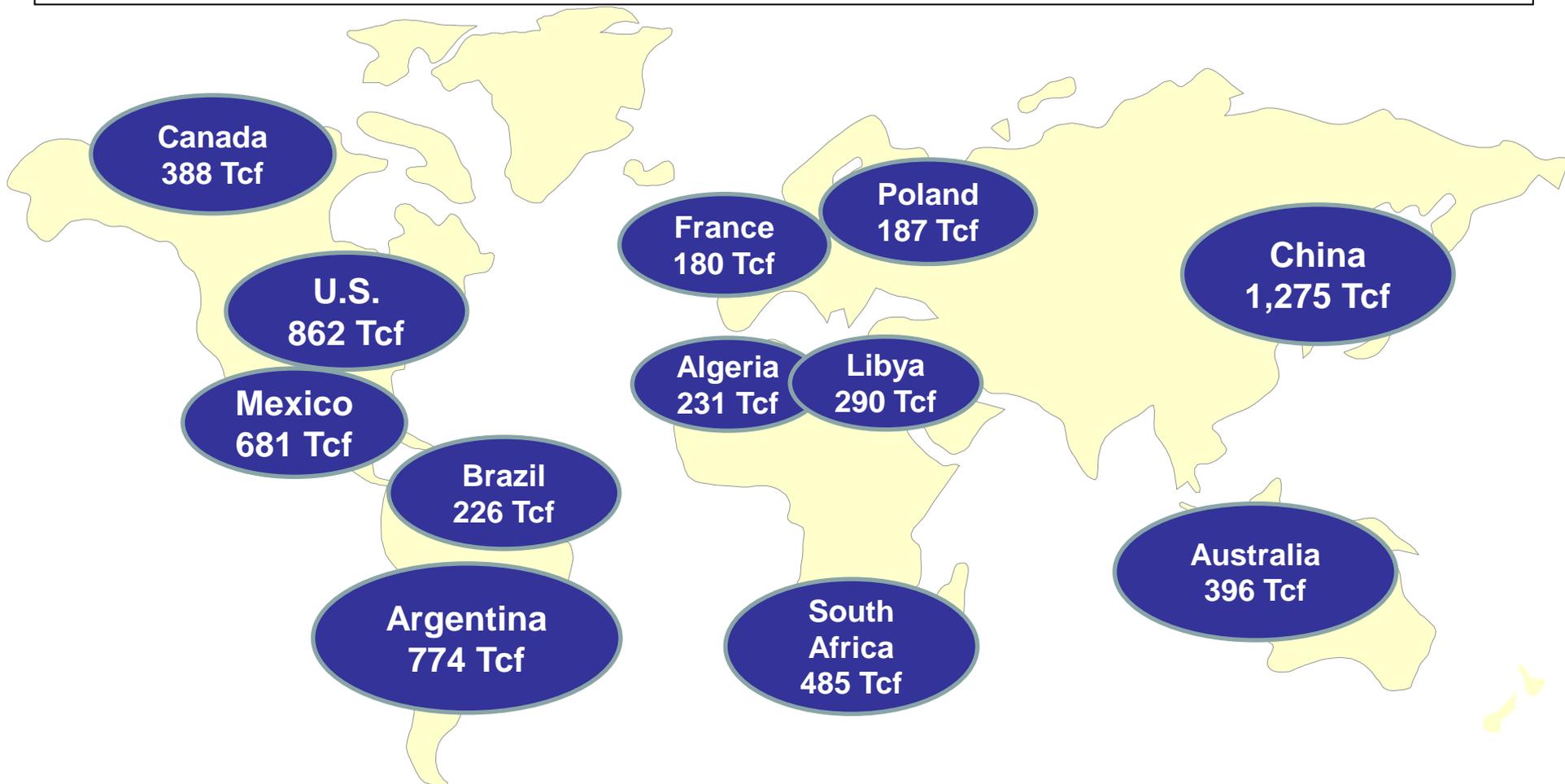
Henry Hub:	WTI:
\$4.50	\$97.00
\$5.00	\$100.00

Note: *uses a BOE conversion of 5.8 Mcf/BOE.

Source: Cheniere.

Basin Competition

Close to 6,000 TCF of shale gas opportunities around the world. Coupled with 9,000 Tcf in conventional suggest a potentially solid resource base for many decades.



Conclusions

Conclusions

- **Natural gas markets continue to be resilient. Prices anticipated to remain affordable and less volatile.**
- **While some (dry methane) wells have shut/back or are shut-in, this has not been enough to stall the increases in production.**
- **Natural gas supply growth increasingly driven by “associated” natural gas – a byproduct of increasing production coming from higher hydrocarbon-based production (Marcellus, Eagle Ford, Bakken).**
- **Economic growth is tepid and likely to not upset this balance – however, a big upward swing in economy-driven demand could make that change happen.**
- **New end uses are a blessing (new manufacturing, more efficient/cleaner power generation) but need to be watched for unanticipated consequences.**



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