

North American Integrated Energy Research

North American Natural Gas: Linkages amid Change

February, 2017

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Gas/Electric Partnership 2017: Opportunities in Infrastructure

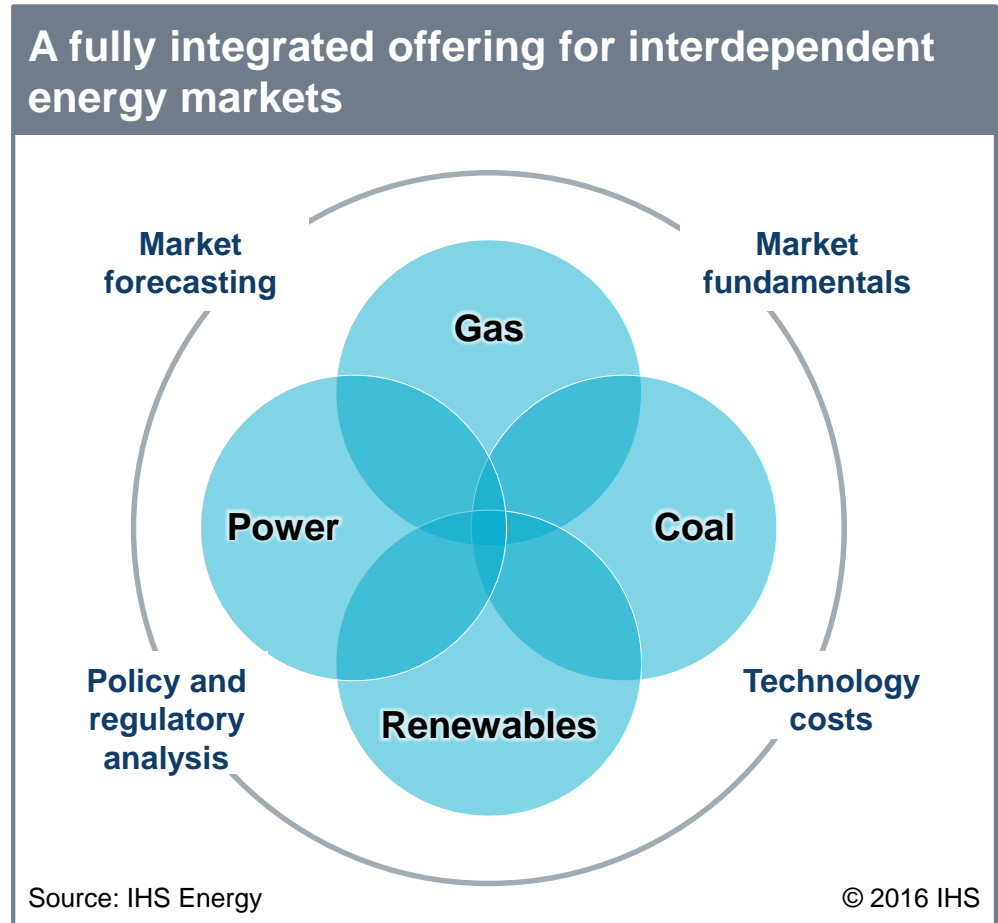
Ed Kelly, Managing Director, North American Gas, Ed.Kelly@ihsmarkit.com



North American Power, Gas, Coal and Renewables: A fully integrated IHS offering for interdependent energy markets

The integration of the North American energy markets means that technologies and fuels are increasingly **interdependent**.

North American Gas, Power, Coal, and Renewables offering highlights **fully integrated** fuels and business areas.



Key Power Themes: Renewables, Gas/Coal Competition

- Supportive policies and technology cost declines support a boom in US wind and solar PV capacity additions through the early 2020s. Federal tax code changes have the potential to moderate the boom, however.
- Utility scale solar PV is the largest renewable segment to 2025 and opportunities expand beyond California.
- The missing money paradox continues to plague the power industry; conventional plant retirements continue, owing to weak market fundamentals and public policy.
- A new competitive fuel dynamic has been established between natural gas- and coal-fired power generation that will increase fuel demand volatility—in response to higher natural gas prices, US coal-fired power generation is expected to increase by more than 10% in 2017, contributing an increase in annual CO₂ emissions of approximately 4%.
- The CPP is unlikely to prevail as a final federal rule; a state patchwork of policies will complement market forces in determining power sector CO₂ emissions to at least 2025.
- Battery cost declines and targeted policies have given rise to niche power applications, but further cost declines are required to be competitive with gas-fired peaking generation.

Key Themes for Natural Gas: Demand Challenge, Moving up a Flat Resource Cost Curve

- **Large resource base:**

- Shale Gas Reloaded research found 1,400 trillion cubic feet (Tcf) of economic natural gas resource at less than \$4.00/MMBtu and over 700 Tcf at sub \$3.00 with major implications across the entire North American energy landscape.

- **Risks from concentration of production:**

- Creates pipeline expansion dependency and challenge of matching supply growth to demand growth.
- Oil price and associated gas production not correlated to natural gas market.
- Tight 2017 with higher prices and gas to coal switching.
- Likely excess thereafter on capex surge to oil and pipeline expansion completions.

- **Global Gas Reset:**

- Shale and US LNG exports changing how global gas prices get set.
- Excess global LNG liquefaction likely concurrent with surge of US production.
- Variable cost pricing leaves US exports uncompetitive until the global market grows into the capacity.

The “Trump Effect” on Natural Gas and Oil Pricing and Production?

- **Marginal:**

- Does not change the reality of the resource base on largely private lands; if the shale revolution occurred under Obama, it is not likely to be slowed by Trump
- However, toward the end of the Obama administration, obstacles to infrastructure developments and new drilling were gathering force and momentum; intervenors are no longer likely to be joined by a supportive federal government
- As such, infrastructure development, and drilling plans, may experience an “interregnum” in which industry investments may occur largely on schedule
- The energy industry is likely strenuously to oppose a “border adjustment tax,” and the fungibility of natural gas would make such a tax difficult to manage

- **Price and supply impacts:**

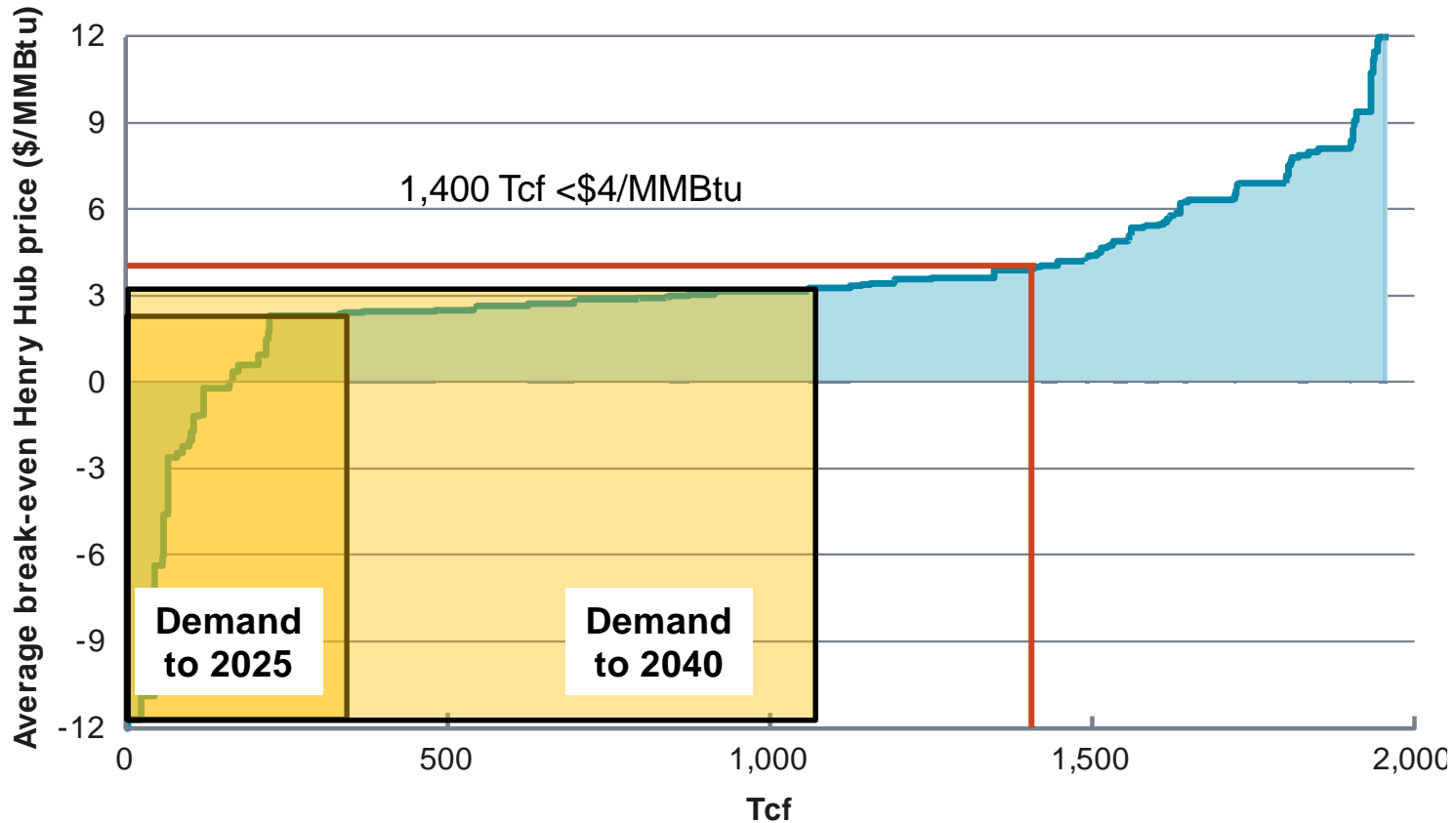
- Oil: unlikely that large new territories will be effectively opened to drilling. Large oil projects often take longer than 4 years, and require investment certainty (if territory is opened by Trump it could be closed again by a later president).
- Natural gas: Appalachian supplies may be more unleashed (limiting price appreciation), with timely completions of planned pipeline projects. Exports to Mexico unlikely to be affected, but do face risk from Mexico political uncertainty.

North American Natural Gas: A Resource in Search of Markets

2016 shale gas reloaded update

1,400 Tcf North American supply at Henry Hub <\$4

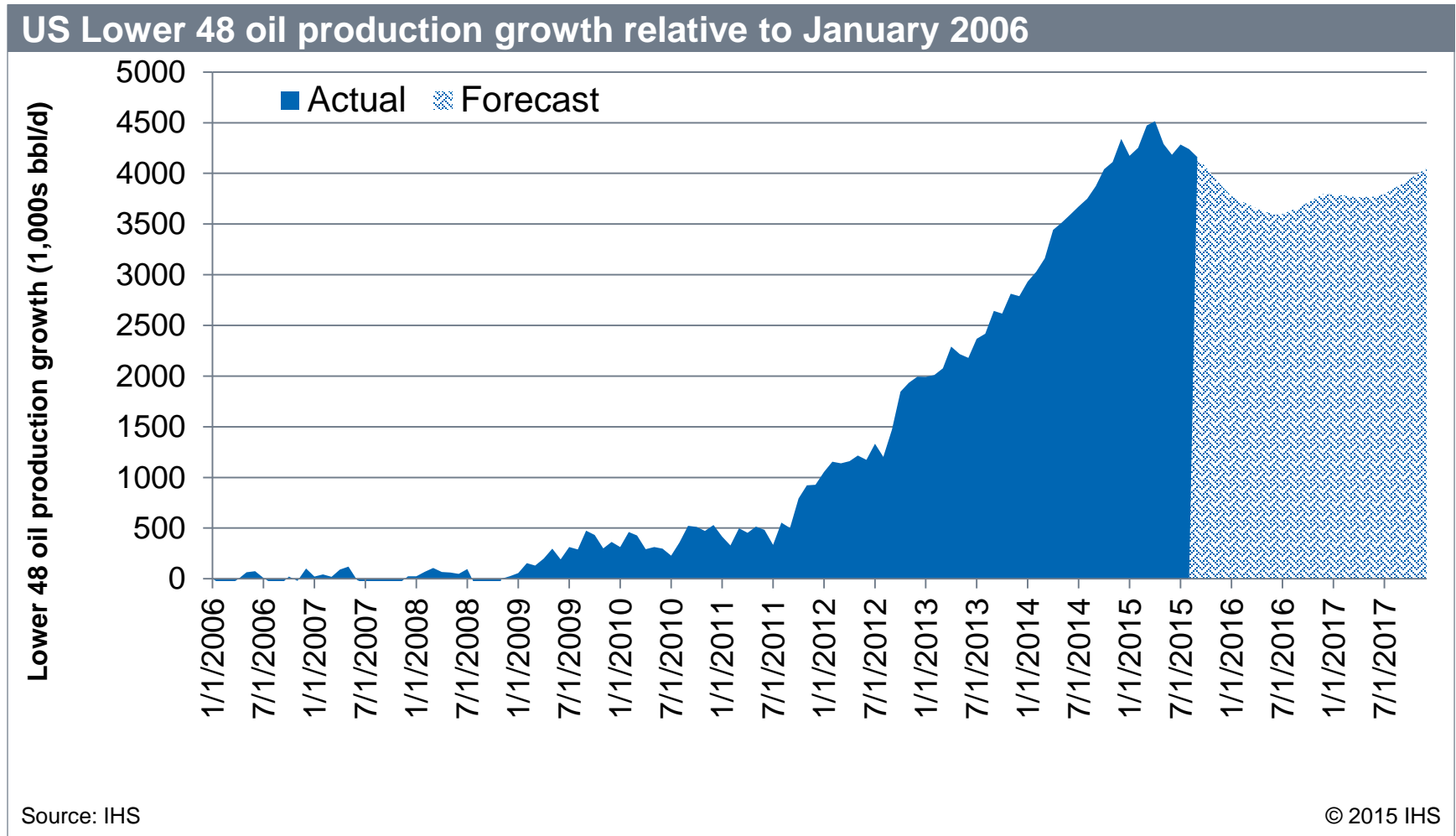
Break-even price at Henry Hub for natural gas resources



Source: IHS Energy

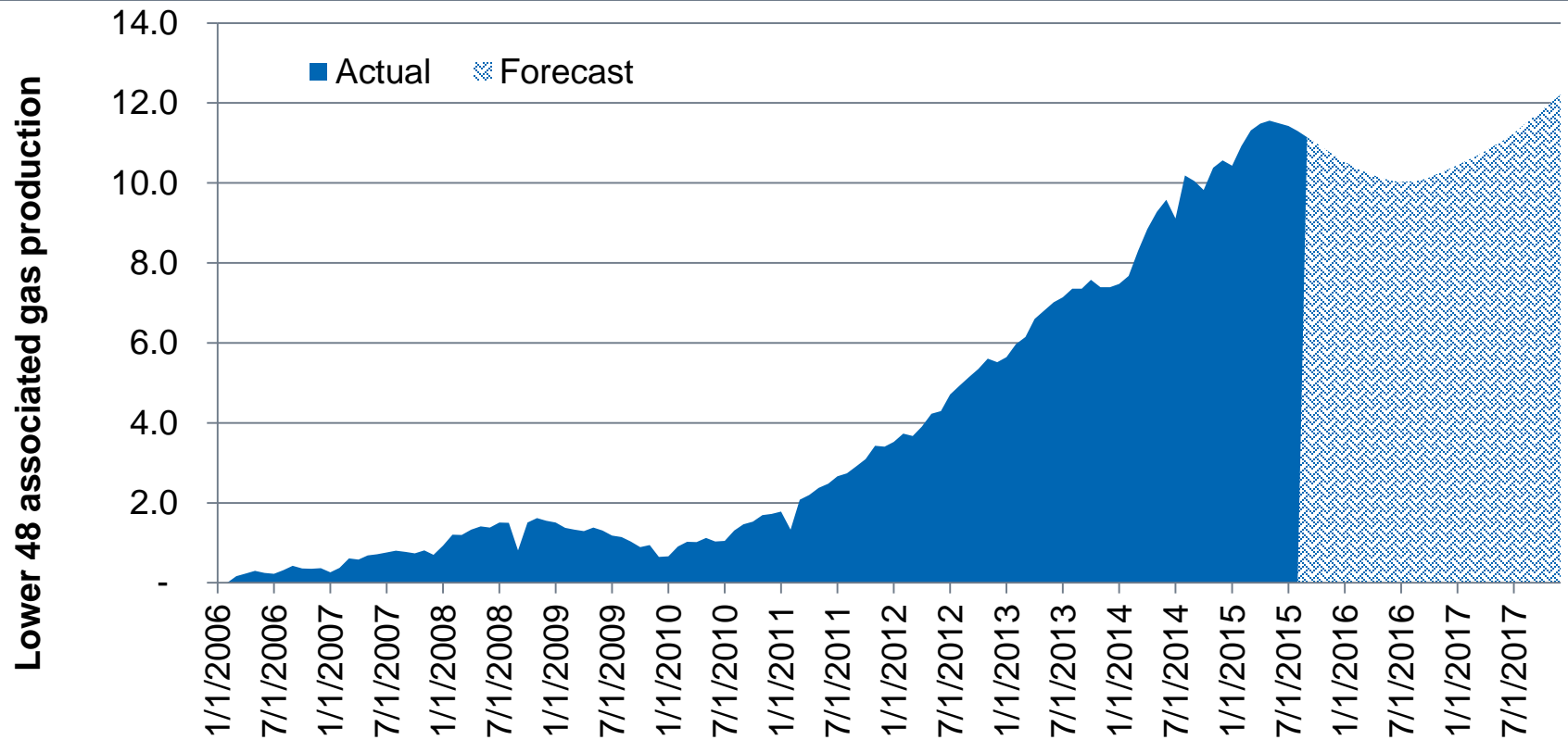
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Porting shale technology from gas to oil



Driving rapid expansion of associated gas production

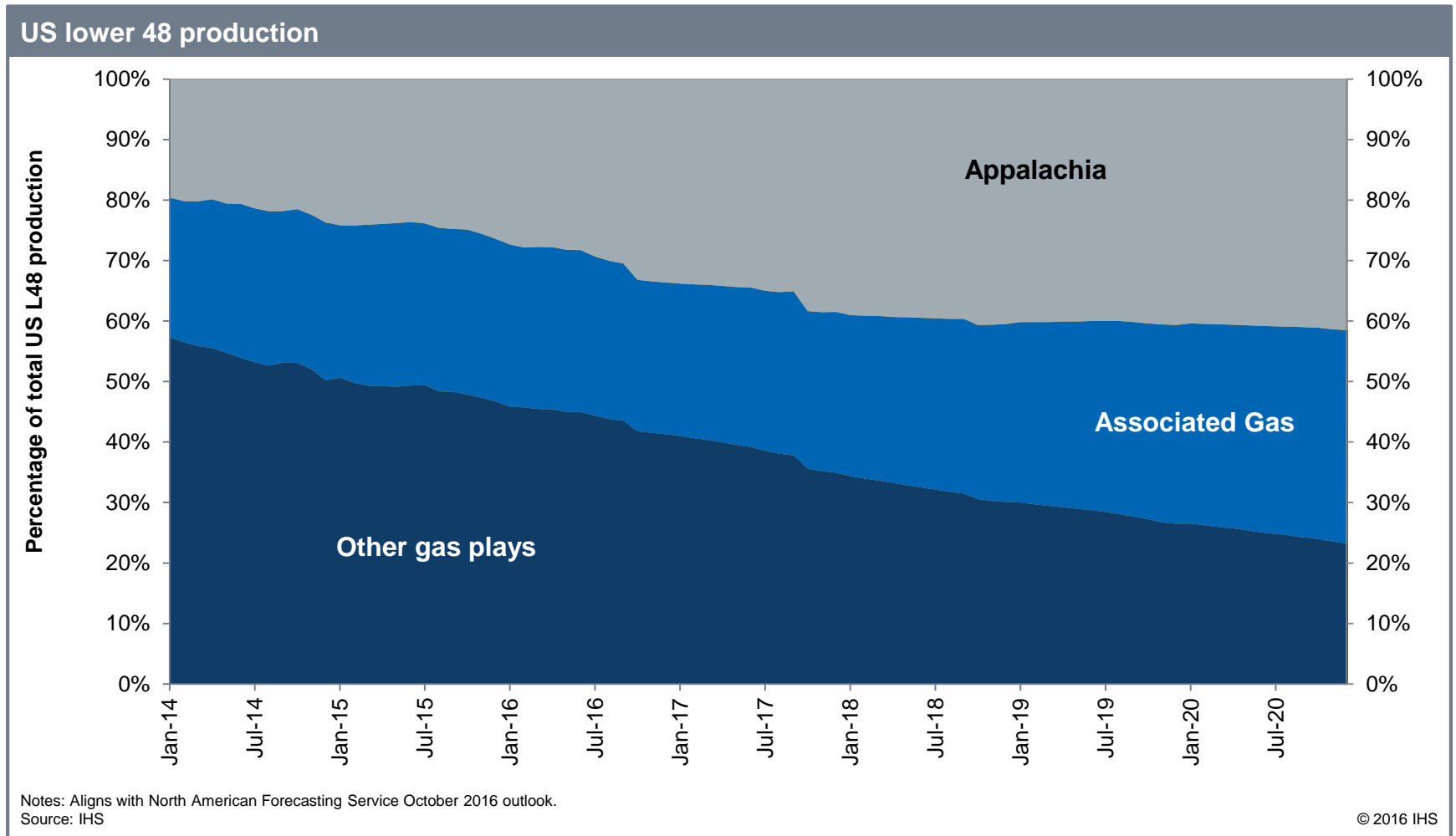
Lower 48 associated gas production growth relative to January 2006



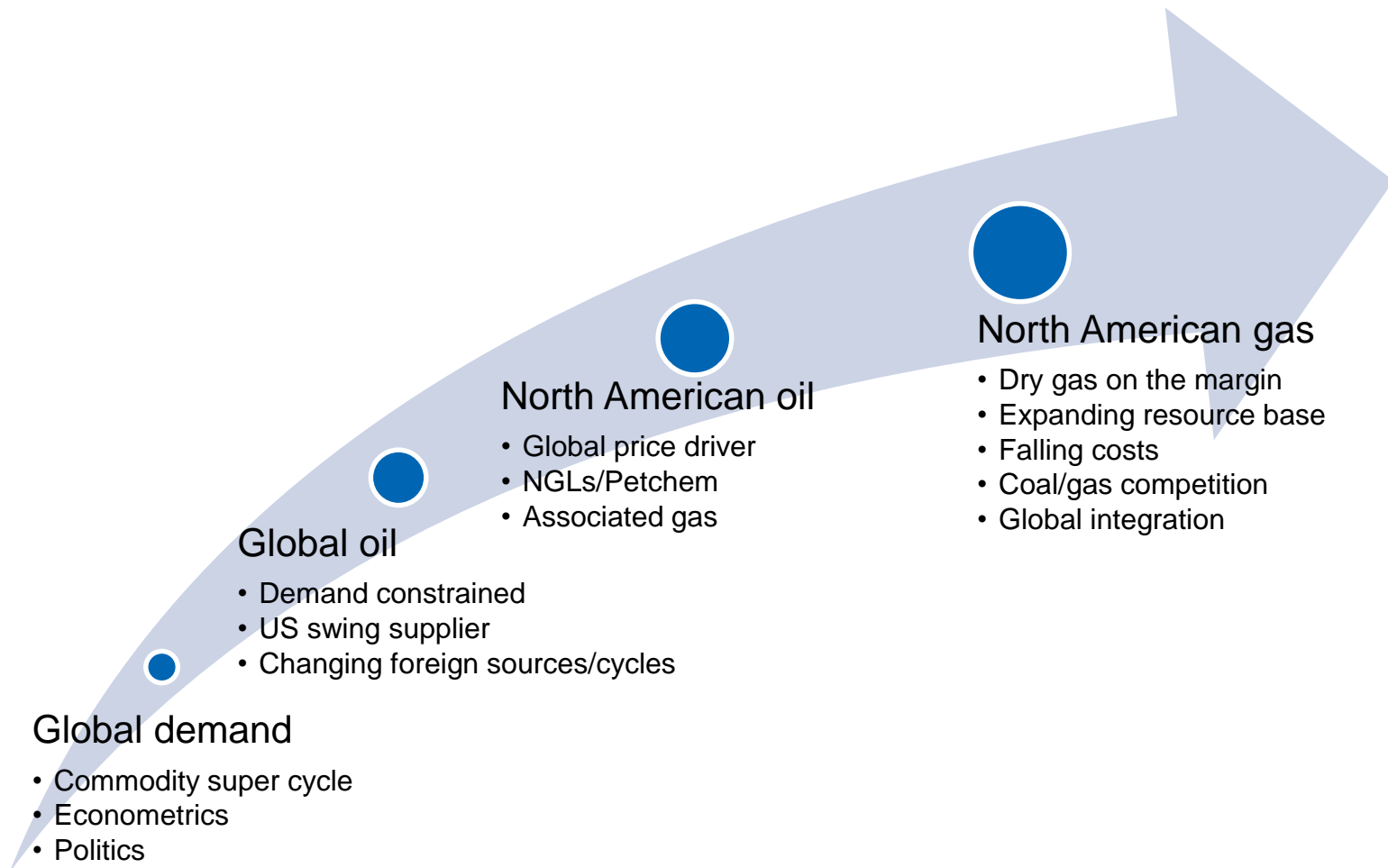
Source: IHS

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Concentration of production Price risk with going oily and Appalachian

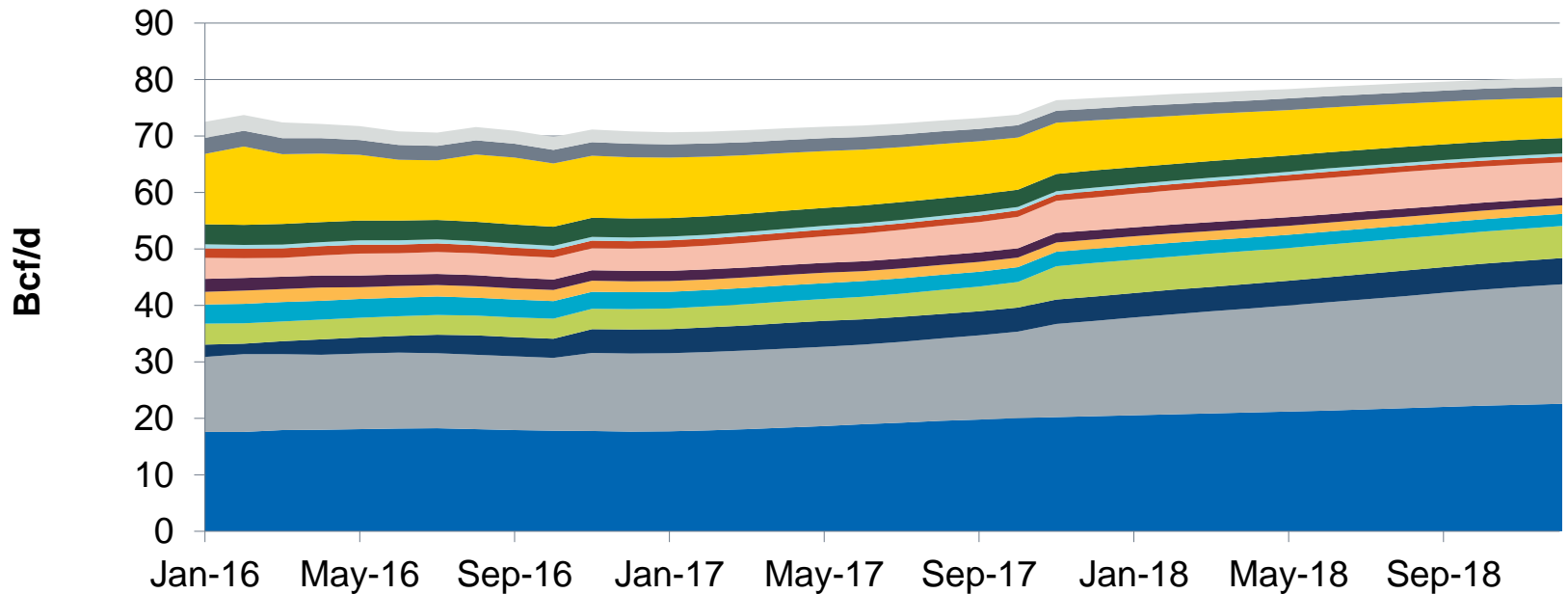


North American gas reloads and reconnects



Appalachia and oil economics drive production growth

US gas production history and outlook by major play



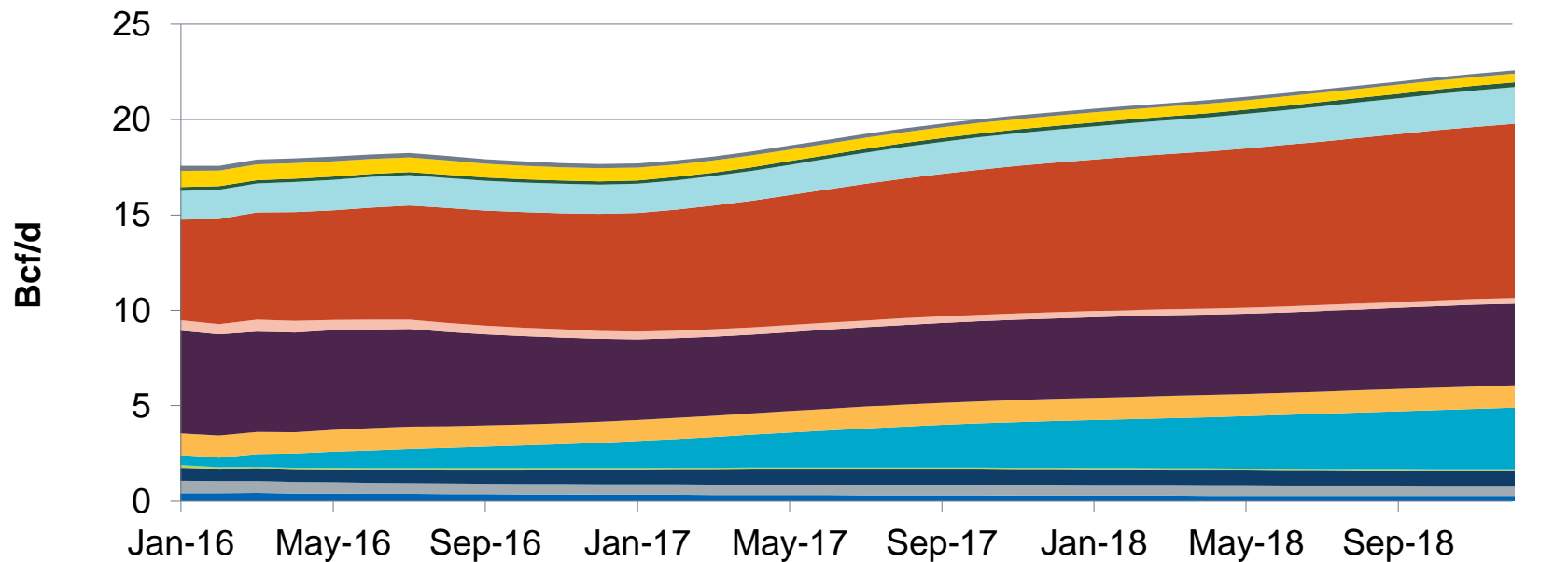
- Associated Gas
- Barnett
- Pinedale
- Other - Wet Gas
- Marcellus PA
- Cotton Valley
- Woodford (Arkoma)
- CBM
- Marcellus WV
- Fayetteville
- Gulf of Mexico
- Utica
- Haynesville
- Other - Dry Gas

Notes: Aligns with North American Forecasting Service January 2017 outlook.
 Source: IHS

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Oil-related economics advancing associated gas production

Associated gas production by play



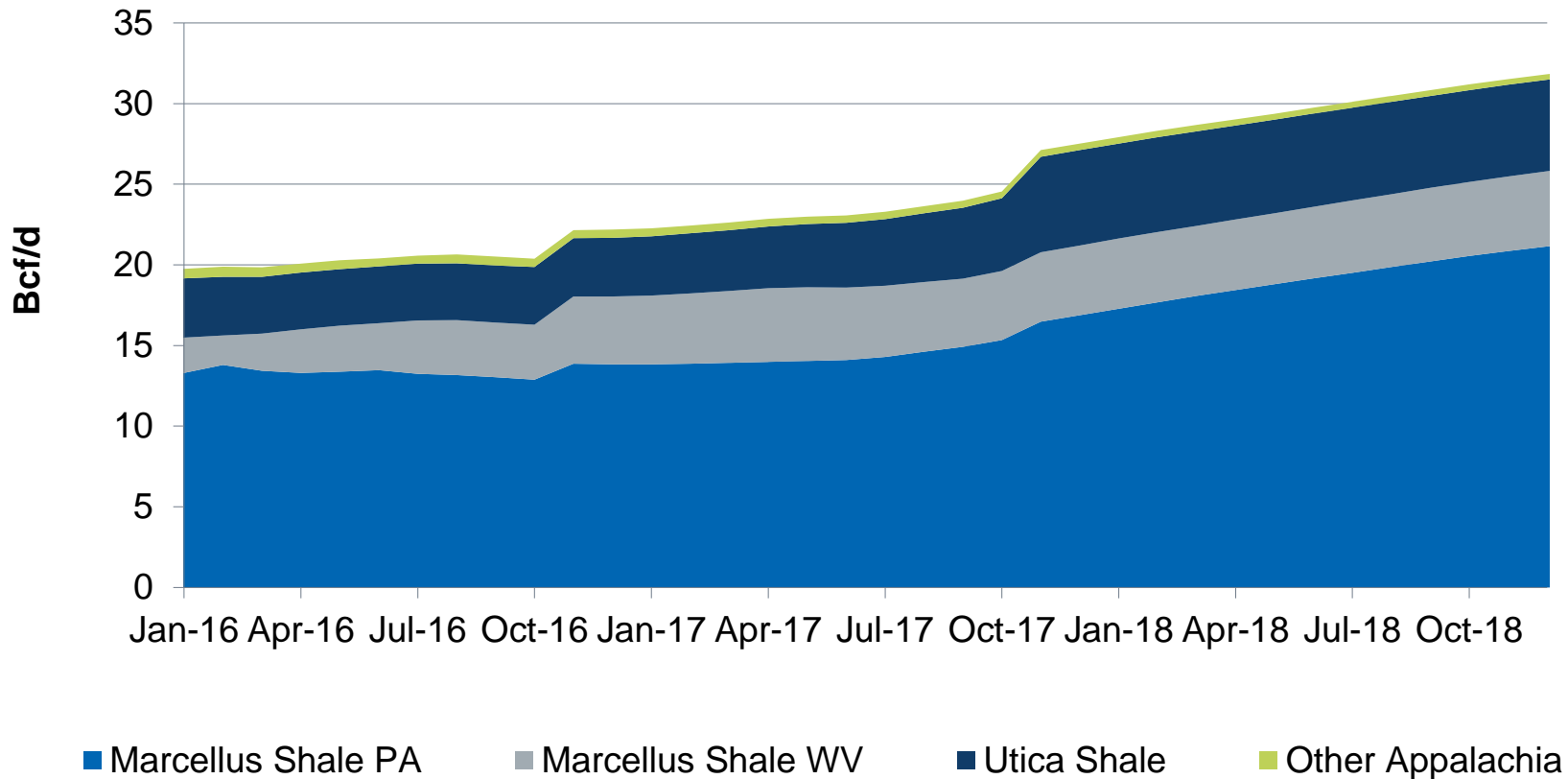
- Anadarko Penn
- SCOOP/STACK
- Permian
- Other - Oil
- Anadarko Wash
- Bakken
- Wattenberg
- Woodford - Cana
- Eagle Ford
- Niobrara Fracture Play
- Woodford - Ardmore
- Mississippian Lime
- Other - Gassy Oil

Notes: Aligns with North American Forecasting Service January 2017 outlook.
 Source: IHS

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Appalachian gas production to continue rising with progressively fewer infrastructure hindrances

Appalachia gas production history and outlook

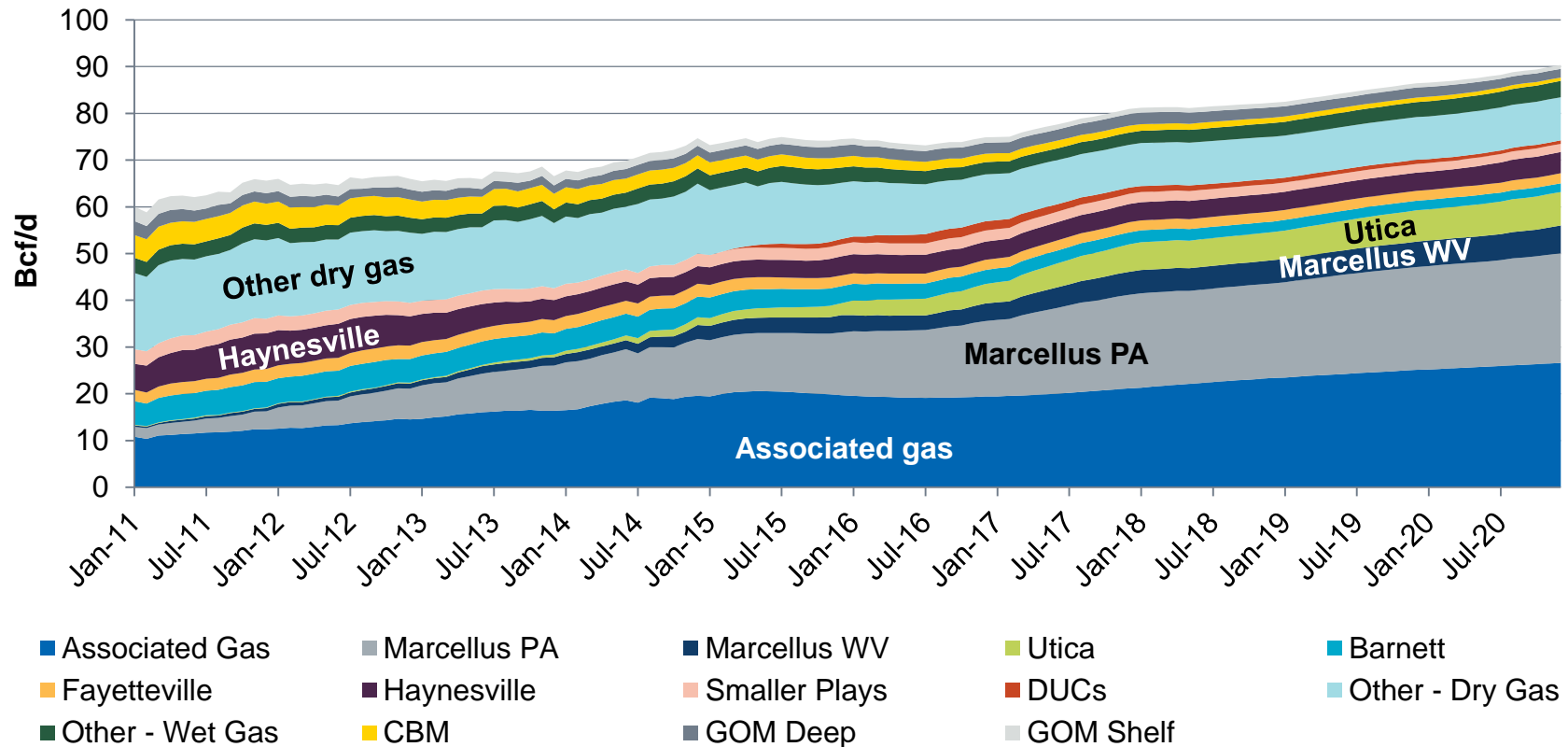


Notes: Aligns with North American Forecasting Service January 2017 outlook.
 Source: IHS

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Future production growth is driven foremost by Appalachia and associated gas

US lower-48 total gas production

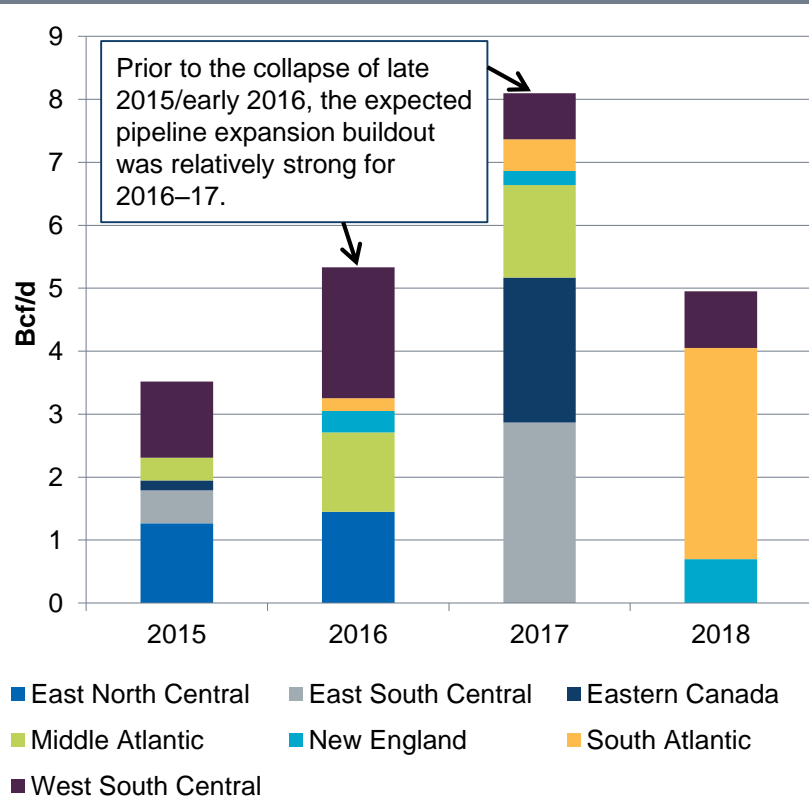


Notes: Aligns with North American Gas April outlook.
Source: IHS

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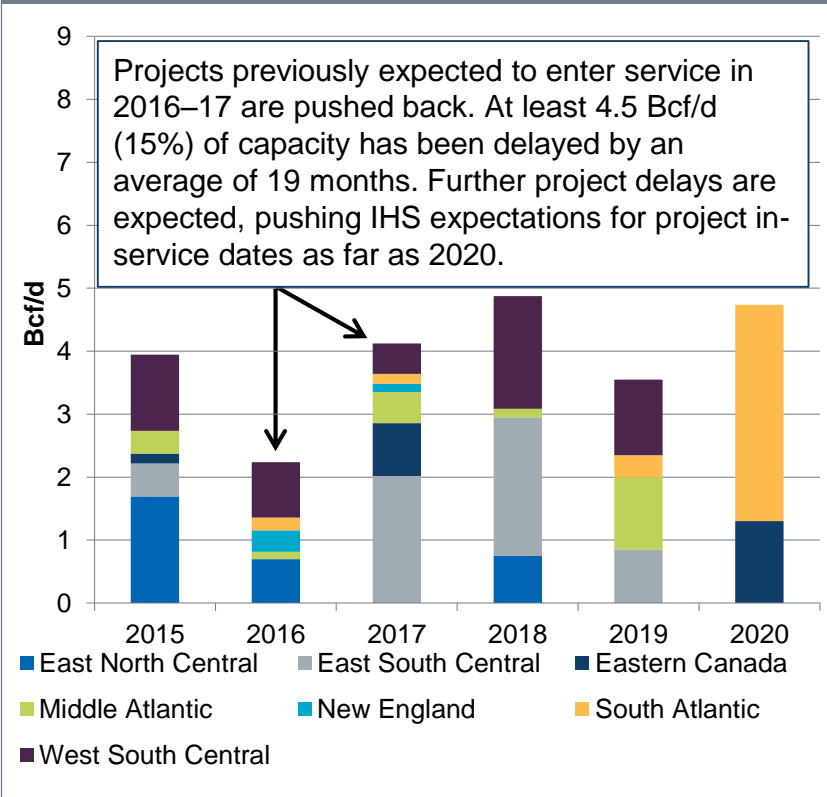
Pipeline expansions delays owing to lengthy regulatory processes (both intervention and regulatory capacity) and low prices

Contracted expansion capacity as of March 2015



Notes: Contracted capacity shown is for a subset of all announced projects, i.e., those designated as an outlet for additional production to reach markets.
 Source: IHS © 2016 IHS

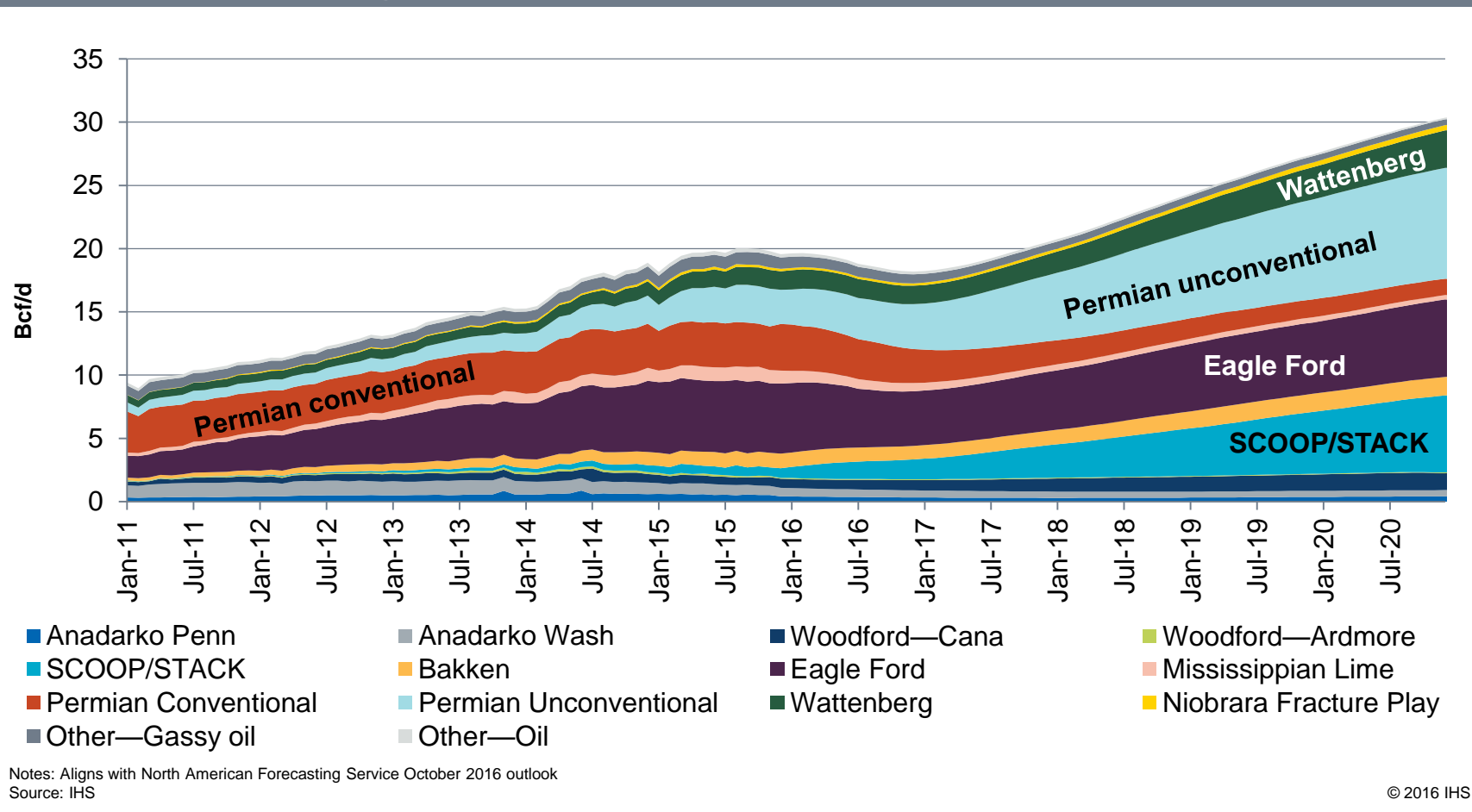
Contracted expansion capacity as of October 2016



Notes: Contracted capacity shown is for a subset of all announced projects, i.e., those designated as an outlet for additional production to reach markets.
 Source: IHS © 2016 IHS

Associated gas will grow steadily between 2018 and 2020 led by Permian, Eagle Ford, and SCOOP/STACK

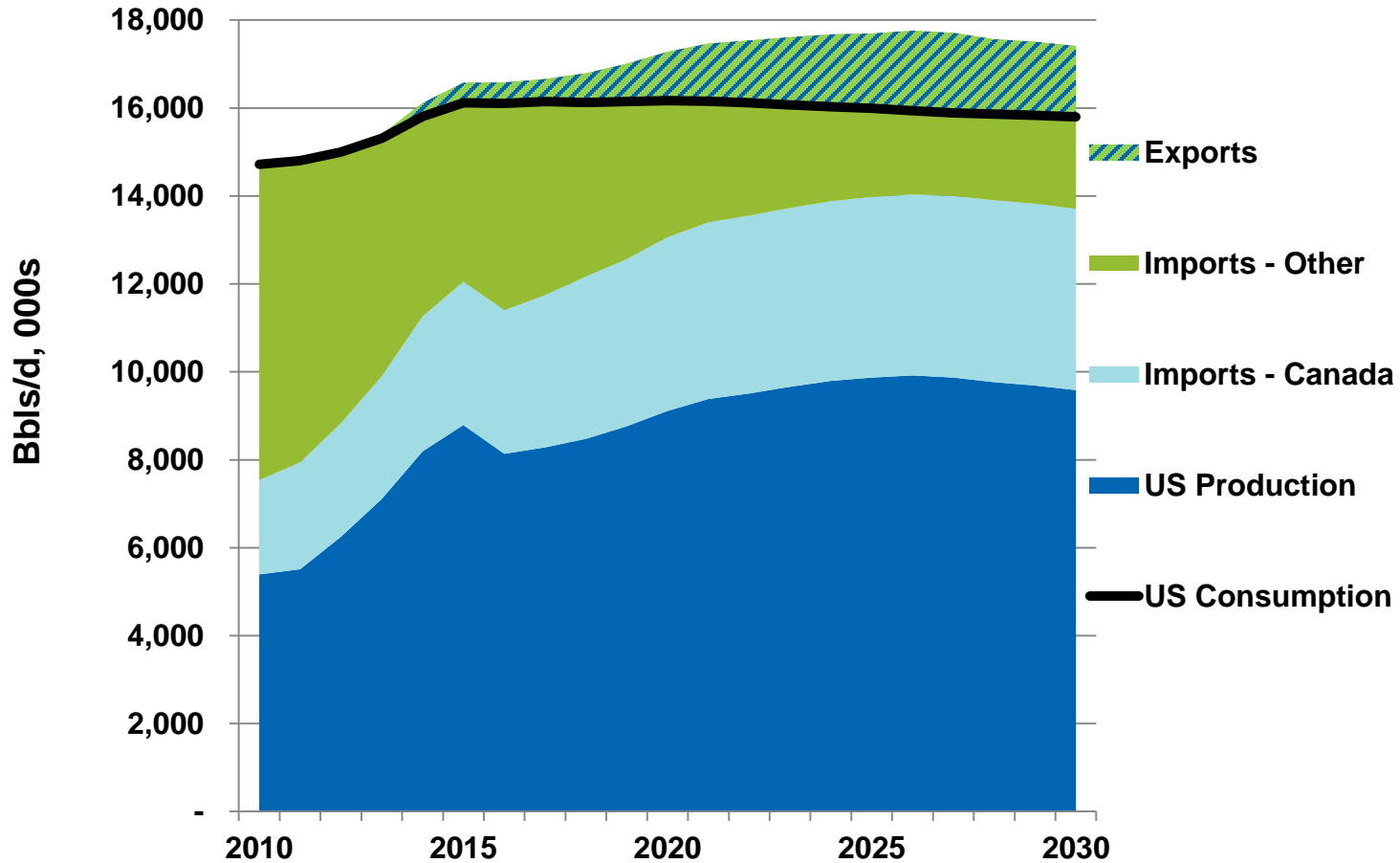
US lower-48 associated gas production



The influence of oil on our natural gas markets?

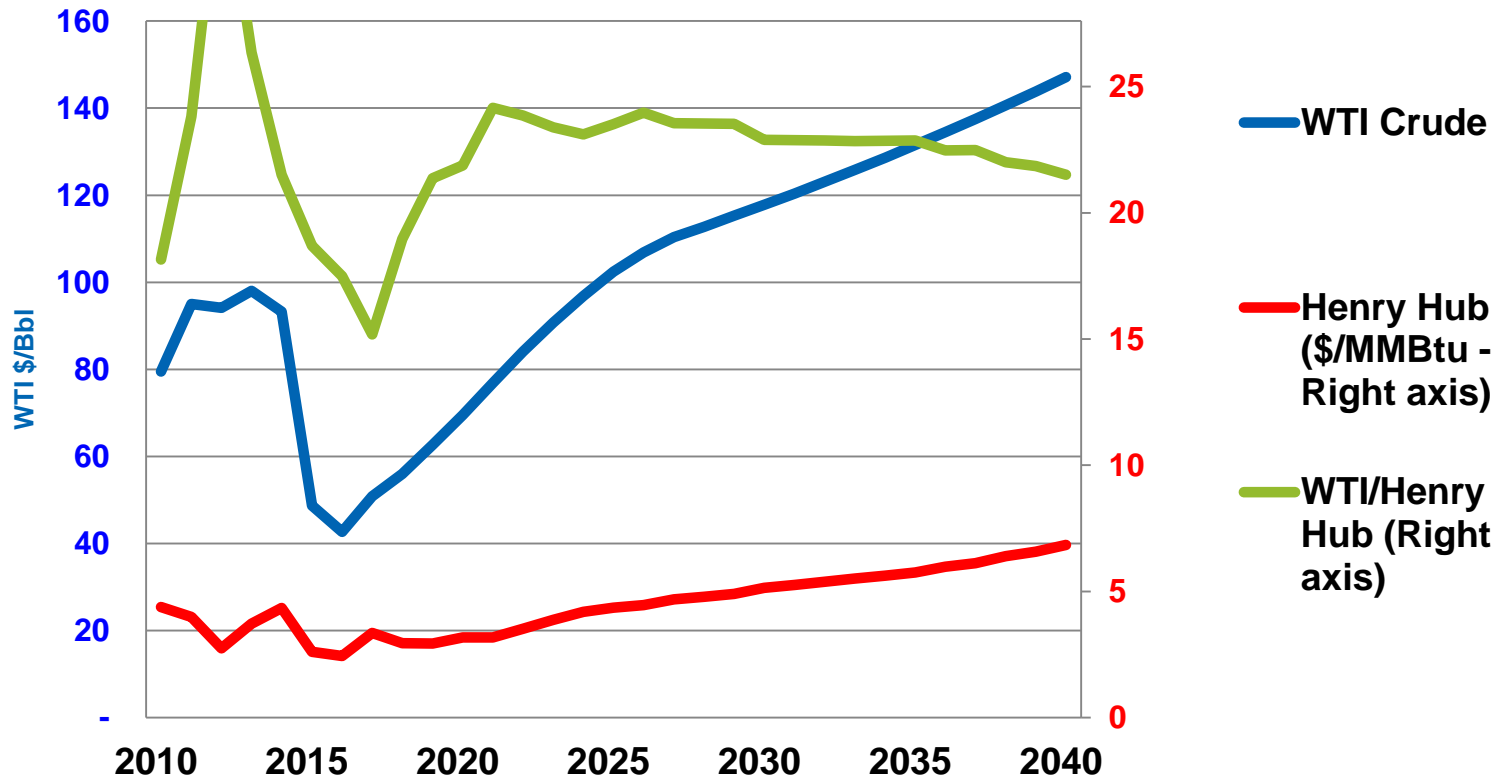
- **It is growing – but for those with long memories, is not and will not be as much as in the 1980s, and the effects are much longer term:**
 - Very little direct switching capability
- **Influences are multi-faceted:**
 - Absolute oil price: a rise in absolute oil prices will encourage associated gas production, adding to gas supplies
 - Relative oil and gas prices: Rise in oil relative to gas will (all else equal)
 - Increase US export demand, eventually
 - Increase associated gas production at the expense of dry gas production (likely net supply decline depending on relative returns from oil and gas drilling)
 - Increase interest and investment in natural gas vehicles, and long-term gas demand potential.
- **On net – high oil prices may increase both gas supply and gas demand, longer term. Any shorter-term impacts are largely psychological and trading-based**

Will the US become “energy independent?” Not necessarily: The IHS US Crude Balance



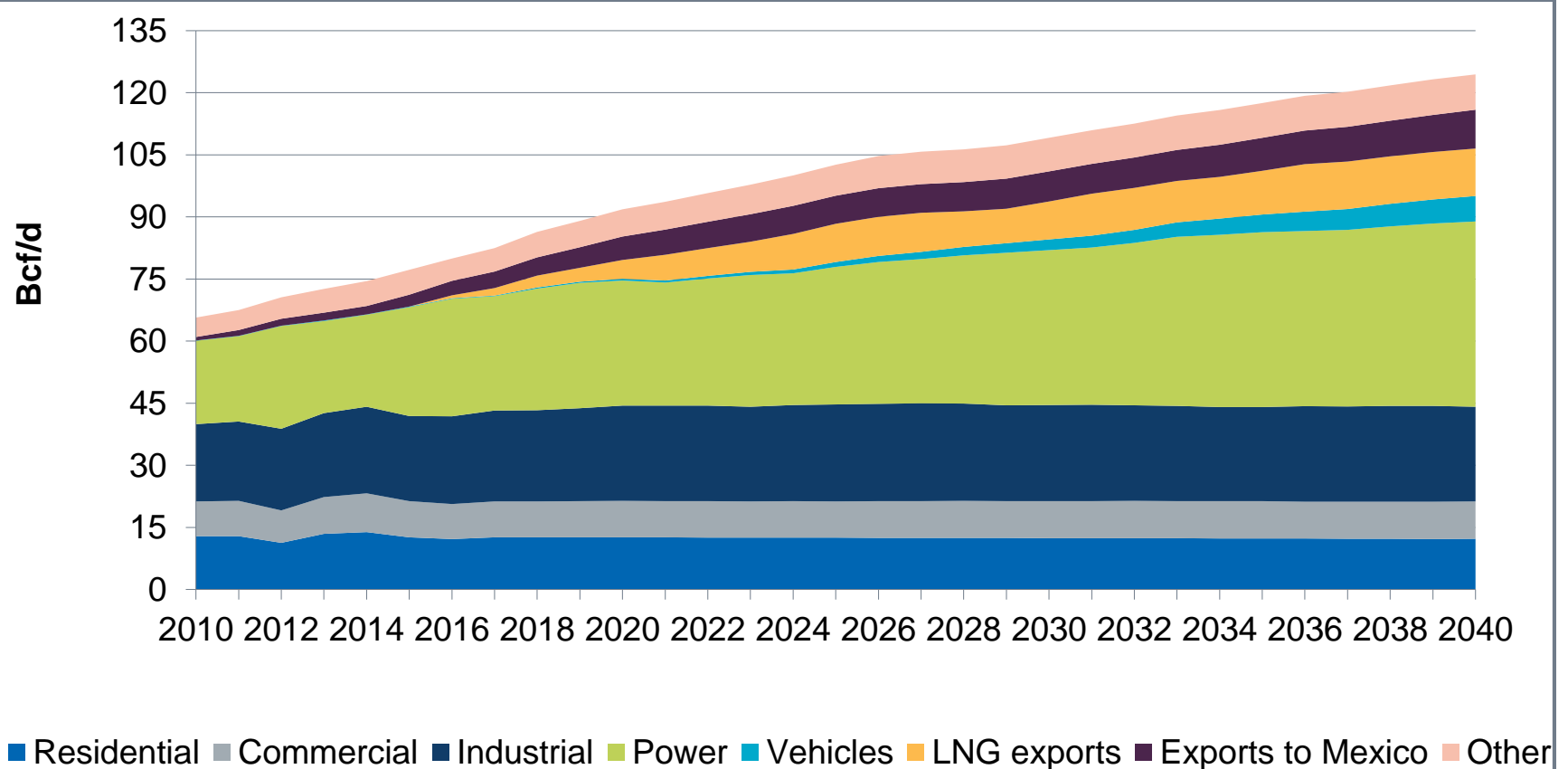
The Oil/gas ratio is expected to recover, led by oil prices; will it reignite interest in NGVs?

Natural Gas and Oil - A Quicker Oil Recovery



US lower-48 demand to approach 125 Bcf/d by 2040; exports and vehicles are material contributors

US lower-48 natural gas demand, 2010 - 2040

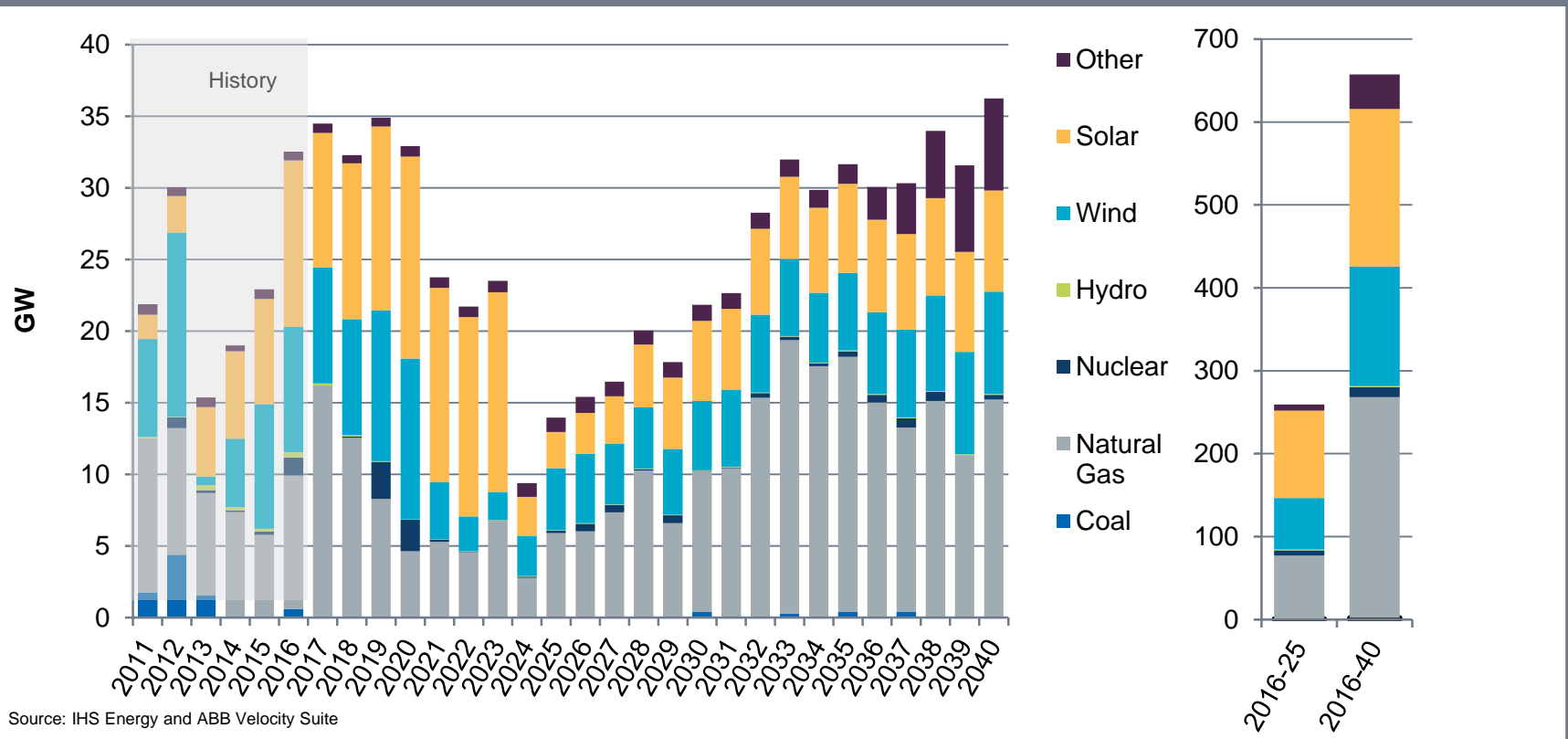


Source: IHS Energy and EIA

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US total capacity additions by year

US Lower-48 total capacity additions, 2011–40

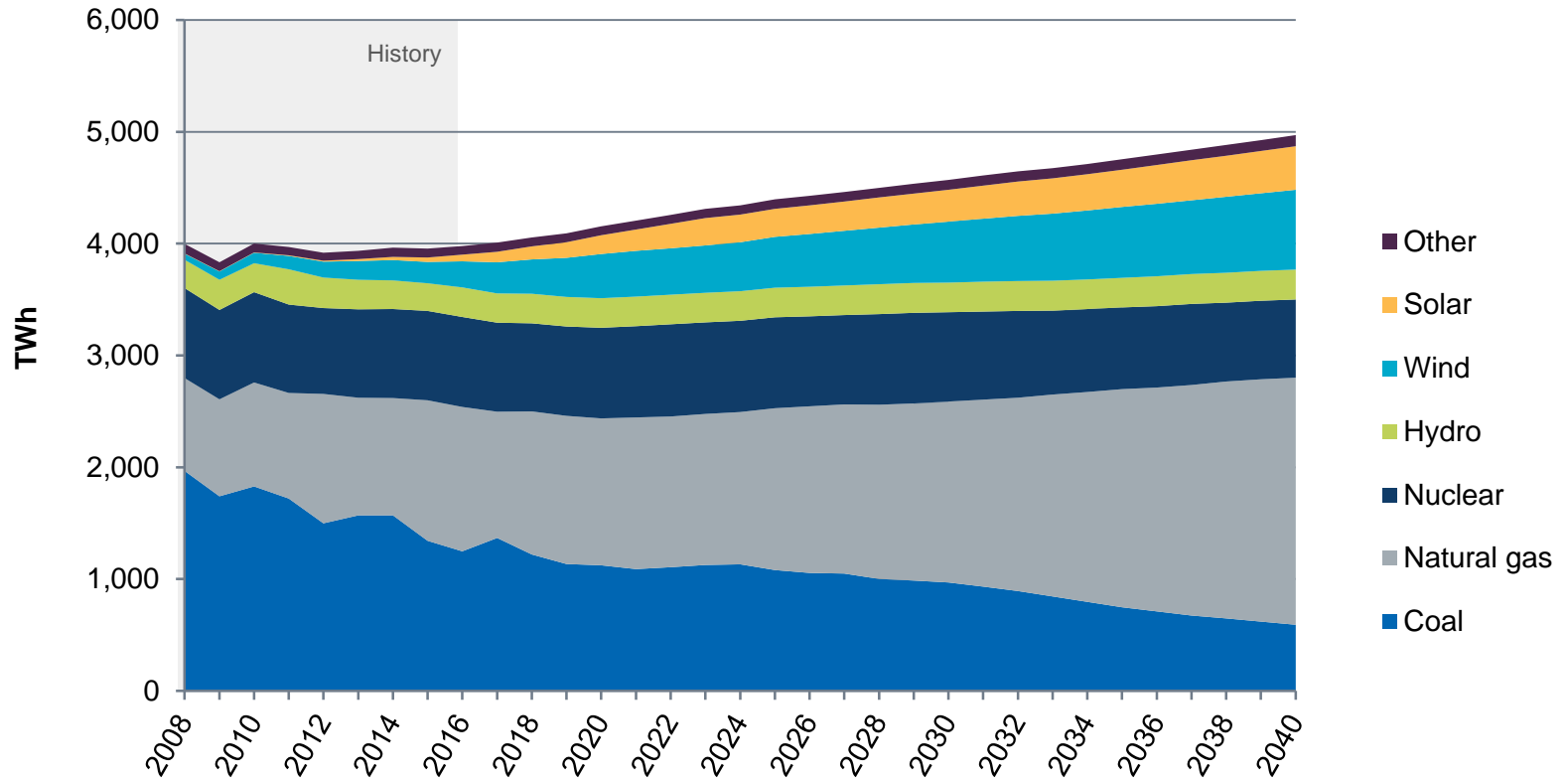


Source: IHS Energy and ABB Velocity Suite

Wind and solar capacity additions dominate the outlook to 2025, supported by federal tax credits available for projects coming online through the early 2020s. Longer term, renewables and natural gas share the market for new additions.

US power generating fuel mix

US Lower-48 power generation by fuel type, 2008-40

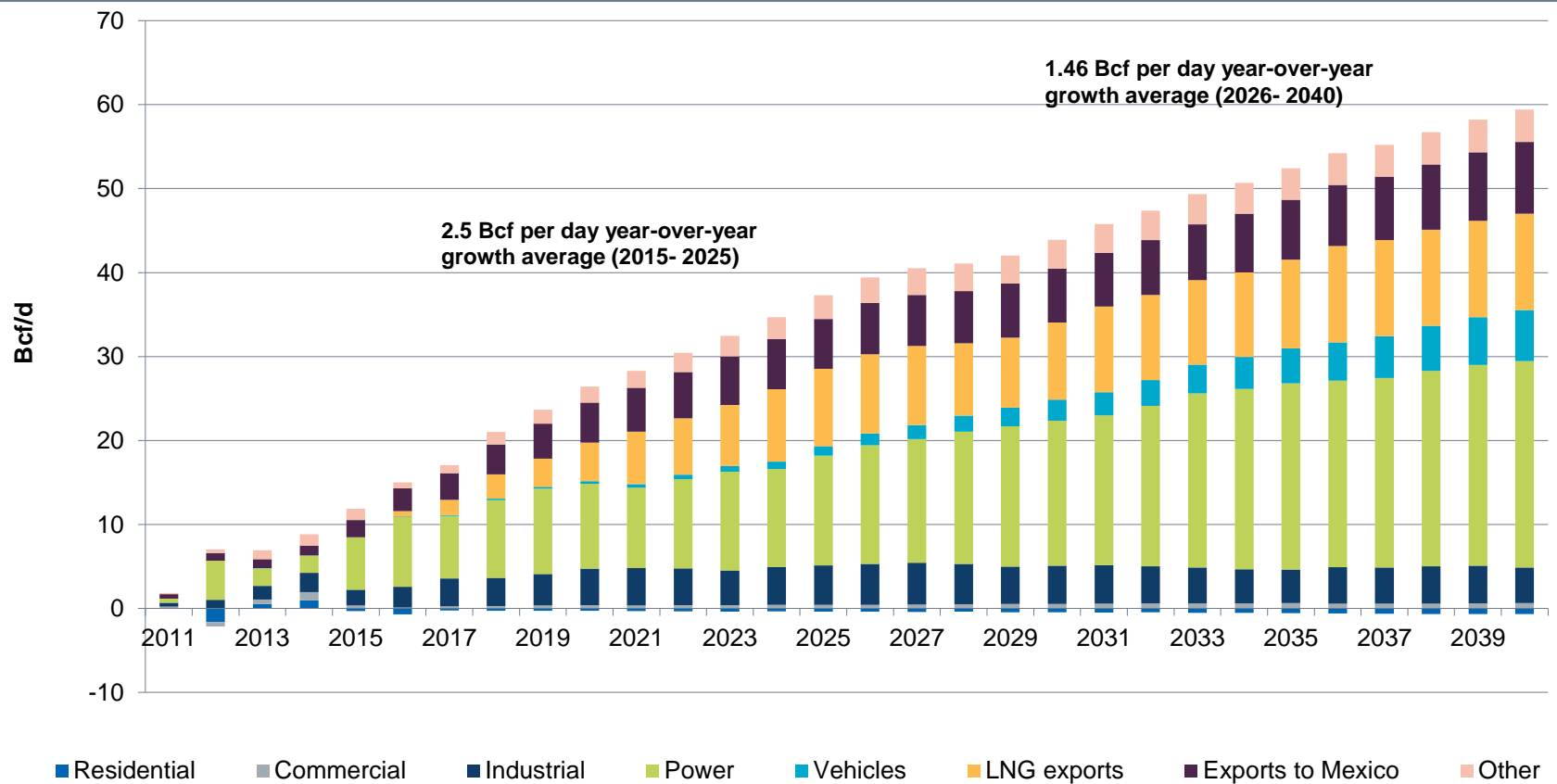


Source: IHS Energy and ABB Velocity Suite

Natural gas and renewable power generation grow at the expense of coal. Penetration of natural gas and non-hydro renewables reaches 35% and 20%, respectively, by 2030.

The US Lower-48 will see nearly 60 Bcf/d of gas demand growth by 2040 over 2010 levels, moving into higher-cost supply areas

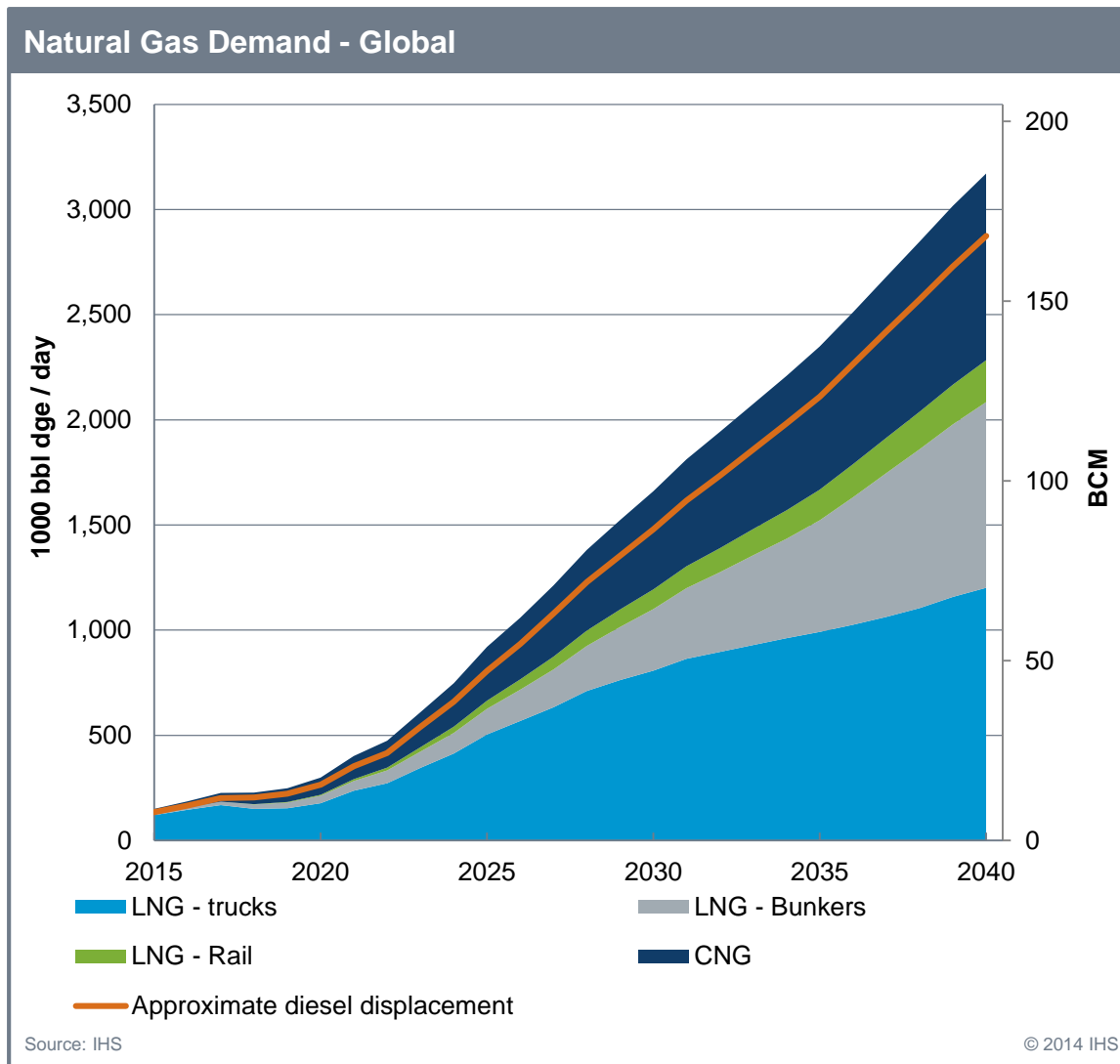
US lower-48 demand growth relative to 2010



Source: IHS Energy and EIA

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Total natural gas demand in heavy goods transportation: globally, it's 2/3 an LNG story



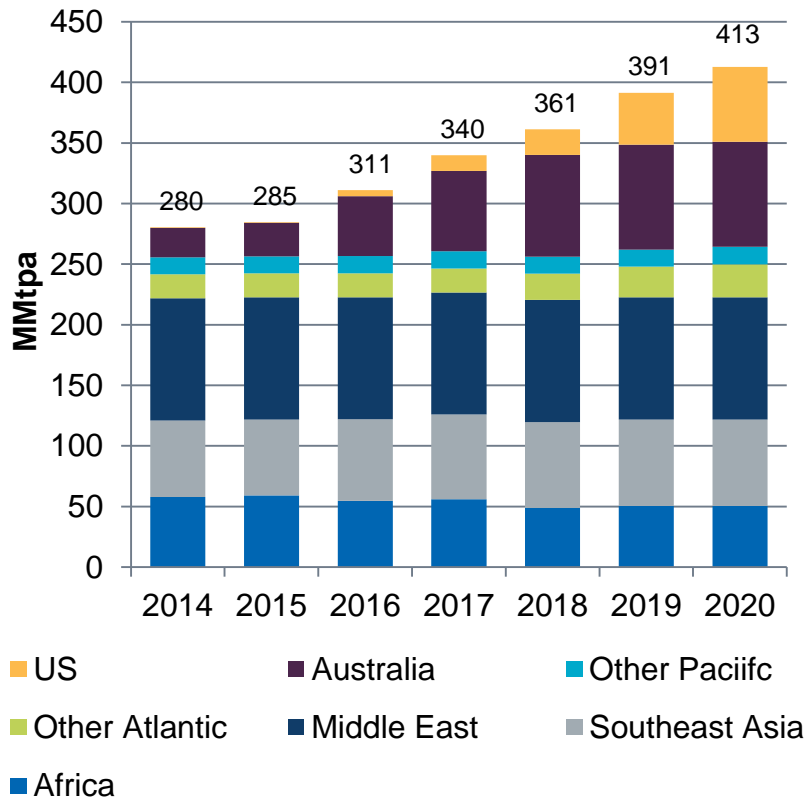
Over 3.1 million barrels per day (185 BCM, **BCM/10 ~ 18.5 Bcf per day**) of diesel equivalent gas demand

Conclusions

- Conversion to natural gas will slow down with low oil prices, but not disappear
- Globally, LNG demand in on-road applications outpaces CNG demand – but this is very market specific
- LNG's use as a bunker fuel remains a major potential market
- Rail conversions are “binary,” based on a few company and national policies
- Diesel displacement is lower than natural gas demand because of efficiency differences.

Australia and US Dominate New Supply Build

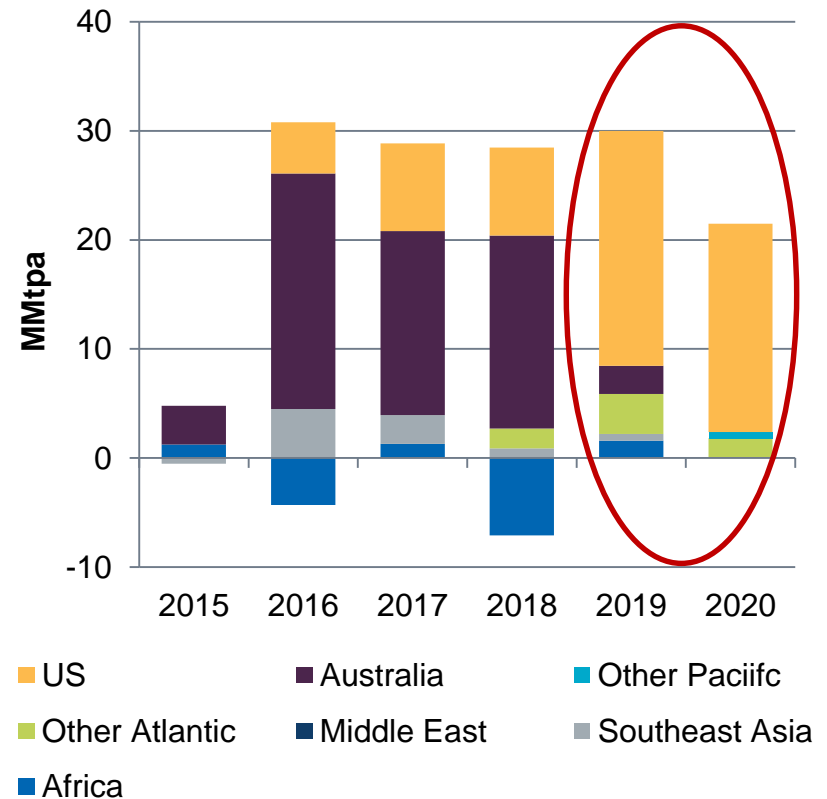
Global liquefaction capacity



Note: MMtpa = Million metrics tons per annum
Source: IHS

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Incremental liquefaction capacity additions

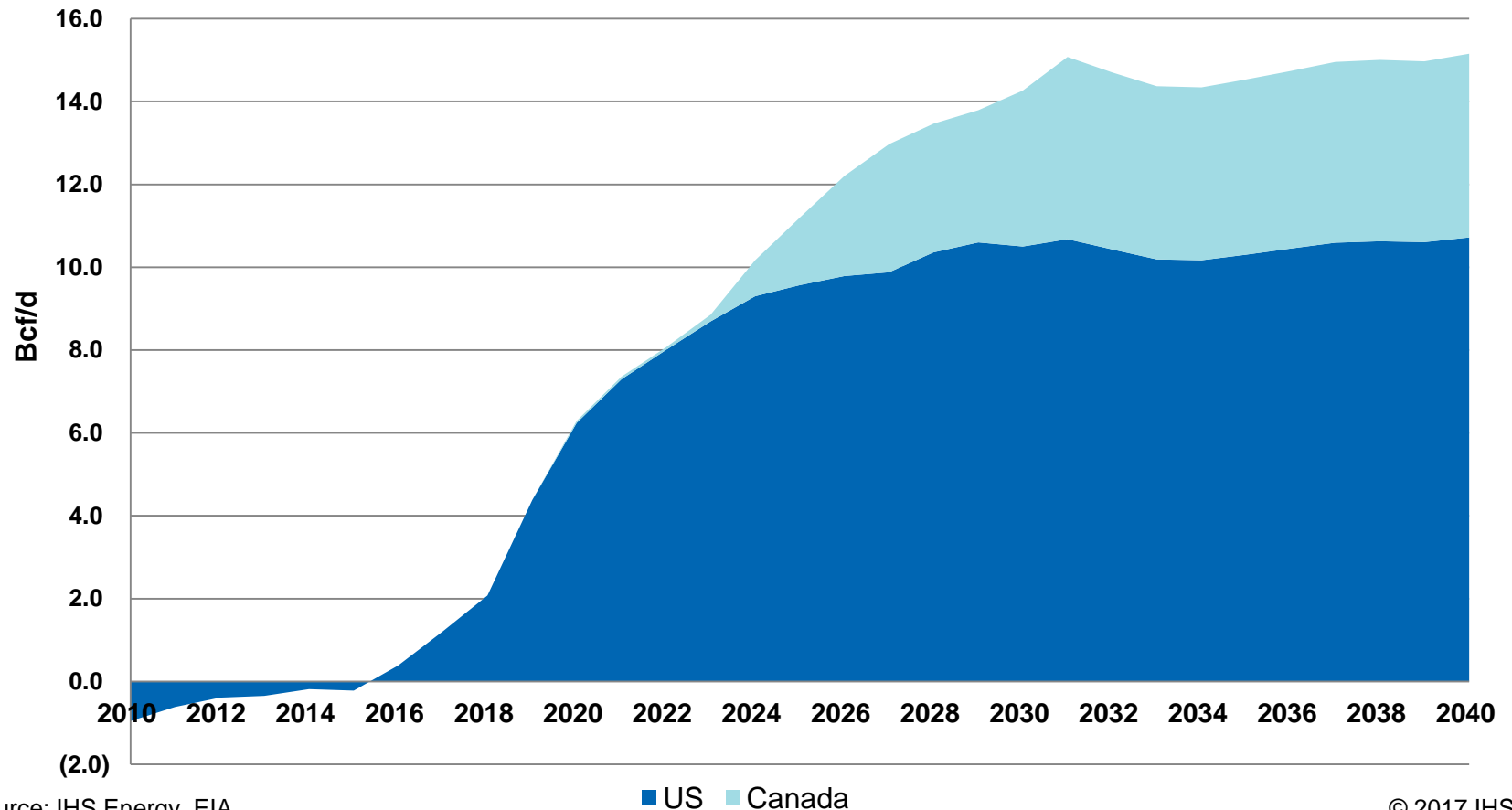


Note: MMtpa = Million metrics tons per annum
Source: IHS

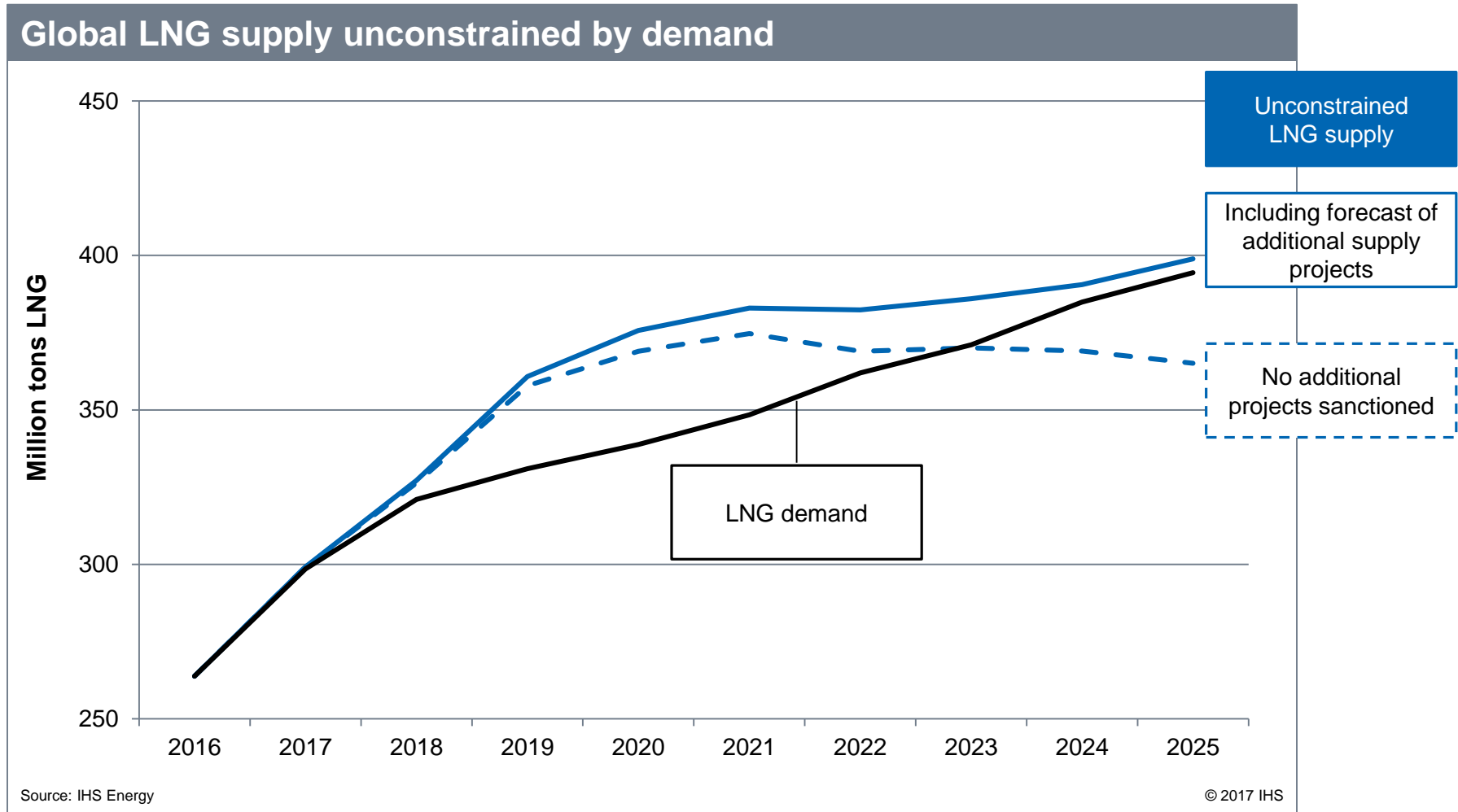
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A steep ramp of North American LNG liquefaction capacity

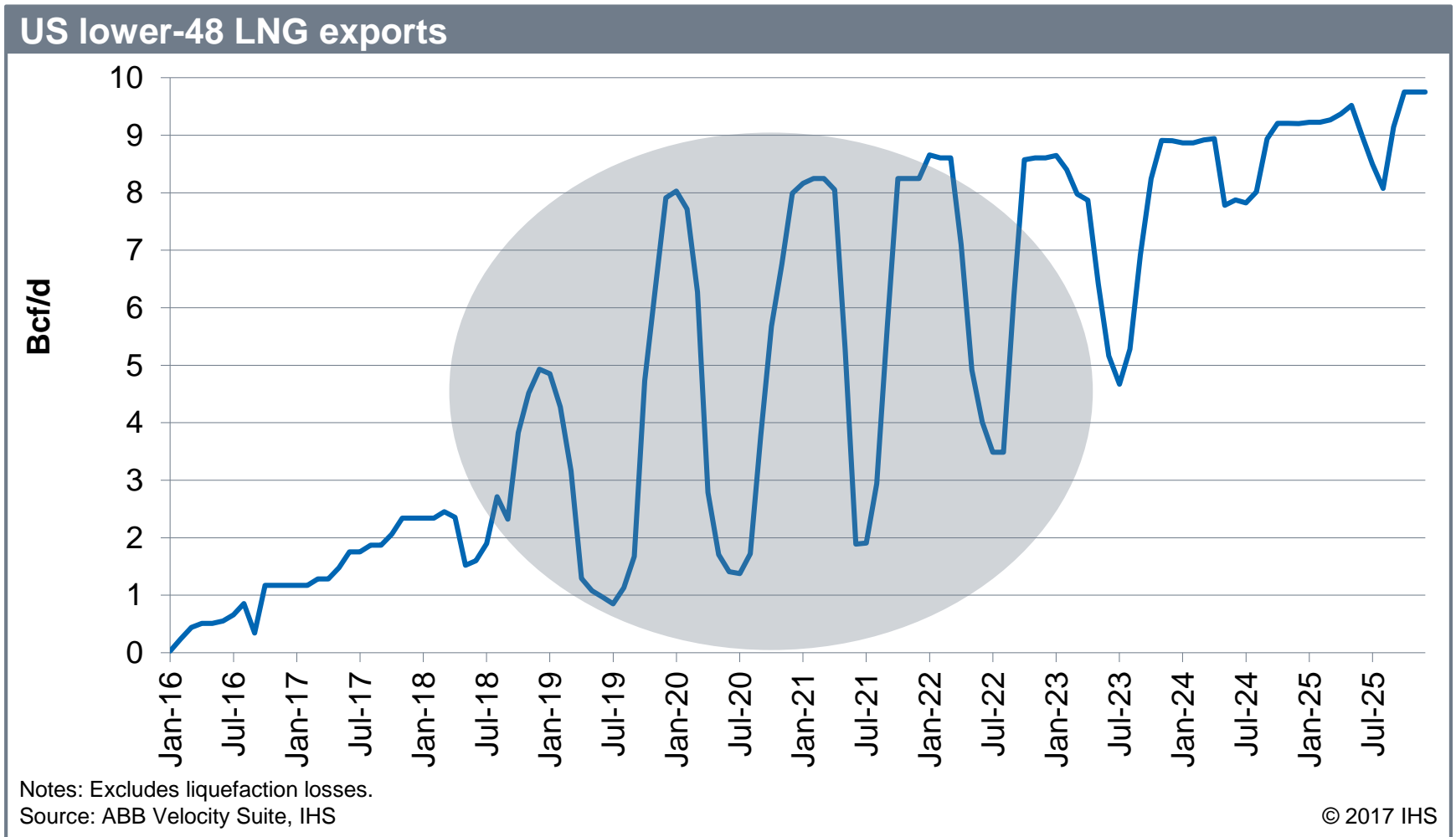
North American LNG exports



Global LNG: How big is the oversupply?



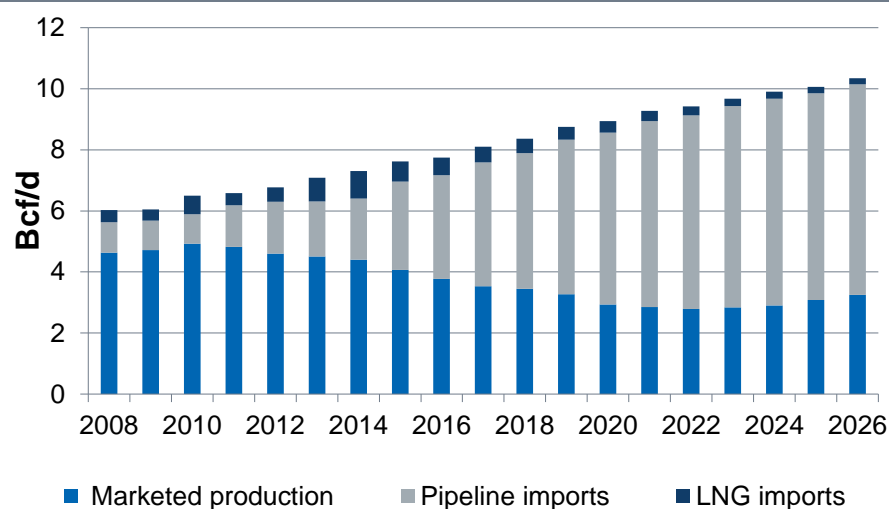
Excess liquefaction capacity reduces US utilization



Mexico: The “push” to import

Mexican supply sources through 2026

Mexico’s natural gas supply outlook

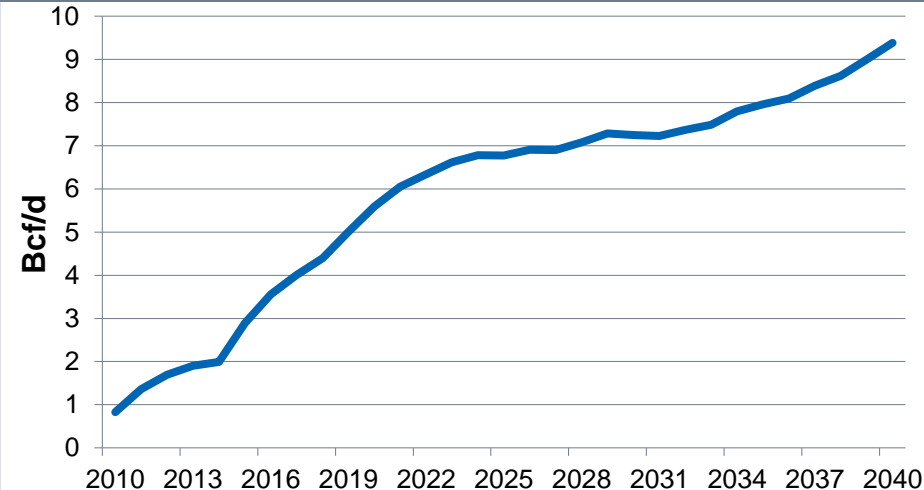


Source: IHS

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Latest export view: + 0.7 Bcf/d added since spring, by 2025

US lower-48 net pipeline exports to Mexico



Source: IHS Energy, EIA

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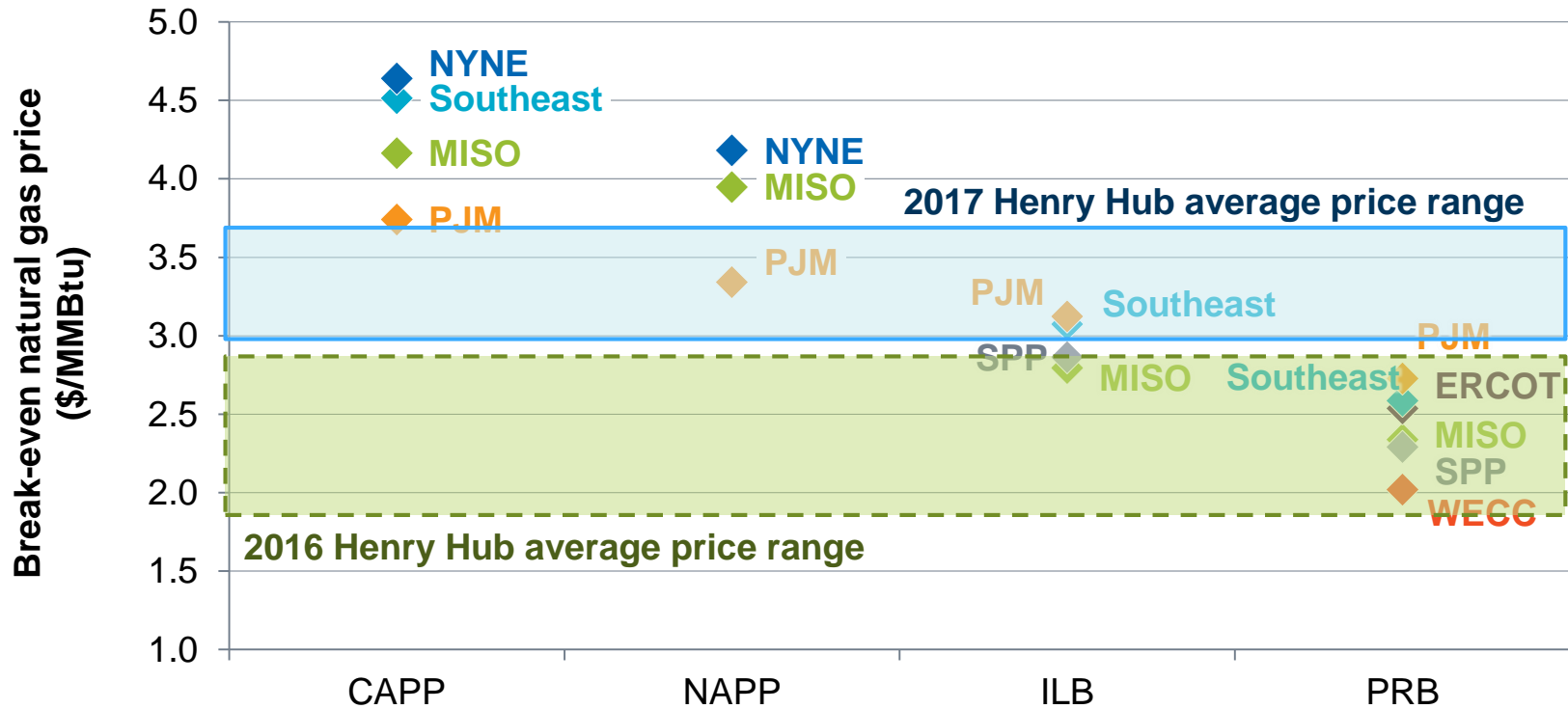
Changes on the margin in the past year:

Mainly Mexican production challenges; slower rebound

Small added demand potential

Market balancing with coal/gas switching

Coal-to-gas delivery economics for 2016



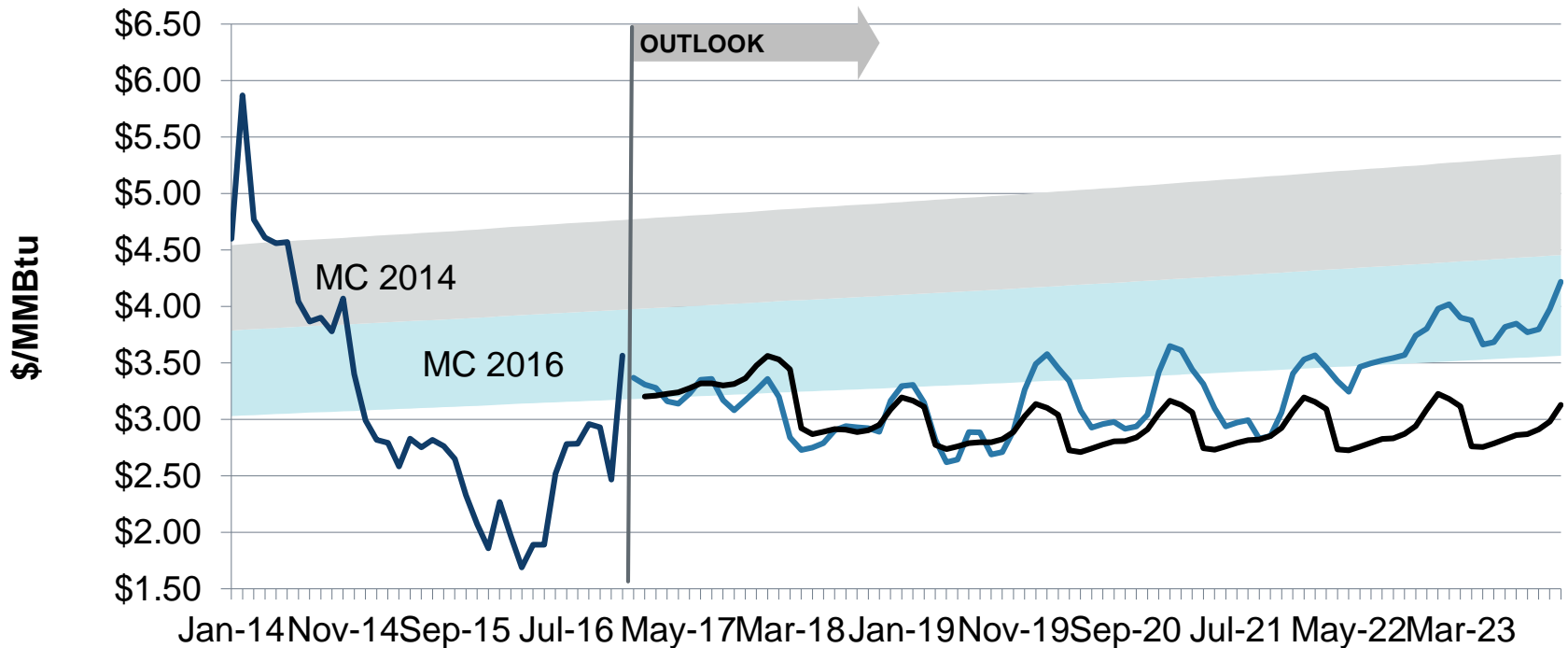
Notes: NYNE = New York and New England; WECC = Western Electricity Coordinating Council. CAPP = Central Appalachia basin; NAPP = Northern Appalachia basin; ILB = Illinois Basin; PRB = Powder River Basin. Coal price adjusted to gas equivalent (10,250 Btu/kWh coal versus 7,800 Btu/kWh gas).

Source: IHS Energy

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Henry Hub price history and outlook

January 2017 Henry Hub history and forecast



■ Marginal cost range 2
 ■ Marginal Cost Range
 — Henry Hub
— IHS forecast, January 2017
 — NYMEX, 20 January 2017

Notes: MMBtu = million Btu.
 Source: IHS, CME, Intelligence Press

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Americas: +1 800 IHS CARE (+1 800 447 2273); CustomerCare@ihs.com

Europe, Middle East, and Africa: +44 (0) 1344 328 300; Customer.Support@ihs.com

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