The U.S. Shale Revolution: Certainty in an Uncertain World

Presentation to:
CCUS Student Week 2018

By:
John Harpole

Mercator Energy

October 16, 2018

The New “Metaphor” by Maytag

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Don’t worry about your future in the energy industry.

“If we didn’t have oil, we would invent it.”

- Robert Bryce

Lesson: Don’t ever think that the renewable energy industry is going to put you out of a job. It is all about energy density.

“ … an all-renewable California would need more solar capacity in the state than currently exists on the entire planet.”*

Source: http://robertbryce.com/all-renewable-energy-in-california/

Preface

In order to meet California's 100% renewable energy target by 2045, the wind energy contribution to that goal would require that "California would have to cover a land area roughly four times the size of L.A. County with nothing but massive windmills."

It is all about energy density and don't forget it.

Source: http://robertbryce.com/all-renewable-energy-in-california/

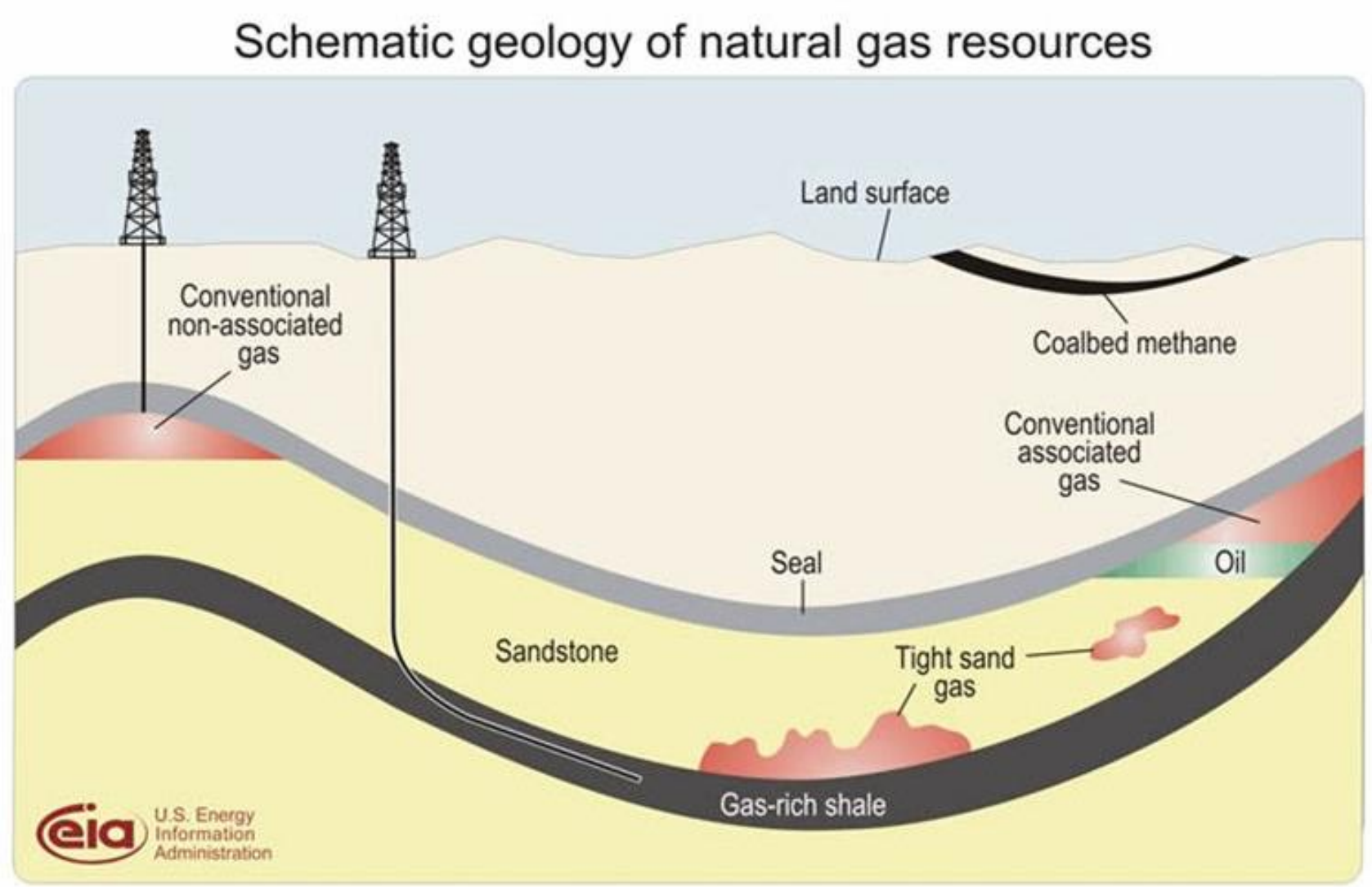
Preface

"According to the EIA, in 1949, oil provided 37 percent of America's total energy needs. In 2009, oil's share of U.S. primary energy stood at … 37 percent."

"Here's the bottom line: Renewables will remain niche players in the global energy mix for decades to come. The past—and the foreseeable future—still belong to hydrocarbons. And we can expect natural gas, the cleanest of the hydrocarbons, to garner a bigger share of the global energy pie in the near term and in the long term."

Source: *Don't Count Oil Out*, Robert Bryce, October 2011

It is not a scarce resource anymore



Source: US Energy Information Administration

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Circa 2007

Russia's Energy Muscle

- Energy Used Over 55 times Against Former Soviet Nations Since 1990

Source: *Europe Doubles Down on Russian Gas to Feed its Energy Appetite,* by Andrew Haney, Ricardo Bracho, Nick Wolfe and Max Faith

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Circa 2007

Gazprom's Current Near-Monopoly Supply Position

% of Supply from Gazprom/Russia	
Slovakia	100%
Macedonia	100%
Finland	99%
Bulgaria	97%
Serbia & Montenegro	87%
Lithuania*	84%
Hungary	80%
Czech Republic	79%
Greece	76%

*Remember

Source: "Domestic Consumption" EIA International Energy Annual, 2007; "Exports 2006 and 2007" Gazexport as cited by Energy Intelligence, March 2008

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Circa 2007

Gazprom's Current Near-Monopoly Supply Position (cont'd)

% of Supply from Gazprom/Russia	
Austria	74%
Slovenia	64%
Poland	62%
Turkey	60%
Germany	40%
Croatia	37%
Italy	30%
Romania	28%
France	25%

Source: "Domestic Consumption" EIA International Energy Annual, 2007; "Exports 2006 and 2007" Gazexport as cited by Energy Intelligence, March 2008

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10/21/2008 in Tehran, Iran
Russia, Iran and Qatar form natural gas cartel

Qatar's Deputy Premier and Minister of Energy and Industry, Abdullah bin Hamad Al-Attiya

Iranian Oil Minister, Gholam Hossein Nozari

Alexei Miller, Chief of Russia's state gas monopoly - Gazprom

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Circa 2007

U.S. Shale Gas Development Could be Slowed by LNG Imports

- "Importing LNG to the U.S. would be economical at an average gas price as low as $3.50/MMBtu."
- "Whereas shale gas requires an average gas price of at least $6.50/MMBtu to be economical."

Source: Scott Thetford. VP of Pace Global Energy Services, LLC

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Wrong!

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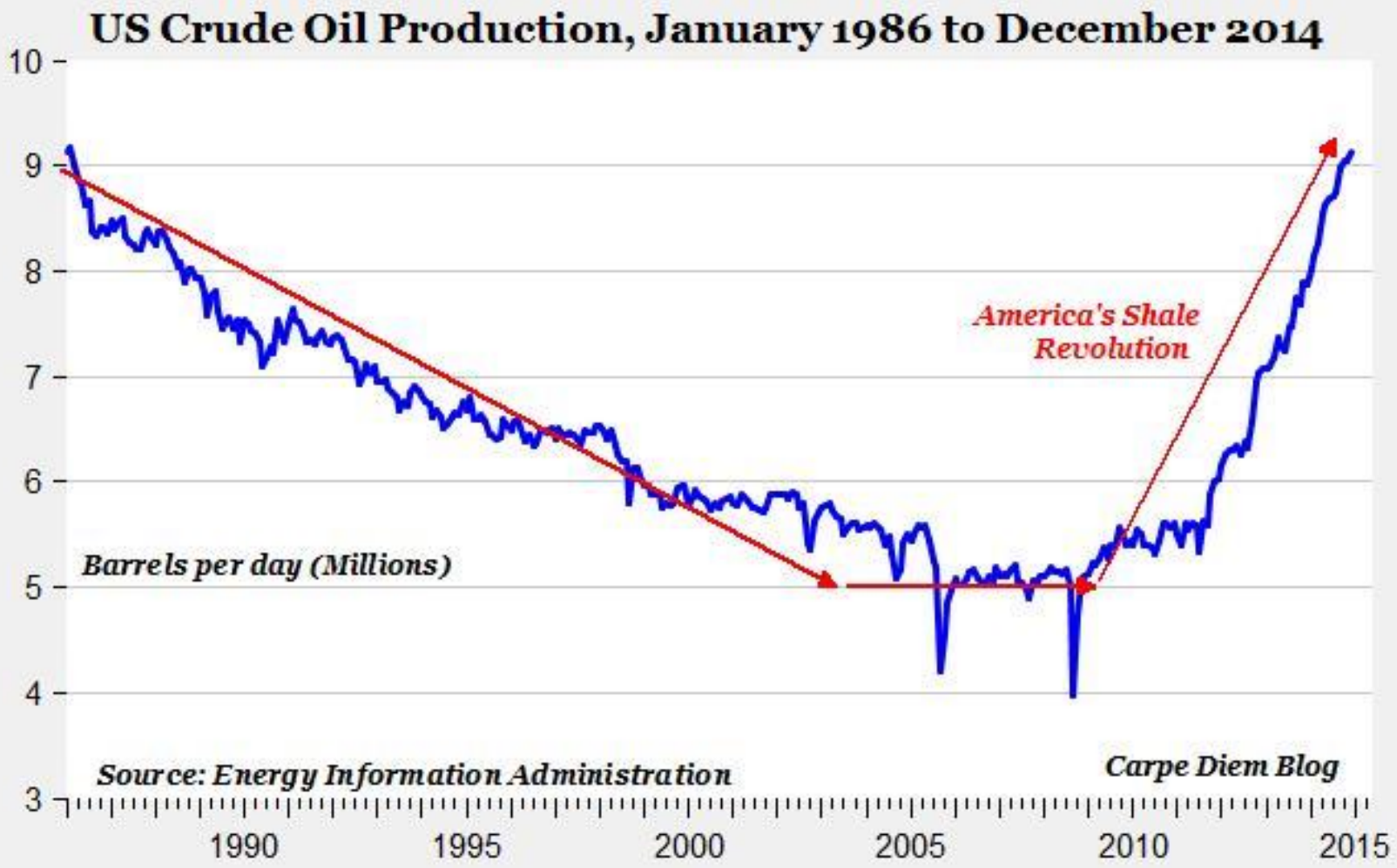
… and then the U.S. Shale Revolution happened… and the world will never be the same again.



Source: *My top ten energy charts of the year for 2014,* Mark J. Perry, American Enterprise Institute, January 5, 2015

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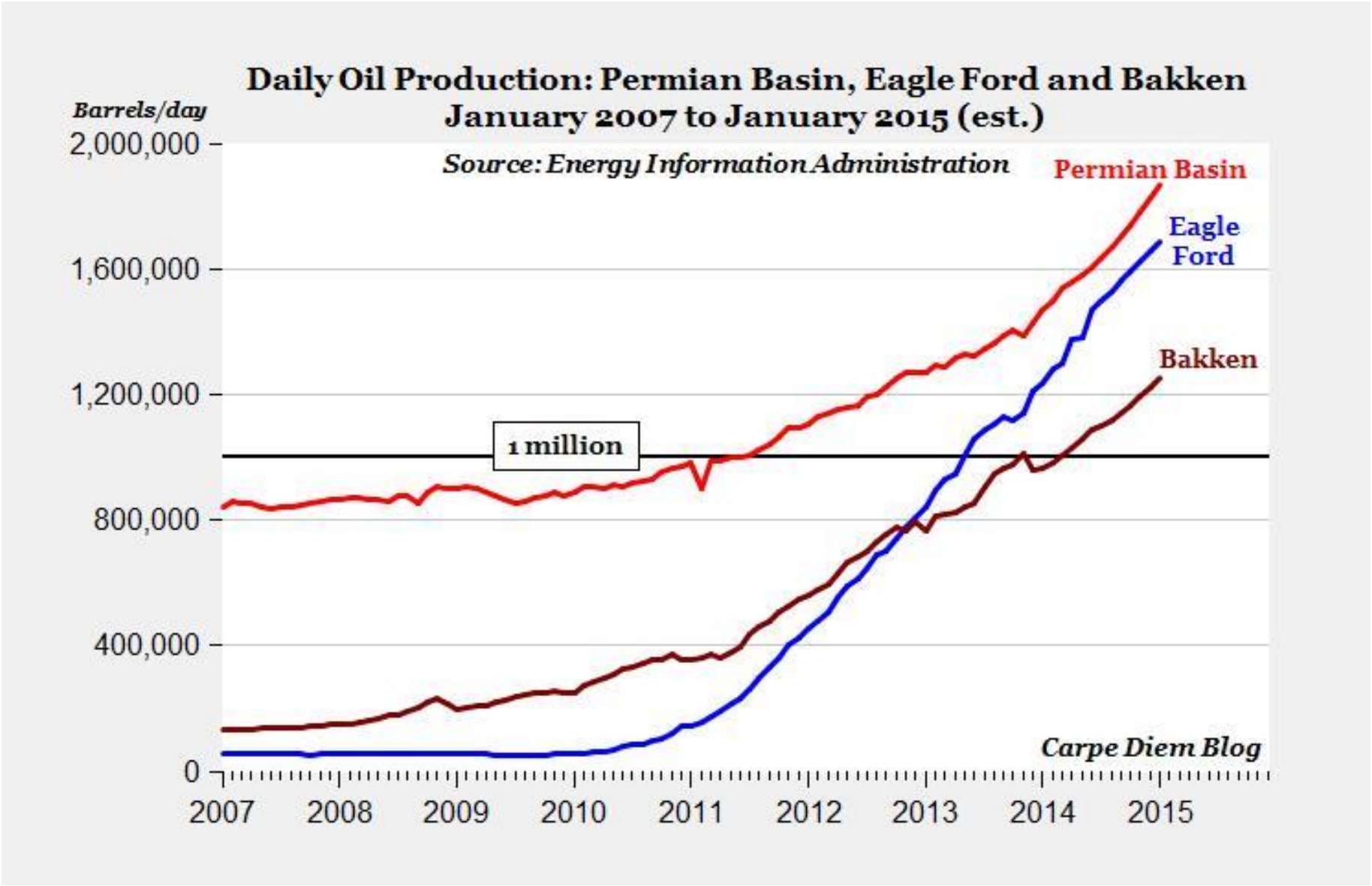

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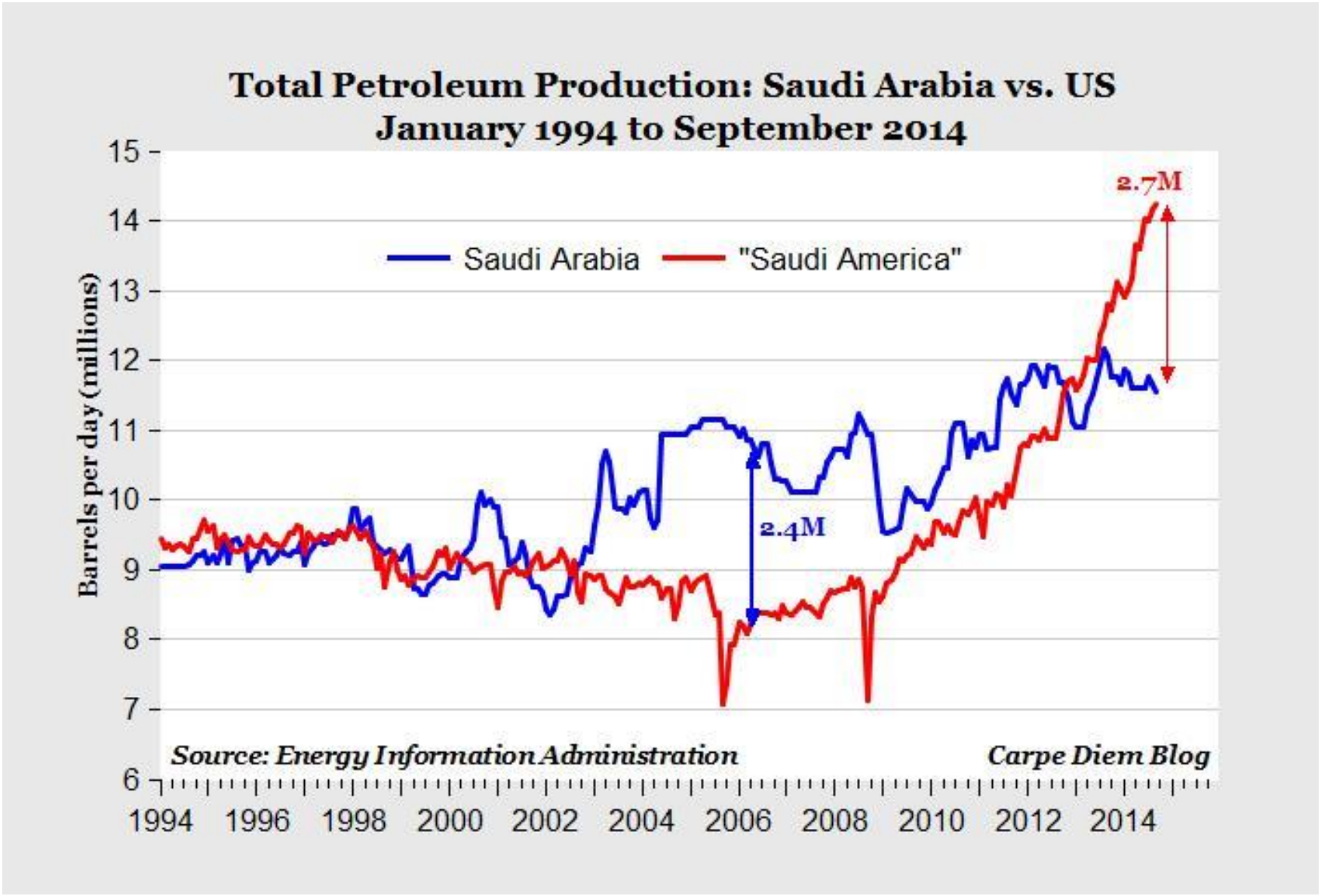

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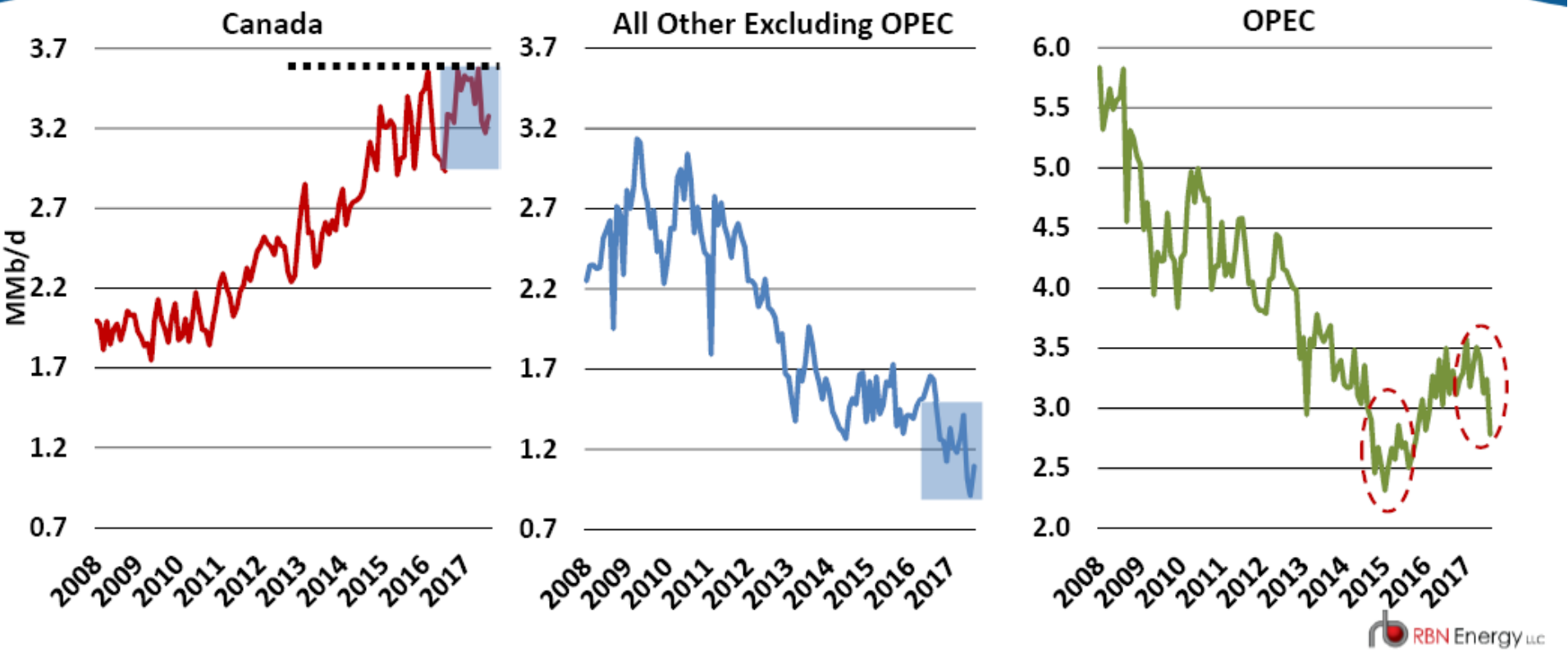
U.S. Crude Oil Imports



Source: *Midstream to Markets: Oil Markets: Out of the Woods?,* RBN Energy, The Energy Summit, August 23, 2017

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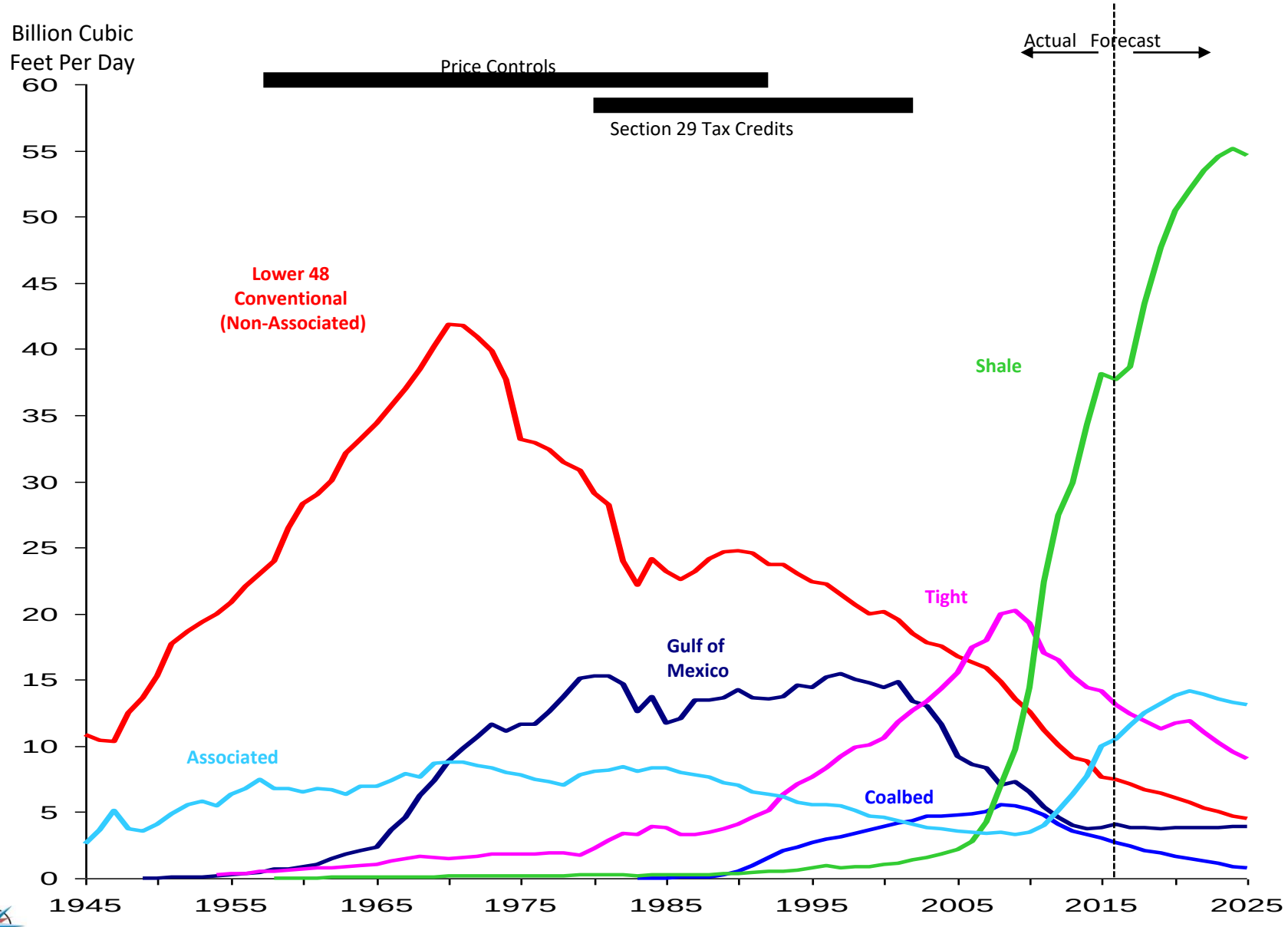
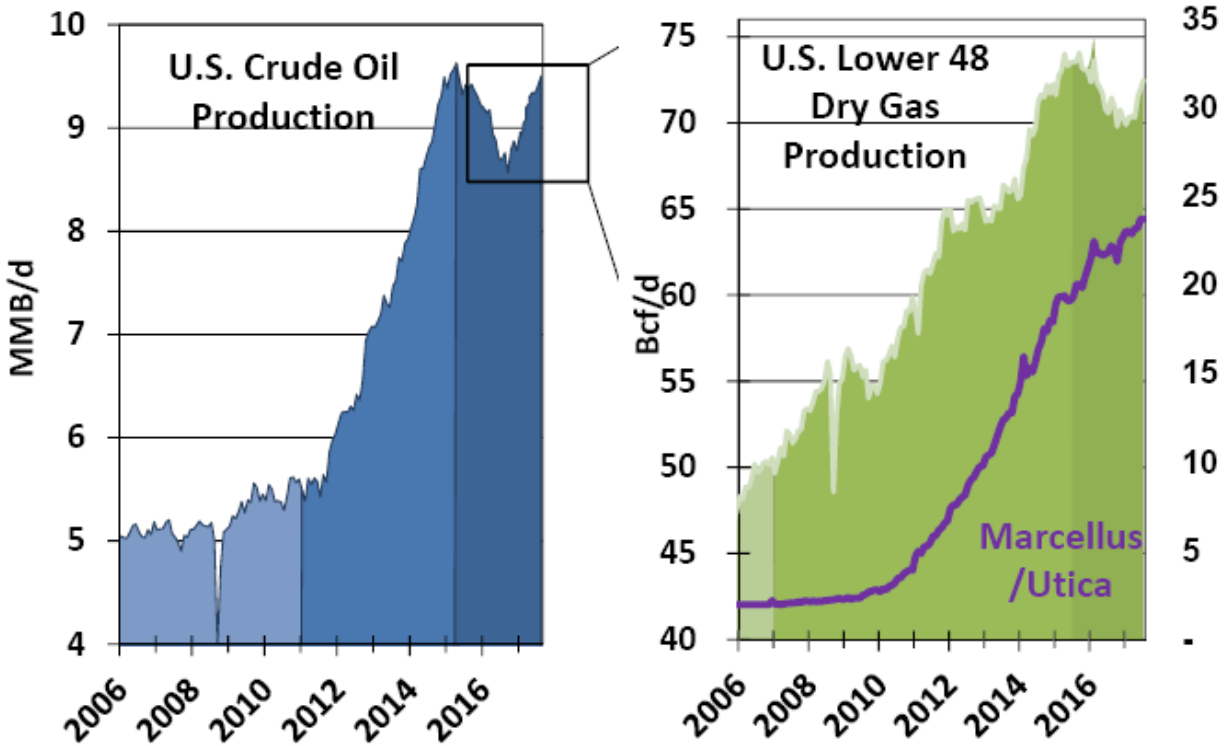
FIGURE 3

UNITED STATES NATURAL GAS PRODUCTION



Source: *The Outlook for Oil and Gas,* Henry Groppe, Groppe, Long & Littell, May 2017

Production of Crude Oil and Natural Gas



RBN Energy LLC

Source: *Midstream to Markets: Oil Markets: Out of the Woods?,* RBN Energy, The Energy Summit, August 23, 2017

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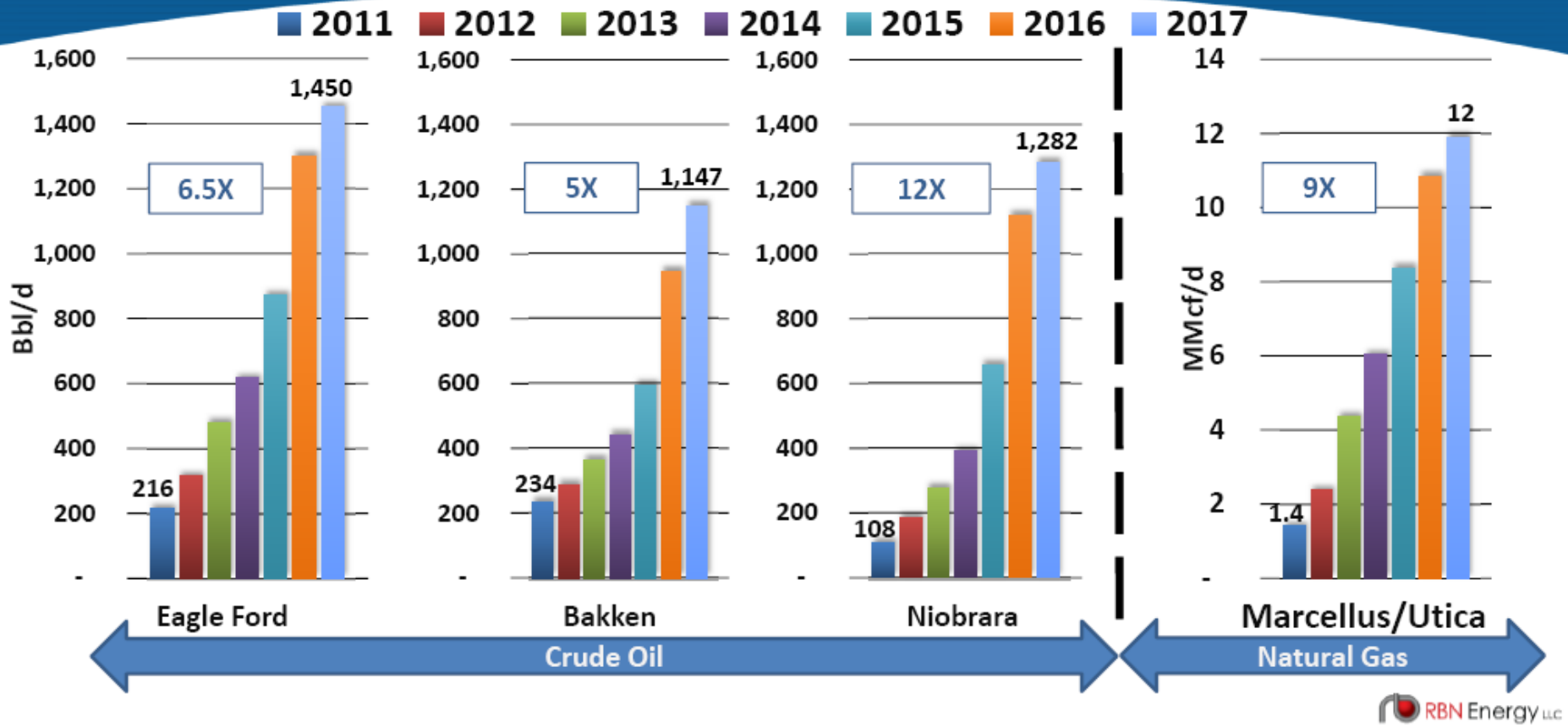
Oil and Gas Production Added Per Rig



Source: *Midstream to Markets: Oil Markets: Out of the Woods?,* RBN Energy, The Energy Summit, August 23, 2017

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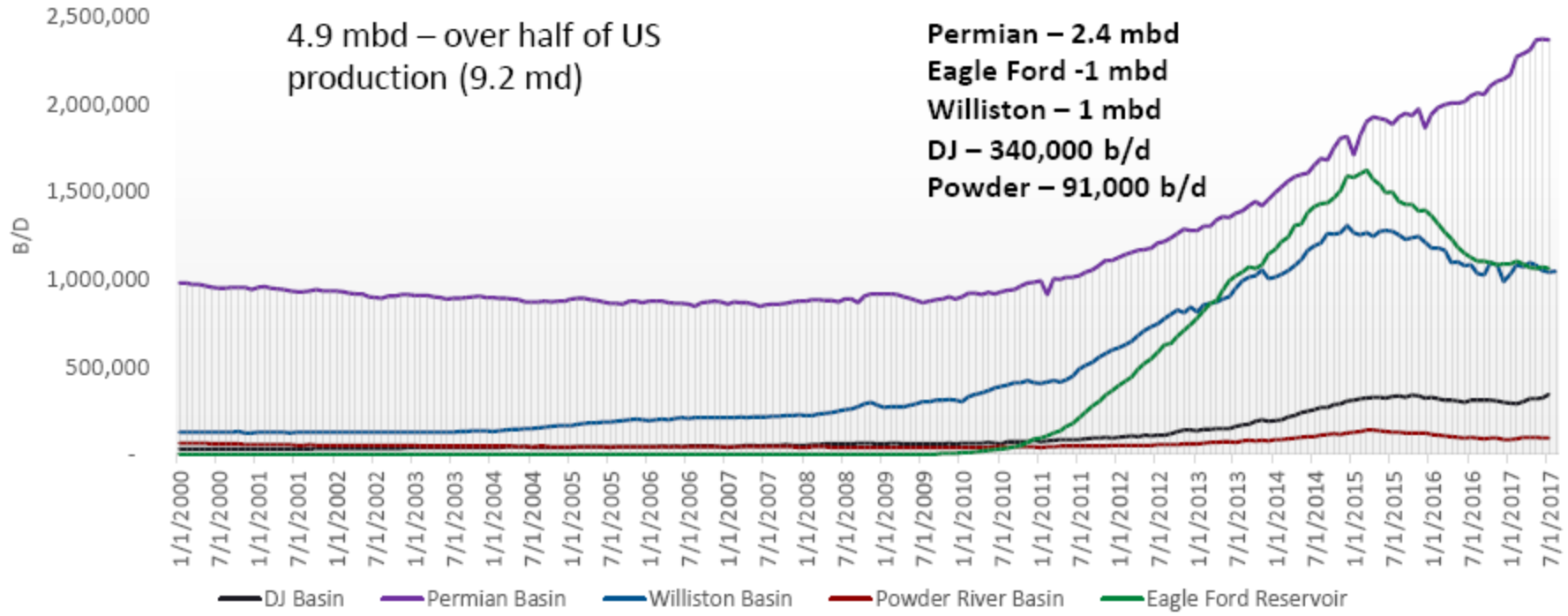
Spud to Total Depth in Less than Three Days

Extraction rig, September 2017

Source: *US Shalers – Beating the Bears,* Trisha Curtis, PetroNerds, presentation to The Oxford Institute for Energy Studies, November 2017

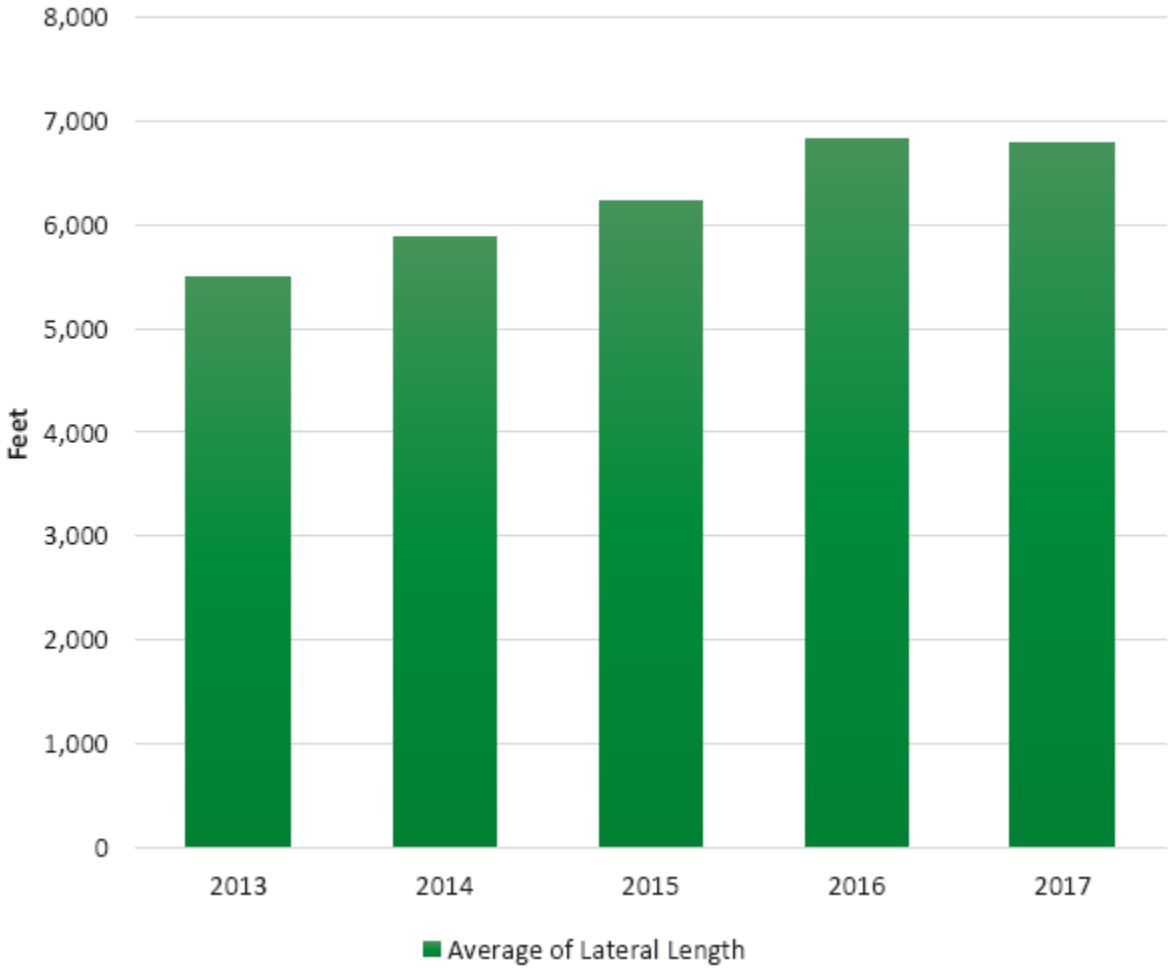
Shale Oil Play Production



Source: PetroNerds, DrillingInfo

Source: *US Shalers – Beating the Bears,* Trisha Curtis, PetroNerds, presentation to The Oxford Institute for Energy Studies, November 2017

Permian Basin Productivity by Average Lateral Length



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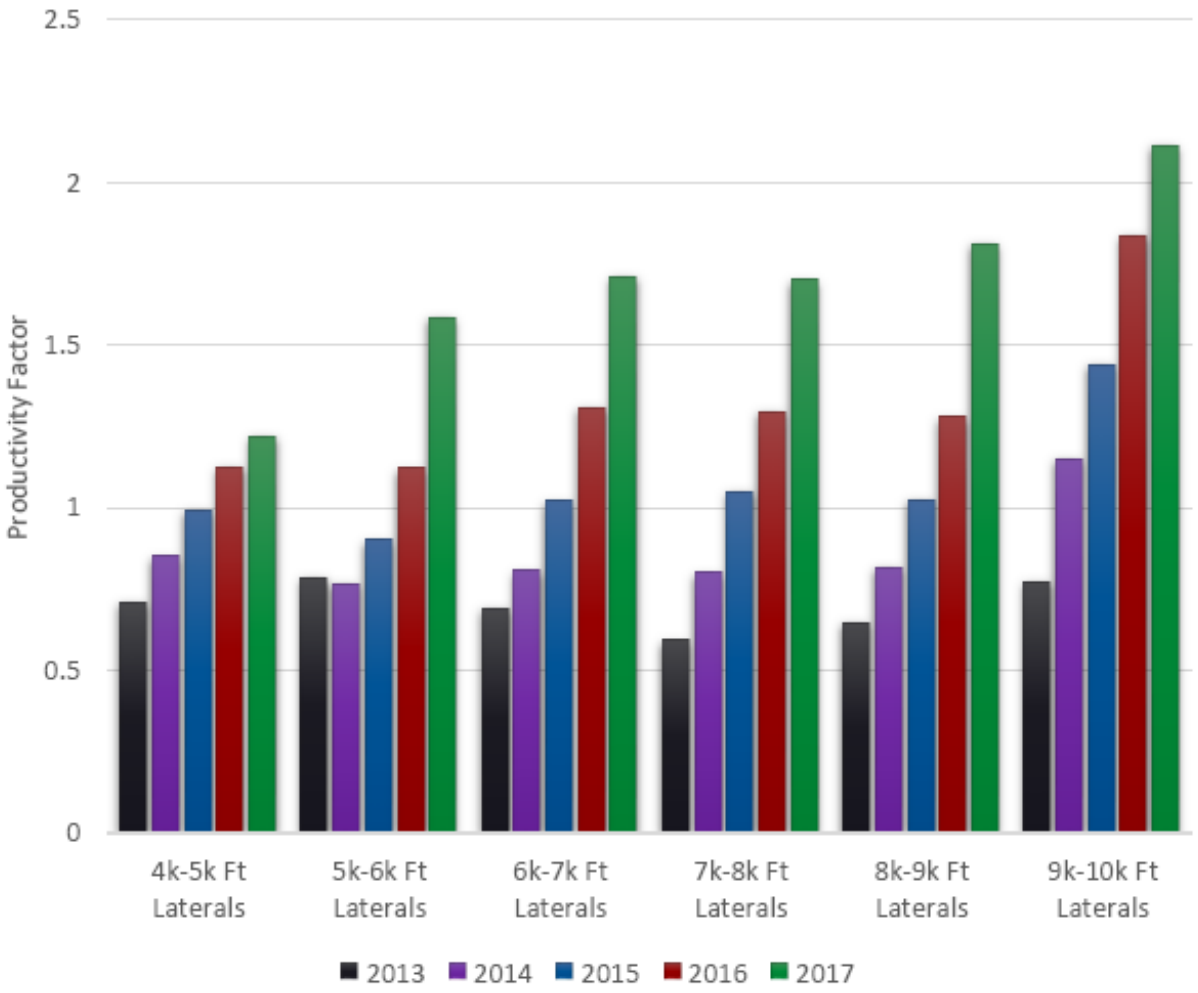

Source: *US Shalers – Beating the Bears,* Trisha Curtis, PetroNerds, presentation to The Oxford Institute for Energy Studies, November 2017

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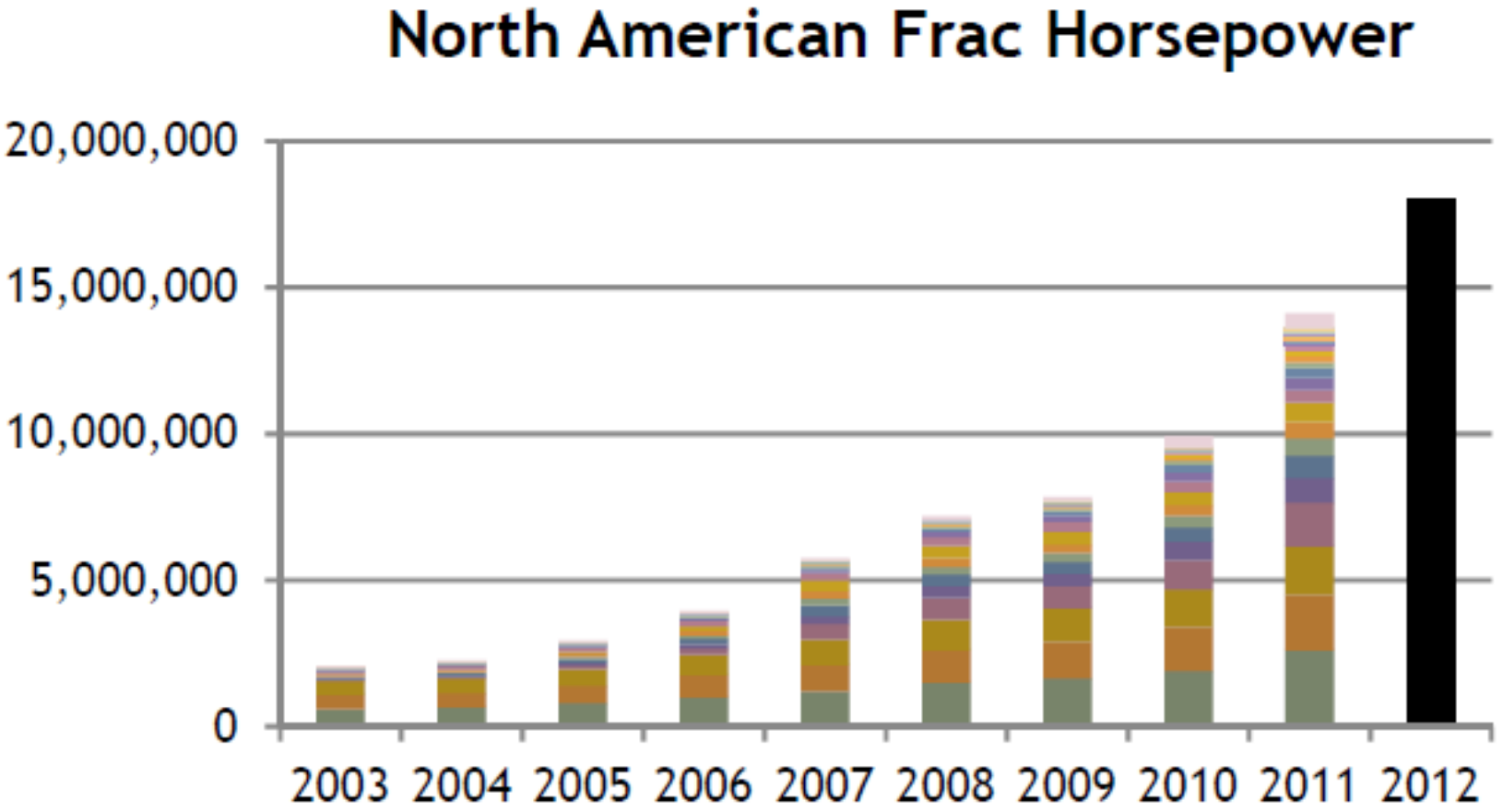
Fracturing Application Exploded



Source: Chris Wright, Liberty Resources Tuesday Lunch Club Presentation, 3/5/13

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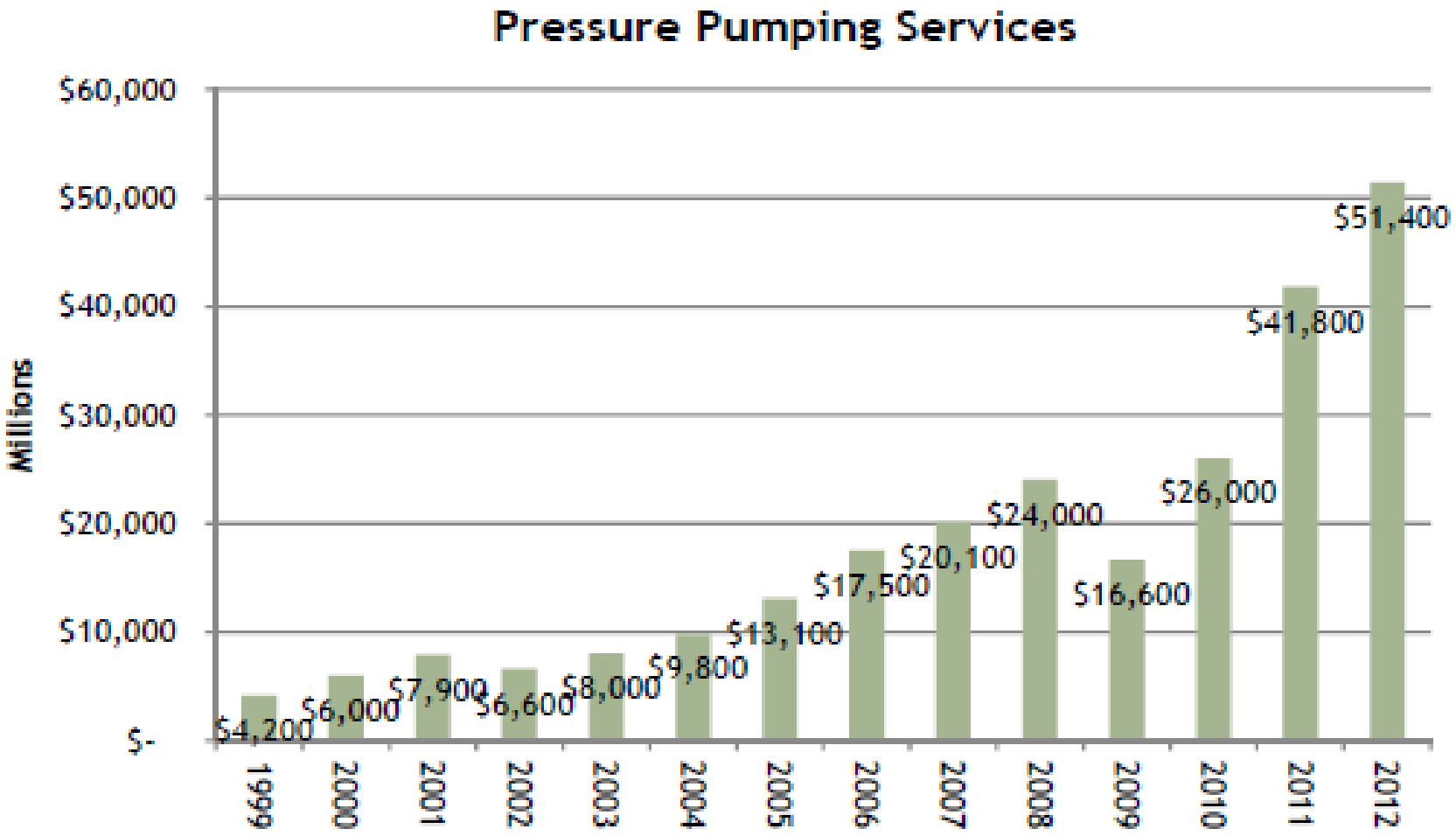
10-fold growth in 10 years



Source: Chris Wright, Liberty Resources Tuesday Lunch Club Presentation, 3/5/13

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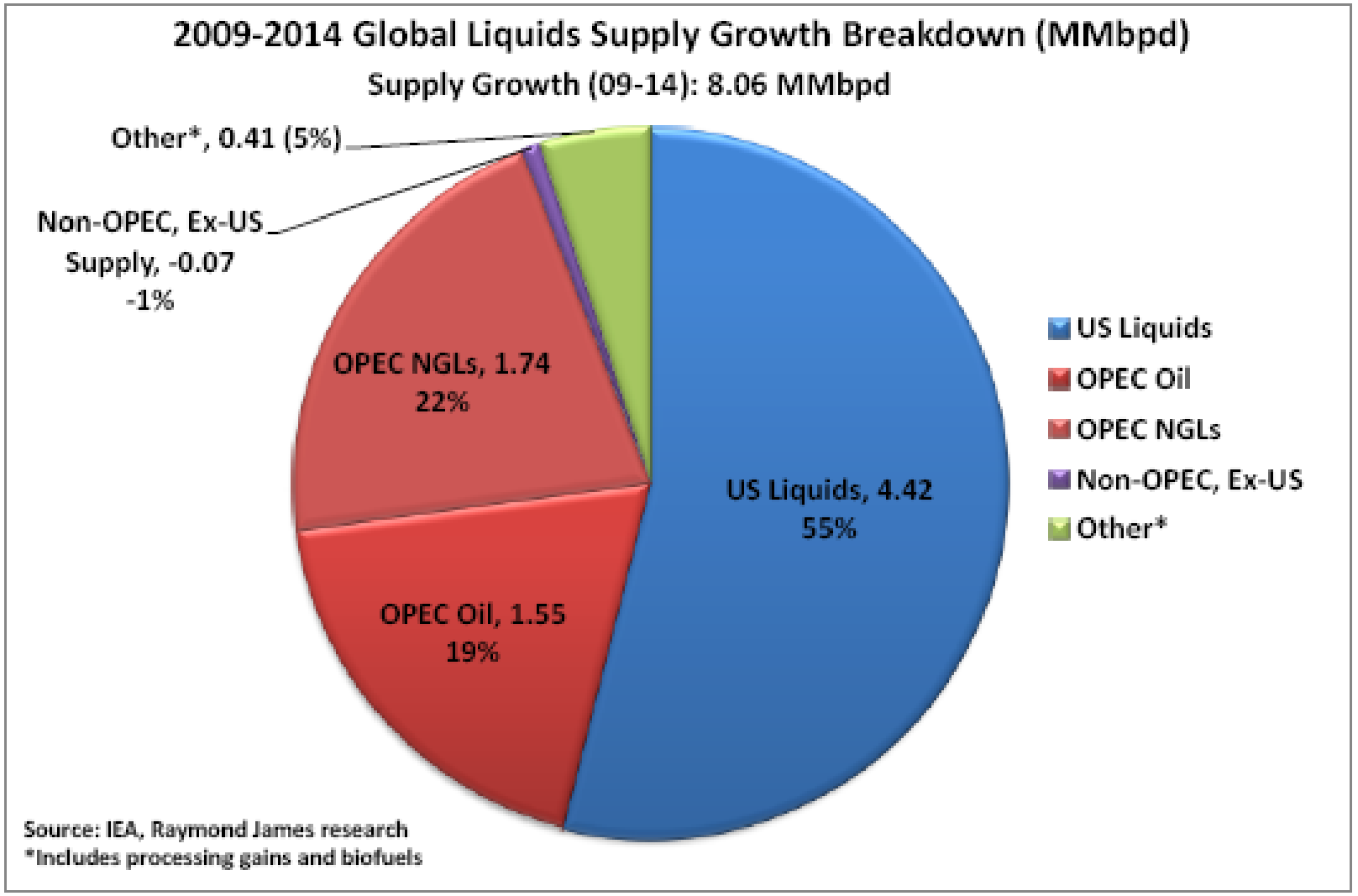
The House of Saud's Motivation



Source: *Raymond James U.S. Research Energy Report,* January 12, 2015

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2014 Quote

OPEC's Strategy?

"In 2016, when OPEC ***completes this objective of cleaning up the American marginal market***, the oil price will start growing again," said Fedun, who's made a fortune of more than $4 billion in the oil business, according to data compiled by Bloomberg. ***"The shale boom is on a par with the dot-com boom. The strong players will remain, the weak ones will vanish."***

- Leonid Fedun, VP and Board Member at OAO Lukoil (LKOD)

Source: *OPEC Policy Ensures U.S. Shale Crash, Russian Tycoon Says,* Asst Natl Dir Melony B. DeFord, Tea Party Command Center, November 28, 2014

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2014 Quote

Oil at $65 Until Mid-2015: Kuwait Official

"The reason, according to Iranian Oil Minister, Bijan Namdar Zanganeh, was to keep prices low enough and long enough to threaten the U.S. shale oil industry and restore OPEC's market share in America. Shale extraction requires expensive methods such as fracking and horizontal drilling, and many observers say it isn't profitable if the price of oil drops below $65 per barrel."

Source: Real Money, The Street Ratings, By: Oilprice.com, December 11, 2014

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OPEC Secretary Urging US Shalers to Slow it Down – Oct 9, 2017

Source: *US Shalers – Beating the Bears,* Trisha Curtis, PetroNerds, presentation to The Oxford Institute for Energy Studies, November 2017

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OPEC Secretary Urging US Shalers to Slow it Down – Oct 9, 2017

"We urge our friends, in the shale basins of North America to take this shared responsibility with all seriousness it deserves, as one of the key lessons learnt from the current unique supply-driven cycle," said Barkindo.

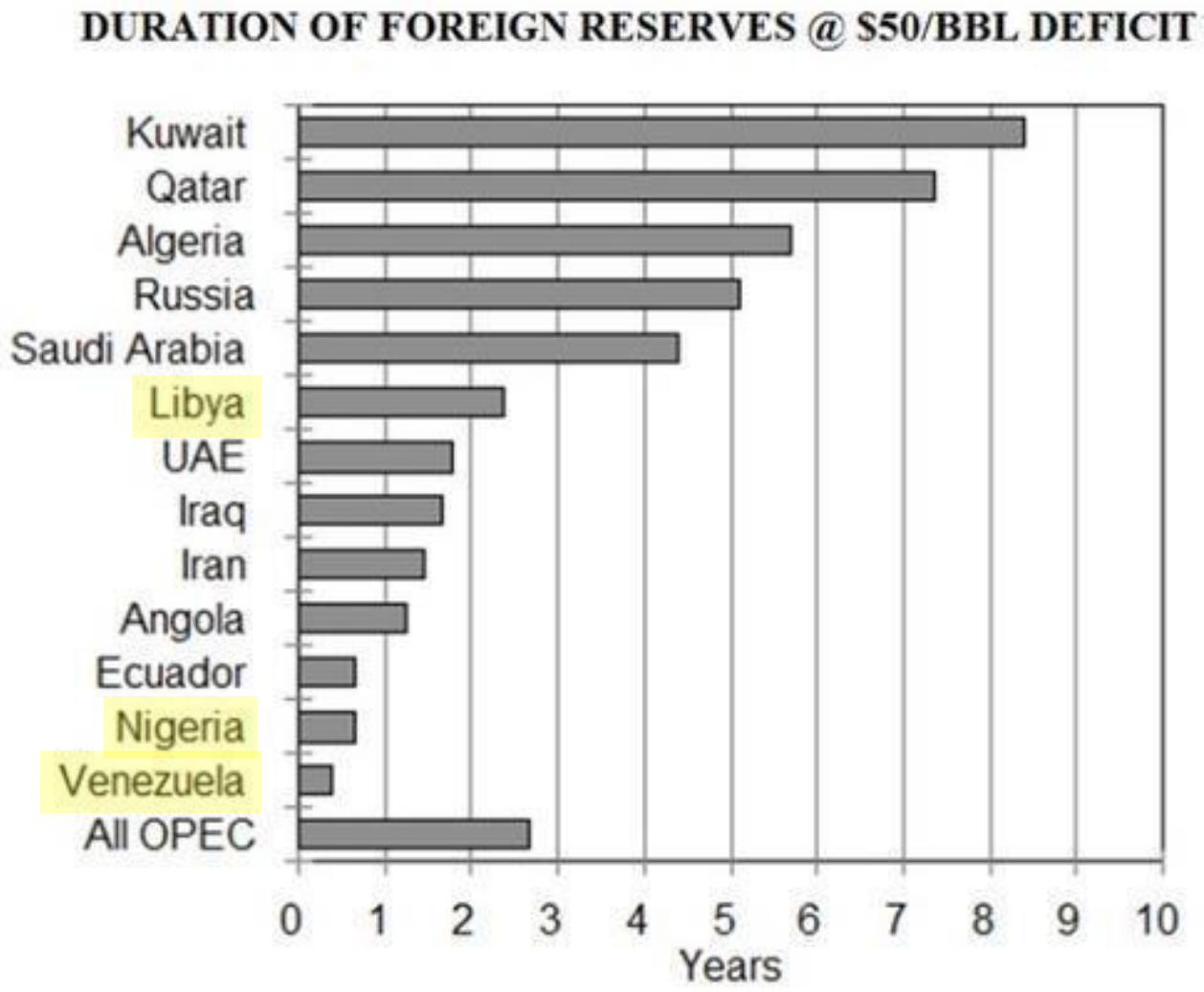
Source: *US Shalers – Beating the Bears,* Trisha Curtis, PetroNerds, presentation to The Oxford Institute for Energy Studies, November 2017

OPEC Member States

Country	Region	Joined OPEC[1]	Population (July 2008)[2]	Area (km²)[3]
Algeria	Africa	1969	33,779,668	2,381,740
Angola	Africa	2007	12,531,357	1,246,700
Ecuador	South America	2007[A 1]	13,927,650	283,560
Iran	Middle East	1960[A 2]	75,875,224	1,648,000
Iraq	Middle East	1960[A 2]	28,221,180	437,072
Kuwait	Middle East	1960[A 2]	2,596,799	17,820
Libya	Africa	1962	6,173,579	1,759,540
Nigeria	Africa	1971	146,255,300	923,768
Qatar	Middle East	1961	824,789	11,437
Saudi Arabia	Middle East	1960[A 2]	28,146,656	2,149,690
United Arab Emirates	Middle East	1967	4,621,399	83,600
Venezuela	South America	1960[A 2]	26,414,816	912,050
Total			**369,368,429**	**11,854,977 km²**

Source: Wikipedia

Survival of the Fittest?



*Circa 2014: Saudis have staying power; $750 billion in foreign country reserves

Source: Oilprice.com, *The Saudi Arabian Oil Conspiracy and What it Might Mean for Your Portfolio,* The Motley Fool, Adam Galas, January 18, 2015

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A Game of Chicken?

Nation	Oil price per barrel required to break even or balance budget
US producers	**$38-$77**
Qatar	$58
Kuwait	$59
UAE	$90
Saudi Arabia	**$92**
Angola	$94
Russia	**$101**
Iraq	$116
Venezuela	$117
Algeria	$119
Ecuador	$122
Nigeria	$124
Iran	**$136**

According to data compiled by Bloomberg, "prices have dropped below the level needed by at least 9 OPEC member states to balance their budgets."

Source: Reuters, *The Saudi Arabian Oil Conspiracy and What it Might Mean for Your Portfolio,* The Motley Fool, Adam Galas, January 18, 2015

Survival of fittest as oil tumbles below $65, Bloomberg News, December 1, 2014

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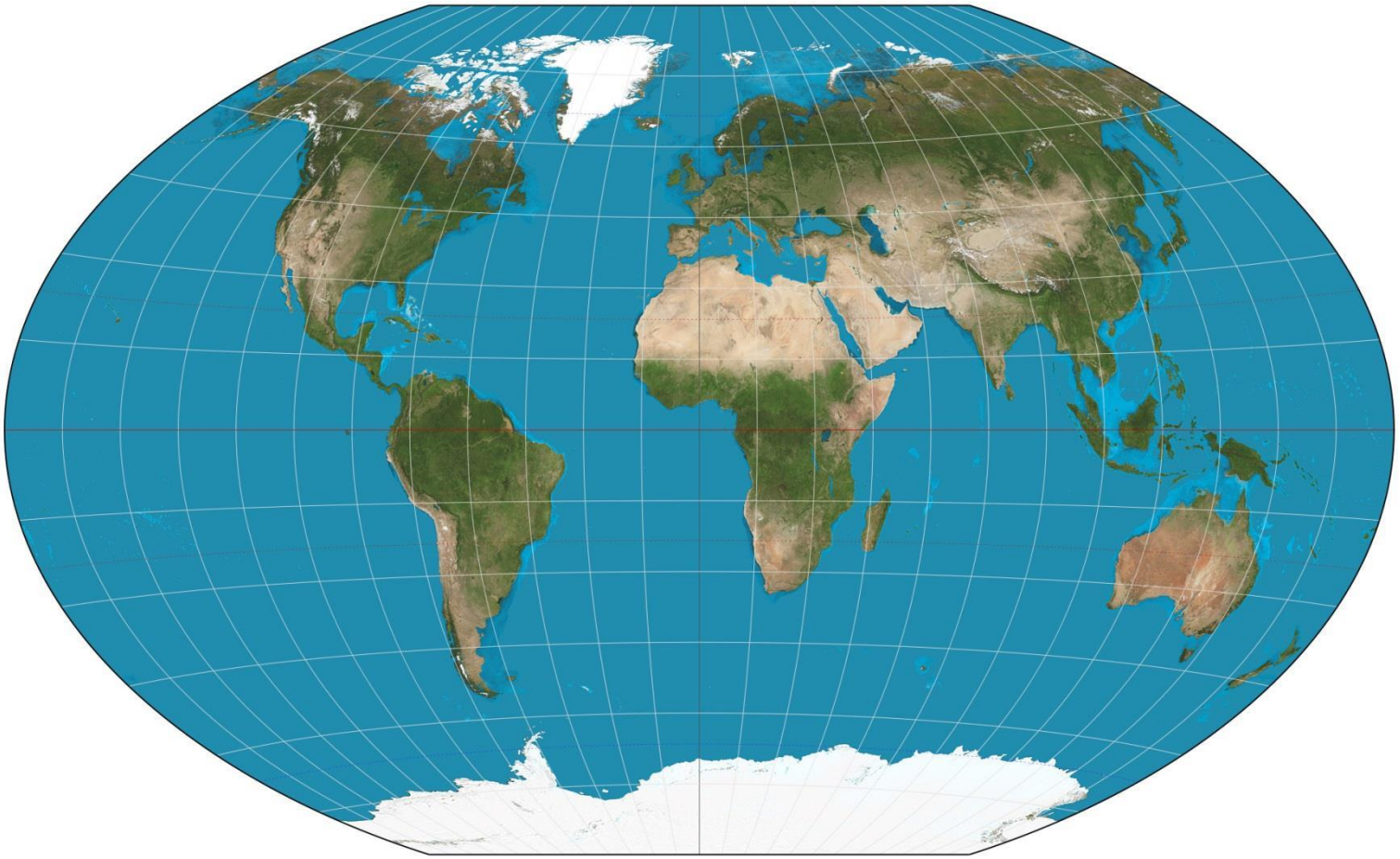
Uncertainty:
An Assessment of the Geopolitical Backdrop



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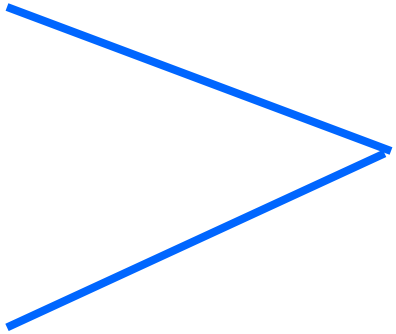
The Problem?

Iran
China
Russia



Are playing for the long- term

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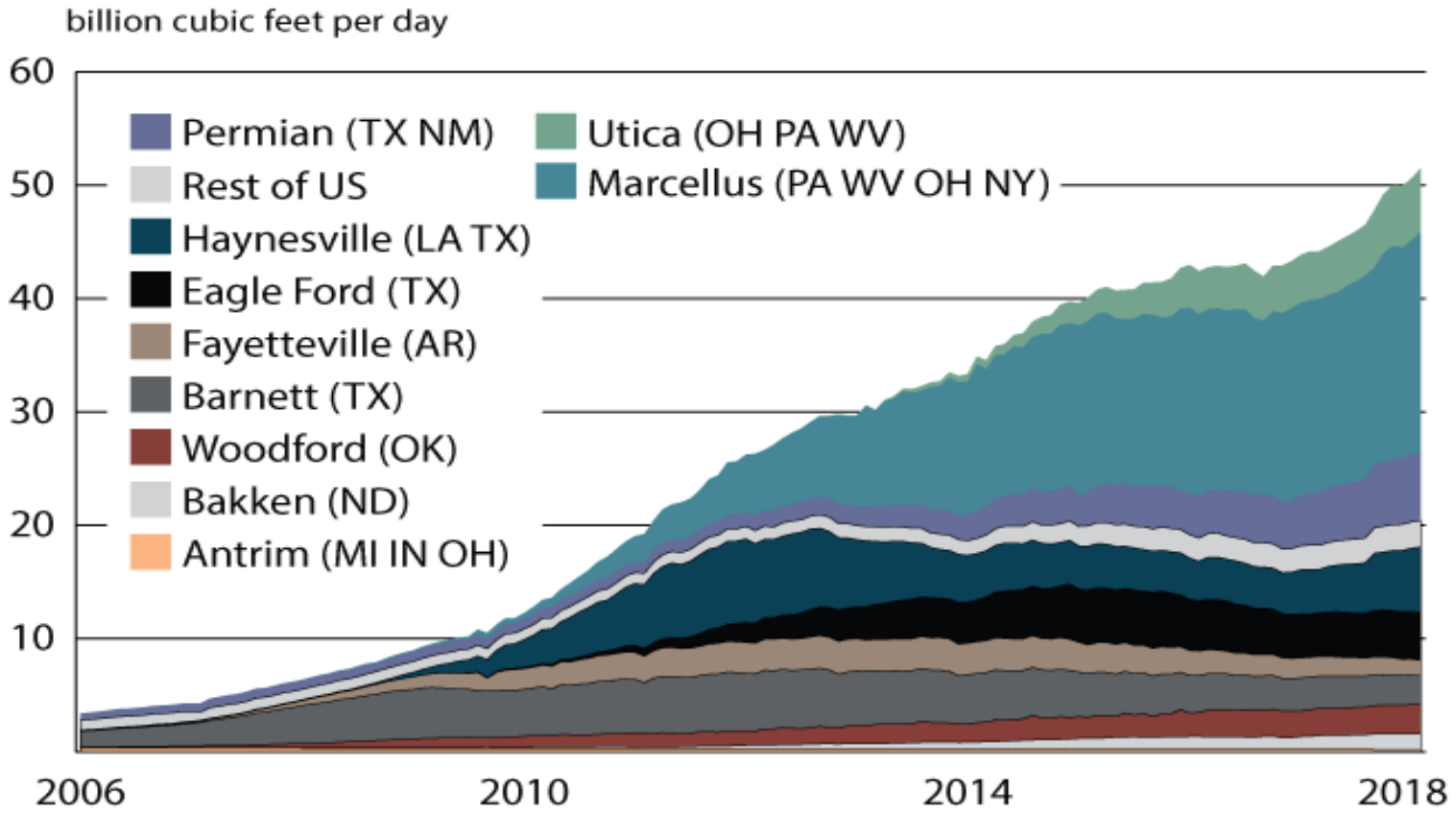
The Answer?

- The short cycle U.S. shale business model is something that OPEC countries don't understand and apparently can't compete with.
- They would have to understand Capitalism and fee ownership of minerals to get it.
- Try explaining George Mitchell and his persistence to someone in the Middle East.

U.S. Dry Shale Gas Production



Source: EIA Natural Gas Weekly Update, 03 May 2018

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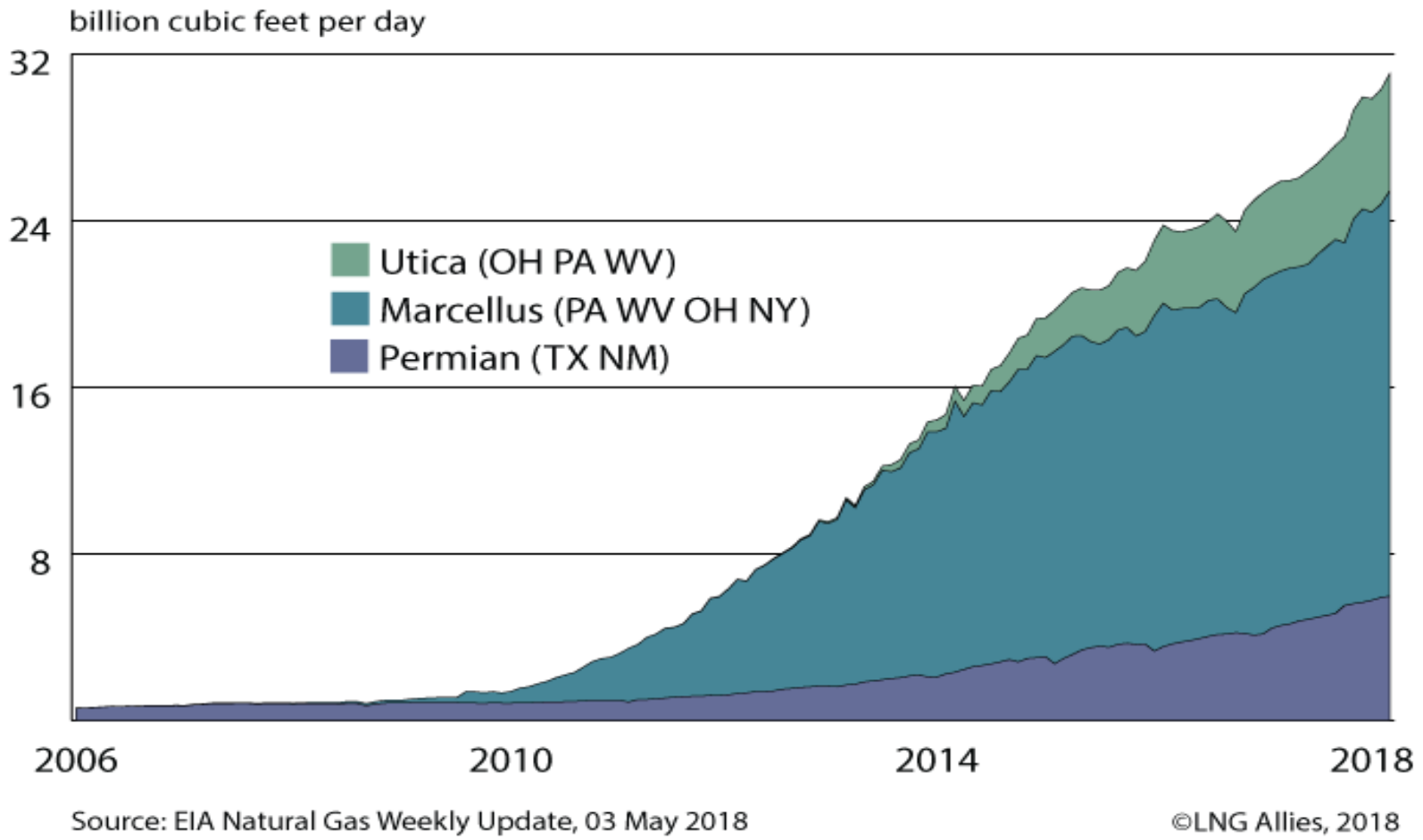
Source: LNG Allies, The US LNG Association, www.lngallies.com

Permian, Marcellus, Utica Shale Gas Production



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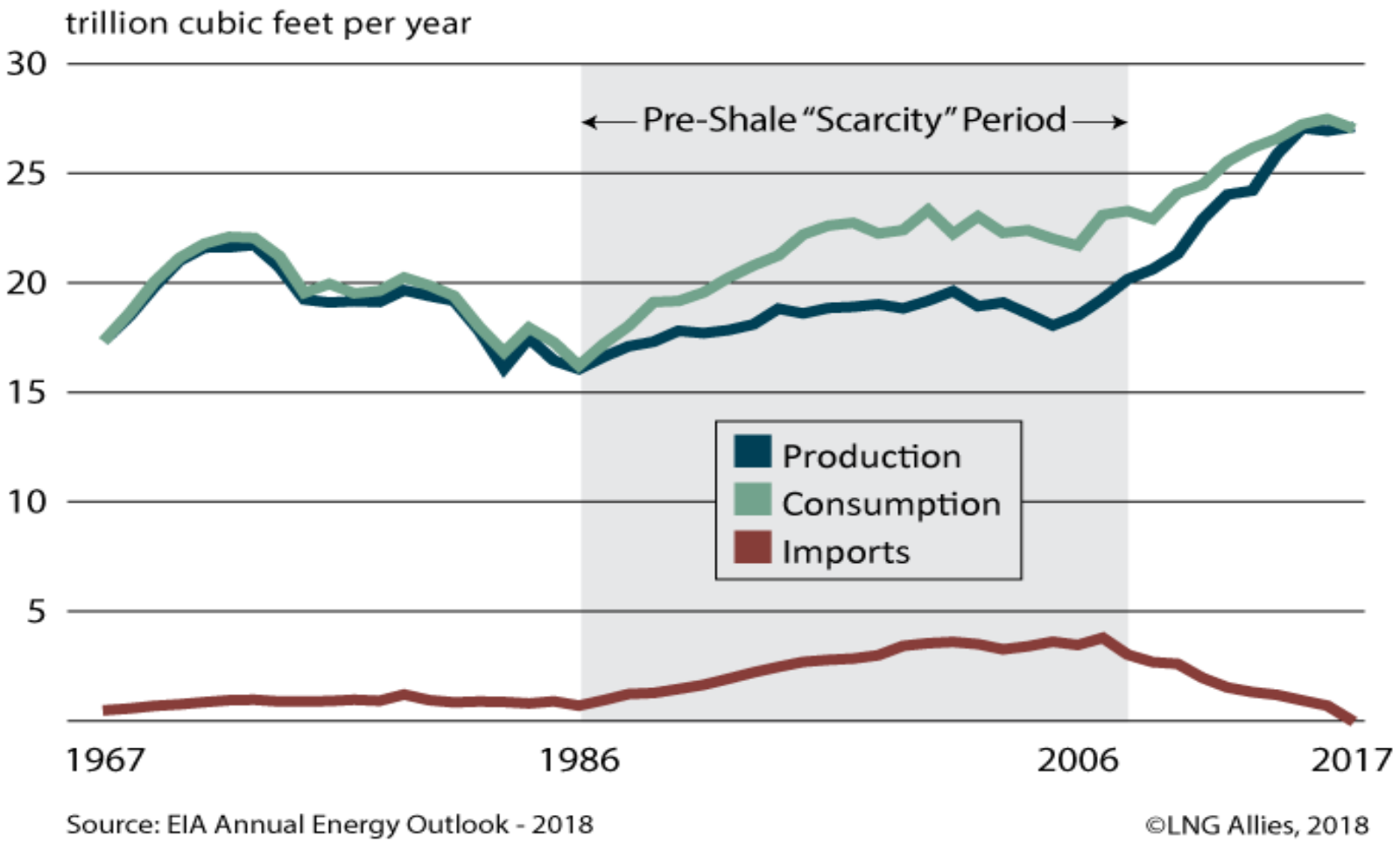
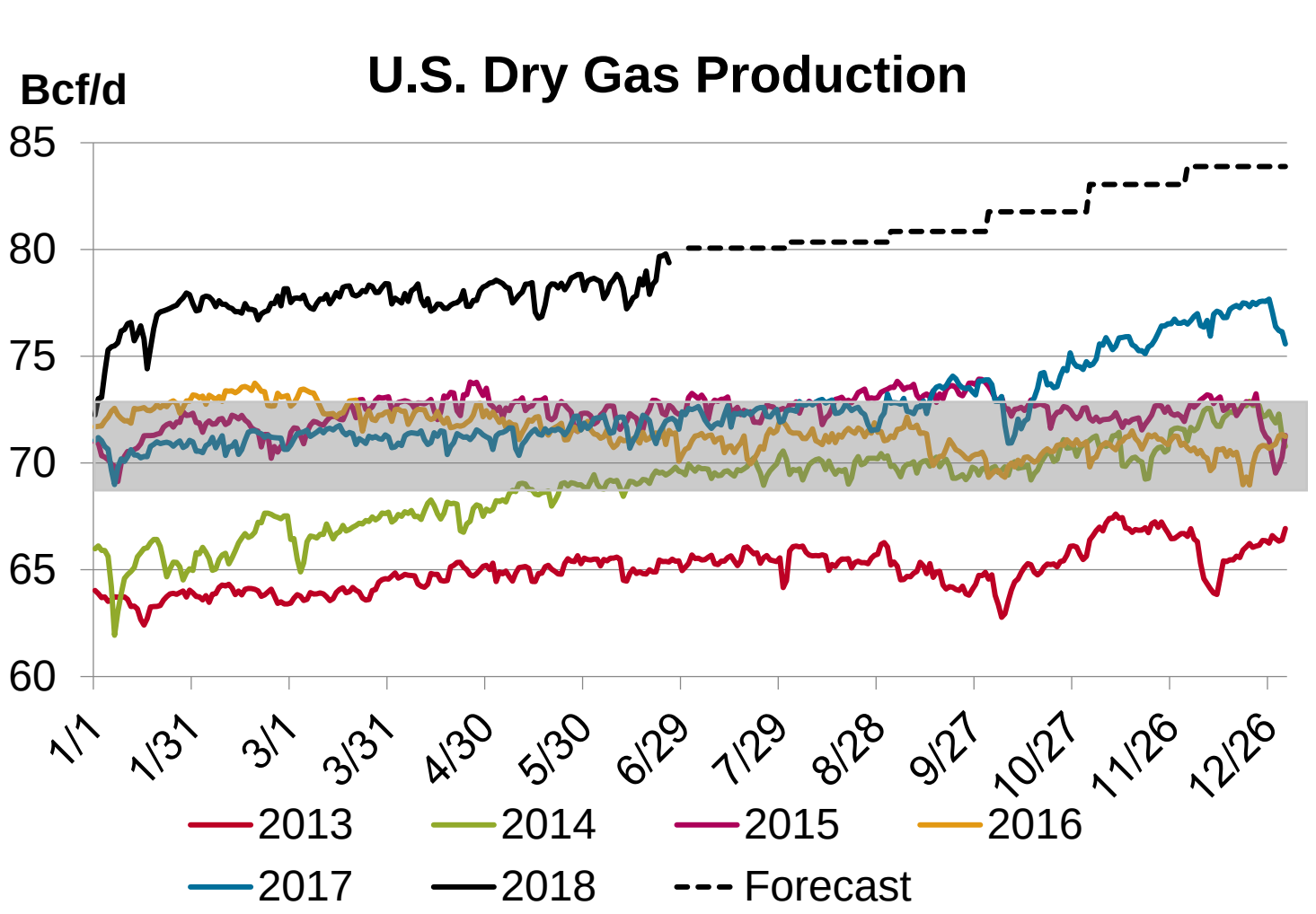
Source: LNG Allies, The US LNG Association, www.lngallies.com

U.S. Natural Gas Production, Consumption, Imports



Source: LNG Allies, The US LNG Association, www.lngallies.com

US supply growing again; largest year-over-year gain in history



Y-O-Y (Forecast) 2017/2018 +7.0 Bcf/d

Y-O-Y (YTD) 2017/2018 +5.0 Bcf/d

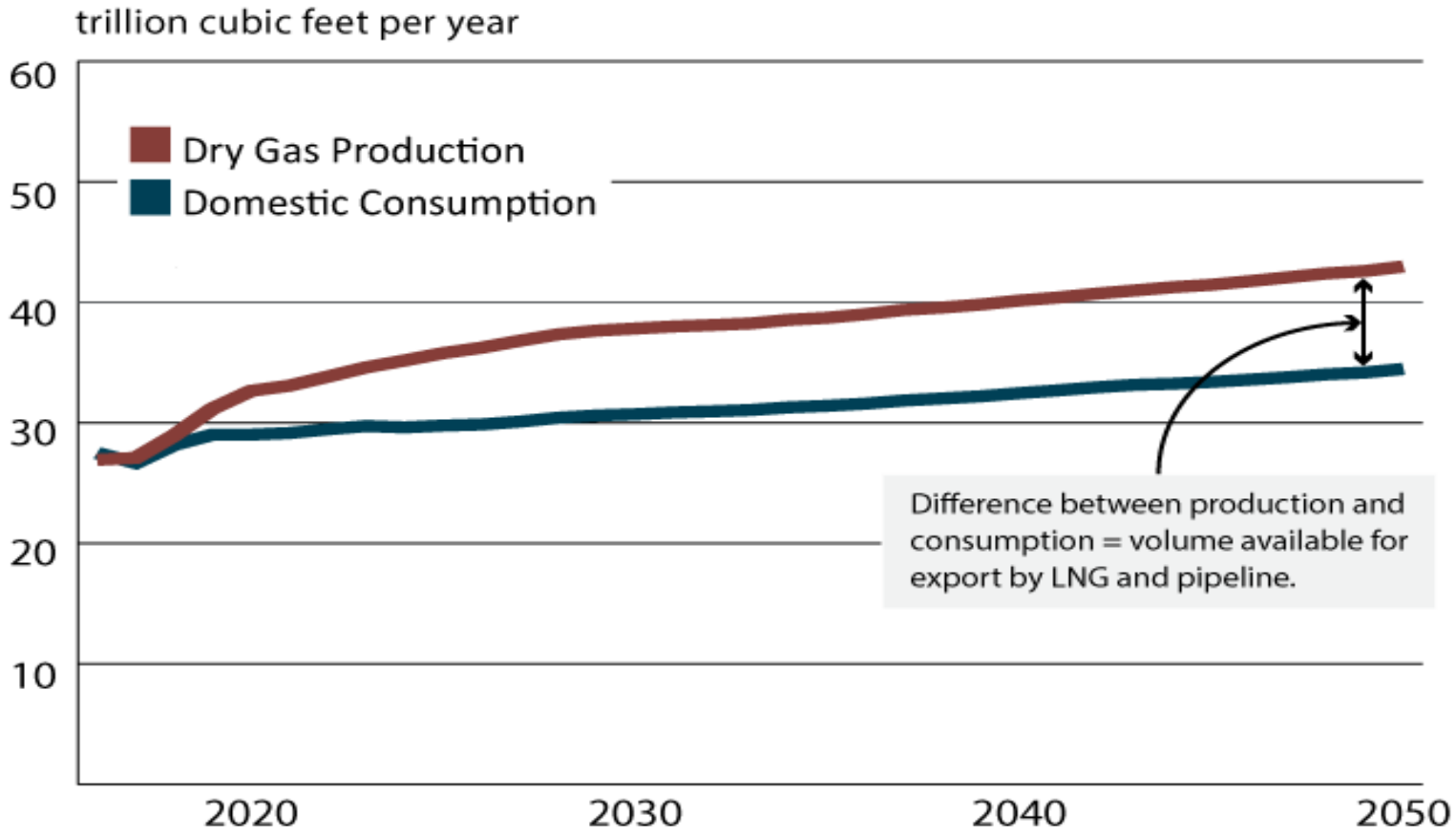
Y-O-Y 2014/2015 +3.4 Bcf/d

Y-O-Y 2013/2014 +4.0 Bcf/d

Source: S&P Global Platts Analytics

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

U.S. Natural Gas Production and Consumption



Source: EIA Annual Energy Outlook 2018 (Reference Case)

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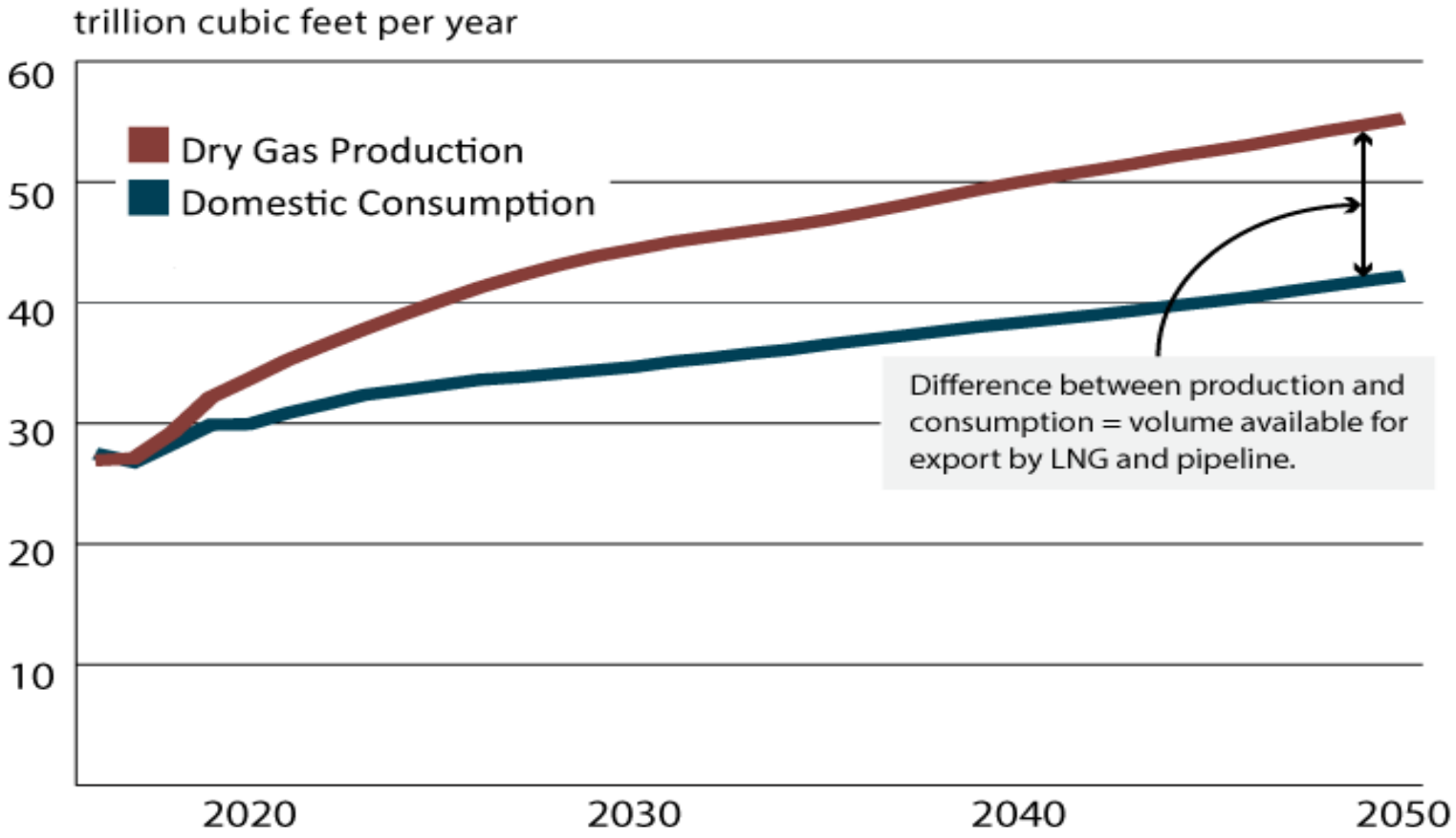
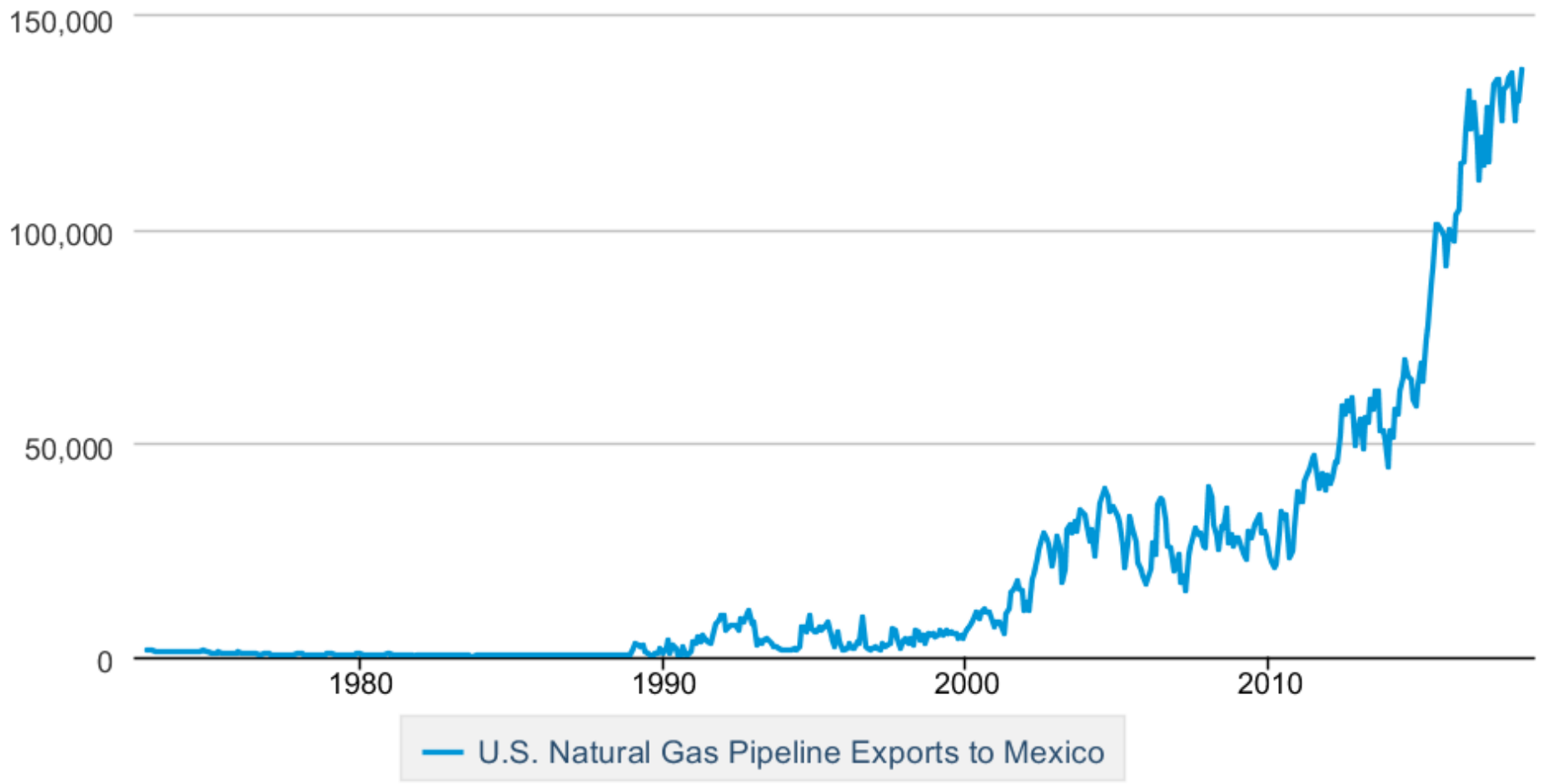
Source: LNG Allies, The US LNG Association, www.lngallies.com

U.S. Natural Gas Production and Consumption



Source: EIA Annual Energy Outlook 2018 (High Oil & Gas Case)

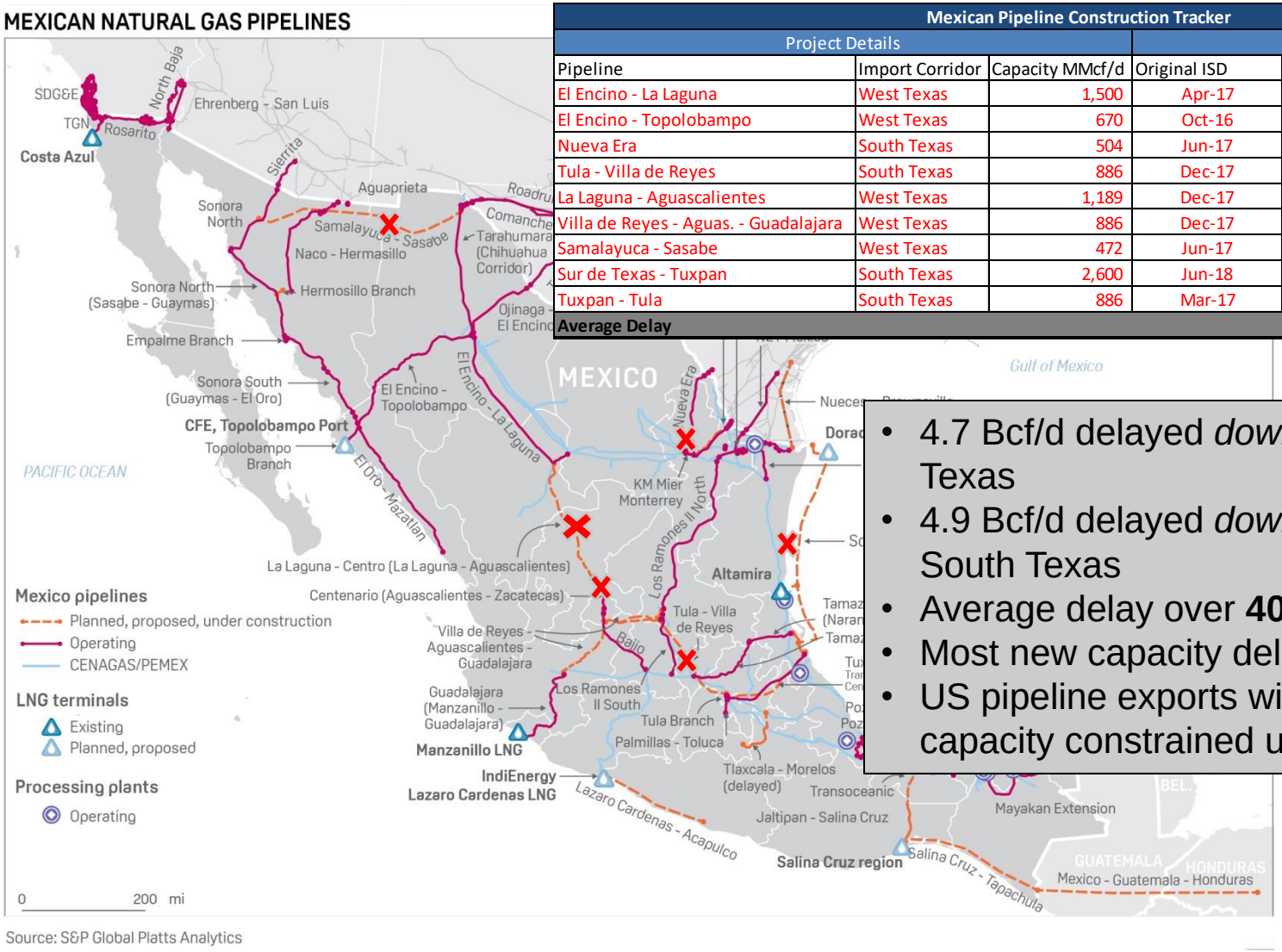
U.S. Natural Gas Pipeline Exports to Mexico



Source: U.S. Energy Information Administration

Source: www.eia.gov/dnav/ng/hist/n9132mx2m.thm accessed 08/20/2018

Major delays on Mexico's interior gas pipelines



Source: S&P Global Platts Analytics

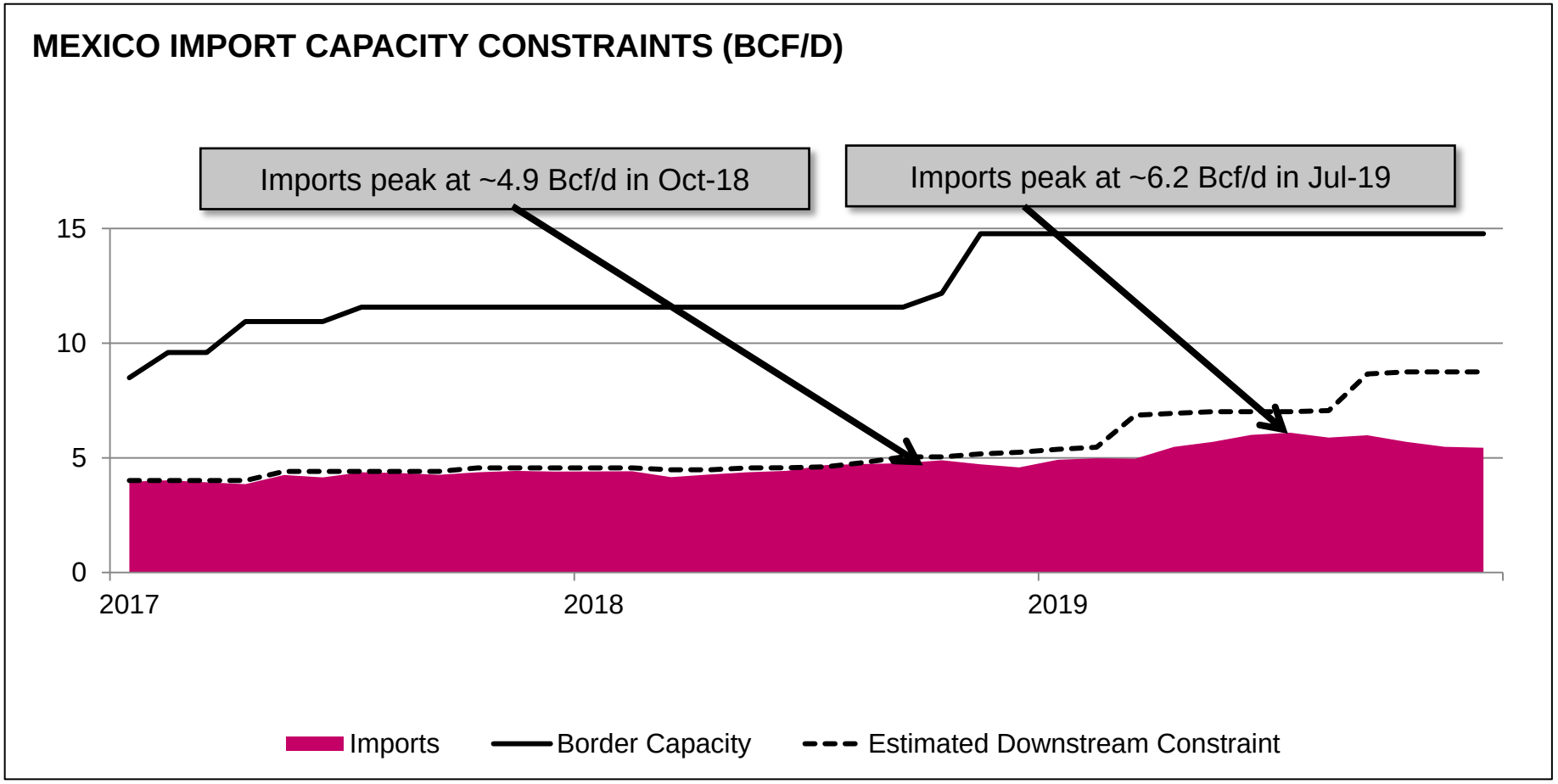
Mexican Pipeline Construction Tracker					
Project Details			Start Date Tracker		
Pipeline	Import Corridor	Capacity MMcf/d	Original ISD	Estimated Start 6/1/2018	Days Delayed
El Encino - La Laguna	West Texas	1,500	Apr-17	Mar-18	334
El Encino - Topolobampo	West Texas	670	Oct-16	Jun-18	608
Nueva Era	South Texas	504	Jun-17	Dec-18	548
Tula - Villa de Reyes	South Texas	886	Dec-17	Jul-18	212
La Laguna - Aguascalientes	West Texas	1,189	Dec-17	Nov-18	335
Villa de Reyes - Aguas. - Guadalajara	West Texas	886	Dec-17	Nov-18	335
Samalayuca - Sasabe	West Texas	472	Jun-17	Nov-18	518
Sur de Texas - Tuxpan	South Texas	2,600	Jun-18	Oct-18	122
Tuxpan - Tula	South Texas	886	Mar-17	Dec-19	1,005
Average Delay					**460**

- 4.7 Bcf/d delayed *downstream* of West Texas
- 4.9 Bcf/d delayed *downstream* of South Texas
- Average delay over **400 days**
- Most new capacity delayed past 2018
- US pipeline exports will remain capacity constrained until 2019

Source: SENER, S&P Global Platts Analytics

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

Downstream constraints alleviated in 2019



Source: S&P Global Platts Analytics

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

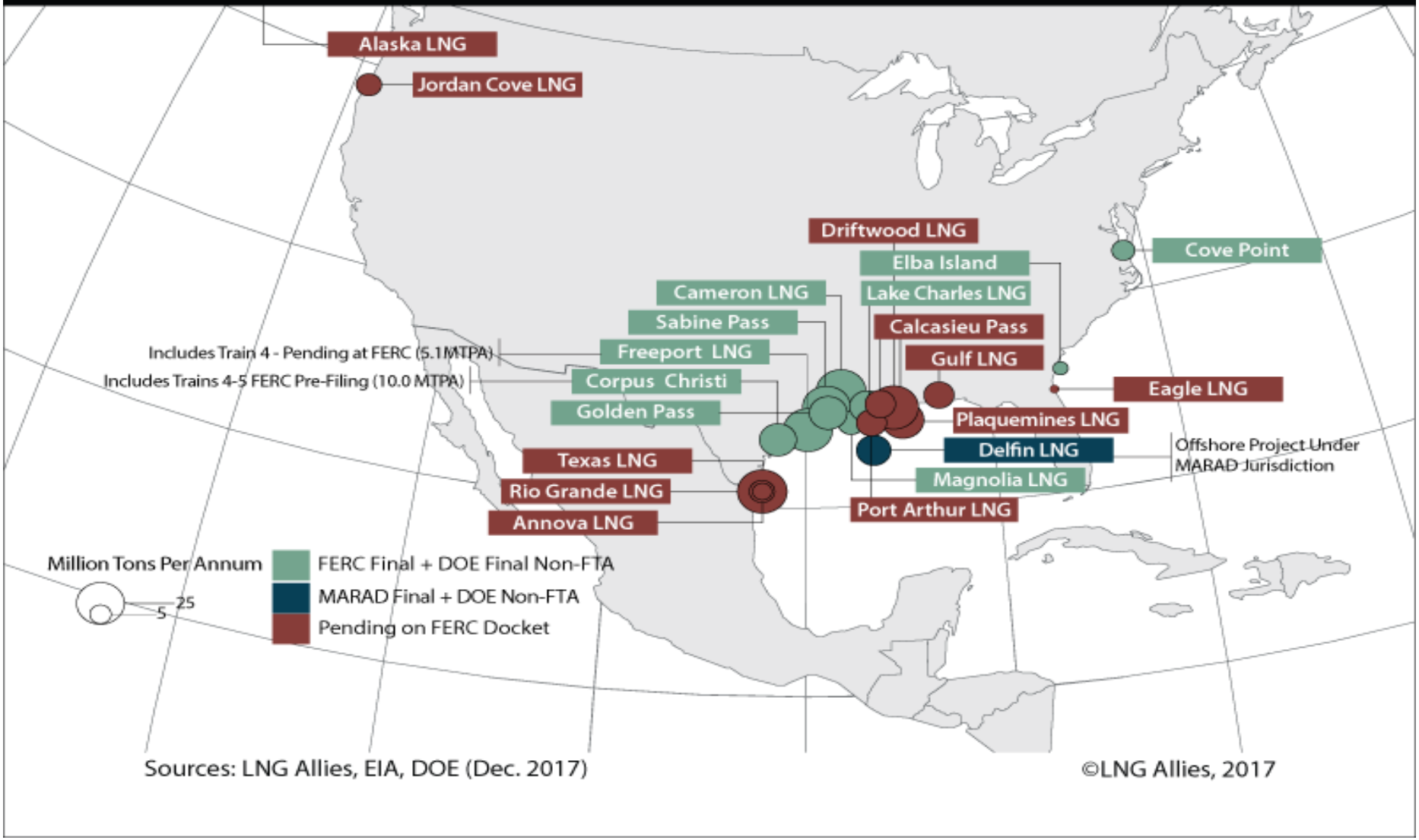
Permitting Status of U.S. LNG Export Projects

Project Stage	Projects	MTPA	Bcm/yr	Bcf/day
Operating / Under Construction	6	70.9	97.7	10.0
Fully Permitted (Major Projects)	4	68.9	95.0	9.7
Fully Permitted (Small Projects)	N/A	9.0	12.4	1.3
Formal FERC Review	11	146.9	202.6	20.9
FERC Pre-Filing	2	24.0	33.1	3.3
Total	**23**	**310.7**	**428.5**	**44.0**

Notes: (1) Projects = individual projects. (2) Additional trains for existing projects not included in the project count, but in the MTPA, Bcm/year, and Bcf/day totals (Sabine Pass #6, Corpus Christi #3, Cameron #4 #5, Freeport #4).

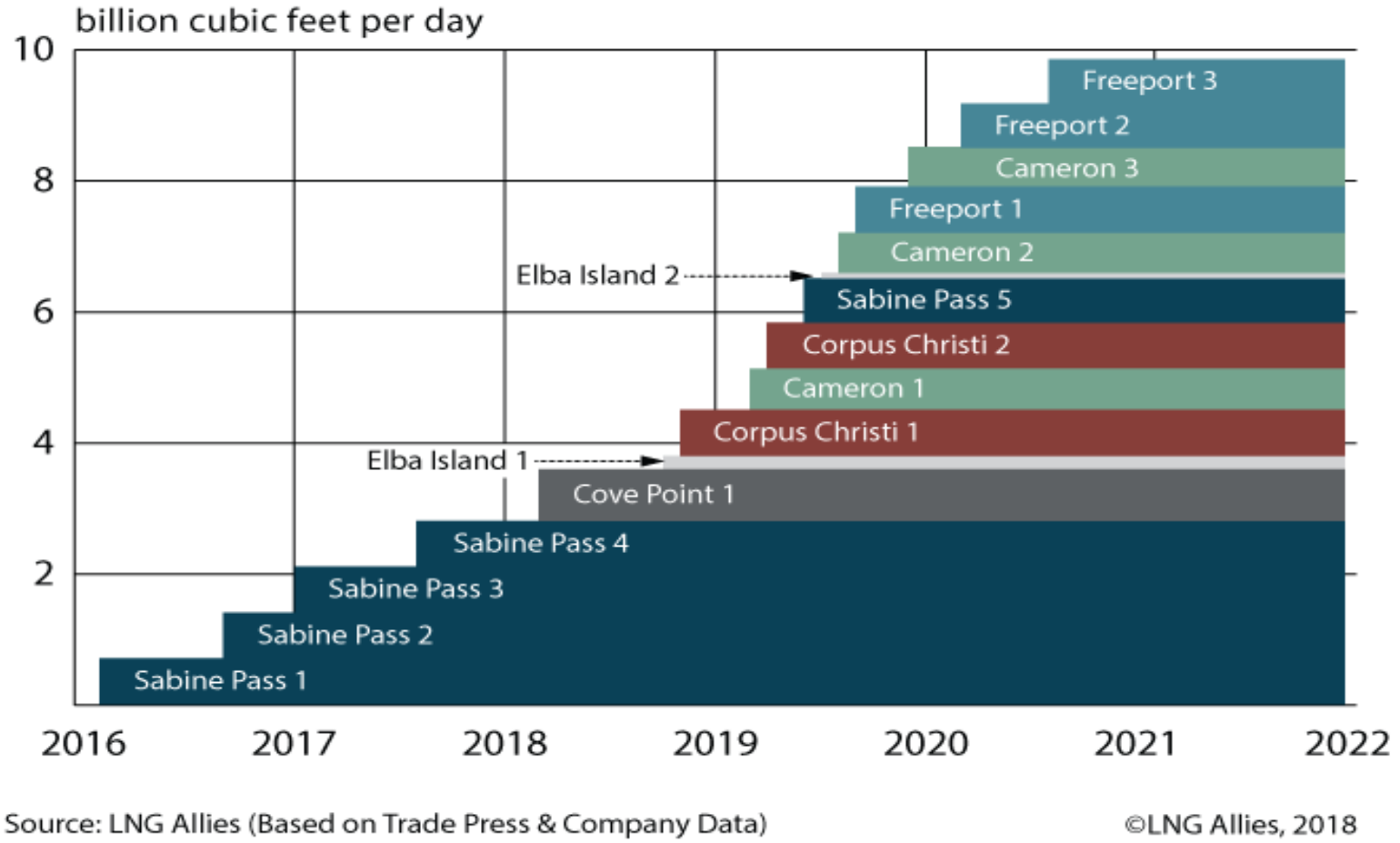
Source: Federal Energy Regulatory Commission & LNG Allies (17 April 2018)

Major U.S. LNG Export Projects - Existing & Proposed



Source: LNG Allies, The US LNG Association, www.lngallies.com

U.S. LNG Liquefaction Capacity Growth



Source: LNG Allies (Based on Trade Press & Company Data)

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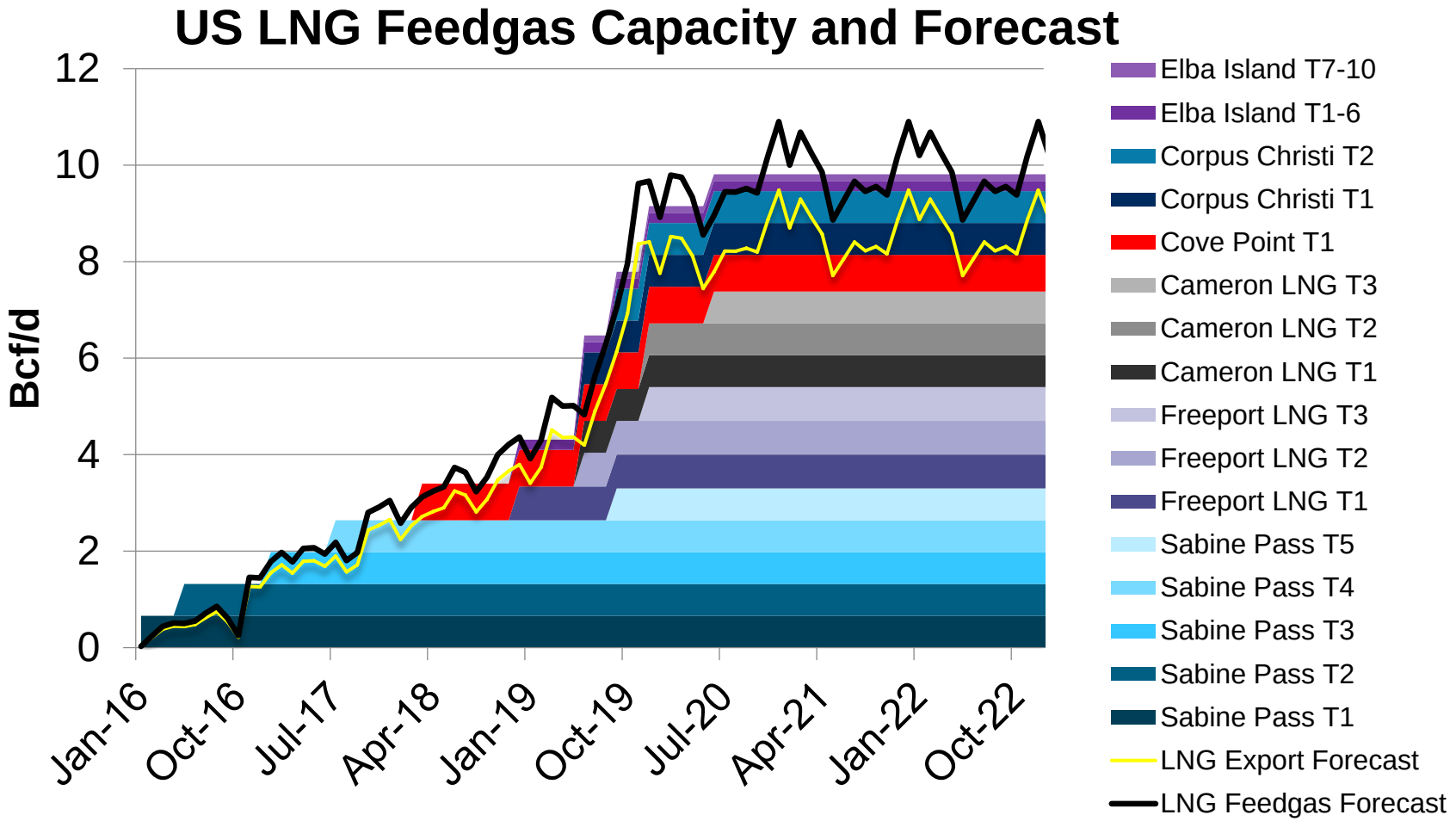
Source: LNG Allies, The US LNG Association, www.lngallies.com

High Utilization of US LNG Expected to Persist



Source: S&P Global Platts Analytics

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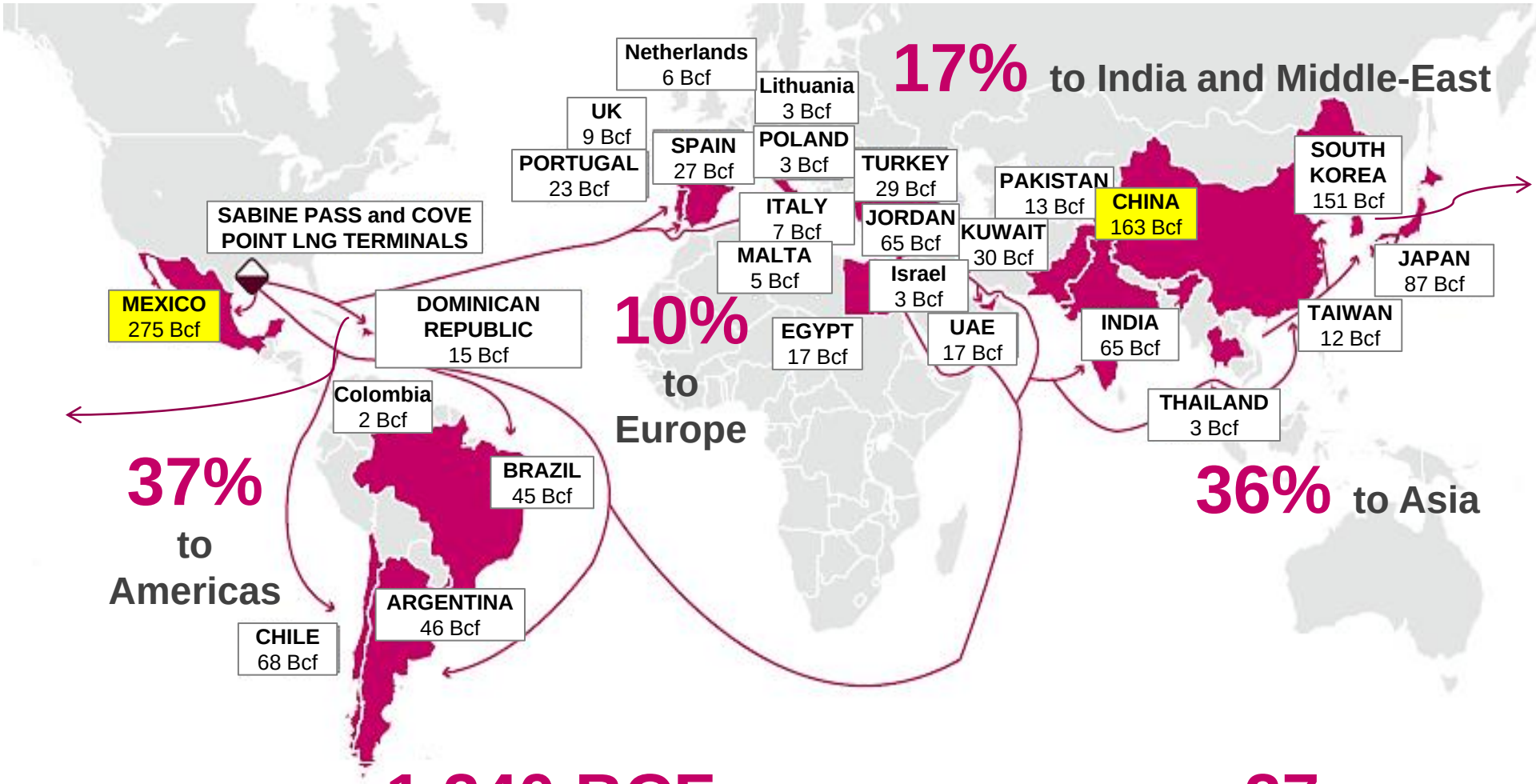
Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

Latin America and Asia main markets US LNG



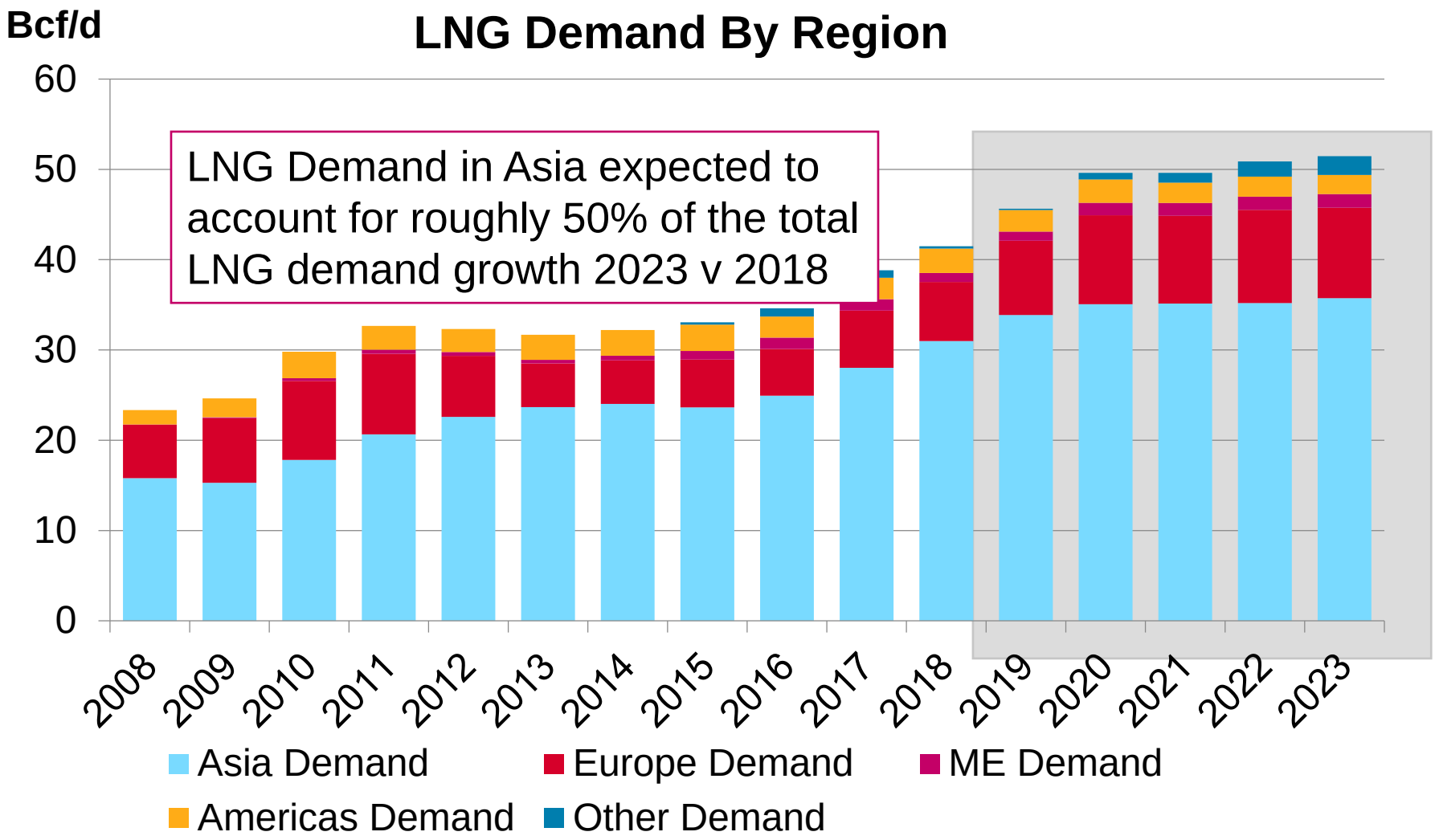
1,240 BCF US LNG exports shipped to **27** countries

*Numbers may not add up to 100% due to rounding

Source: S&P Global Platts Analytics

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

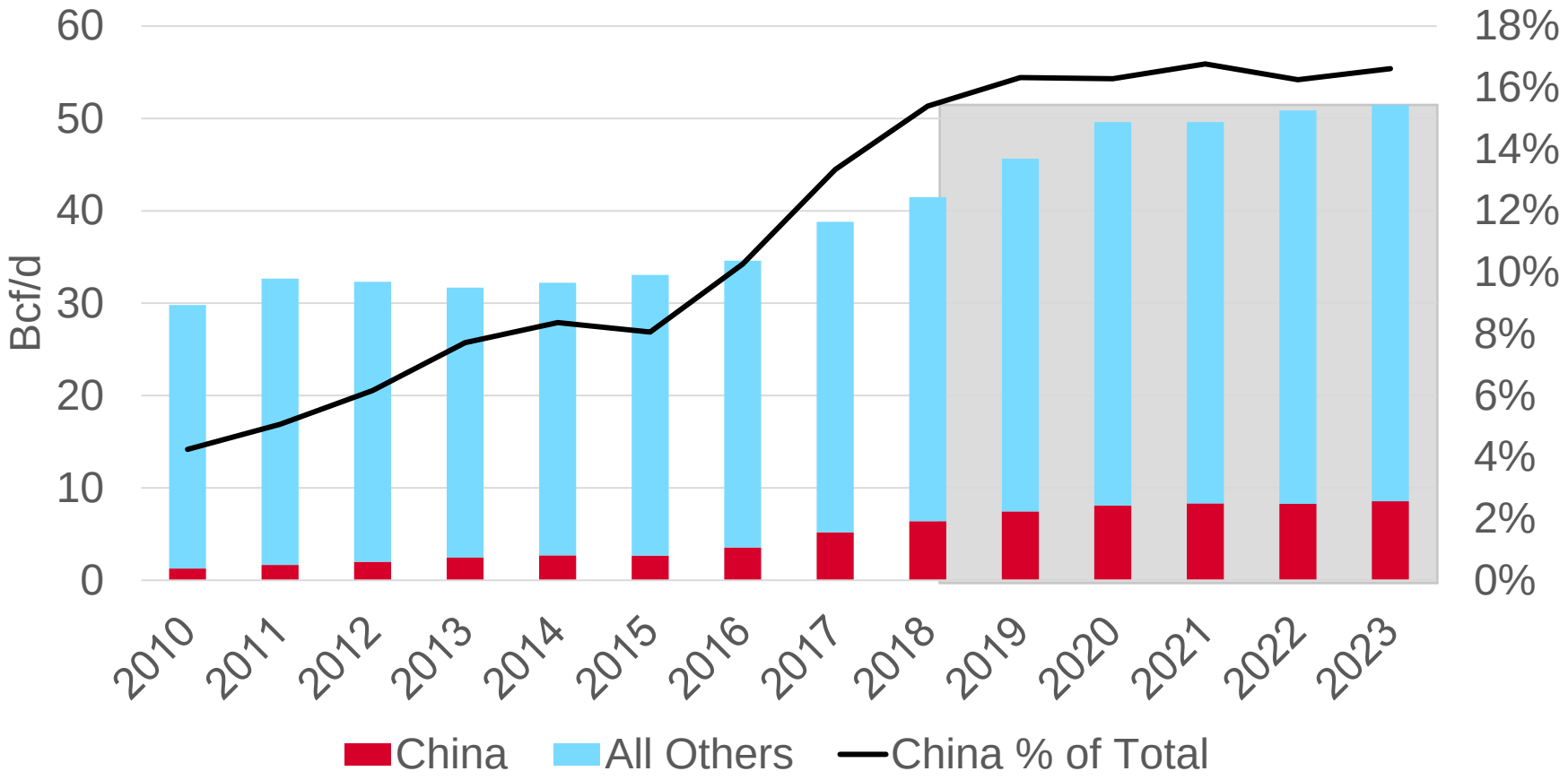
Asia Clearly Driving LNG Demand



Source: S&P Global Platts Analytics

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

China almost 30% of growth in global LNG demand (2018 to 2023)

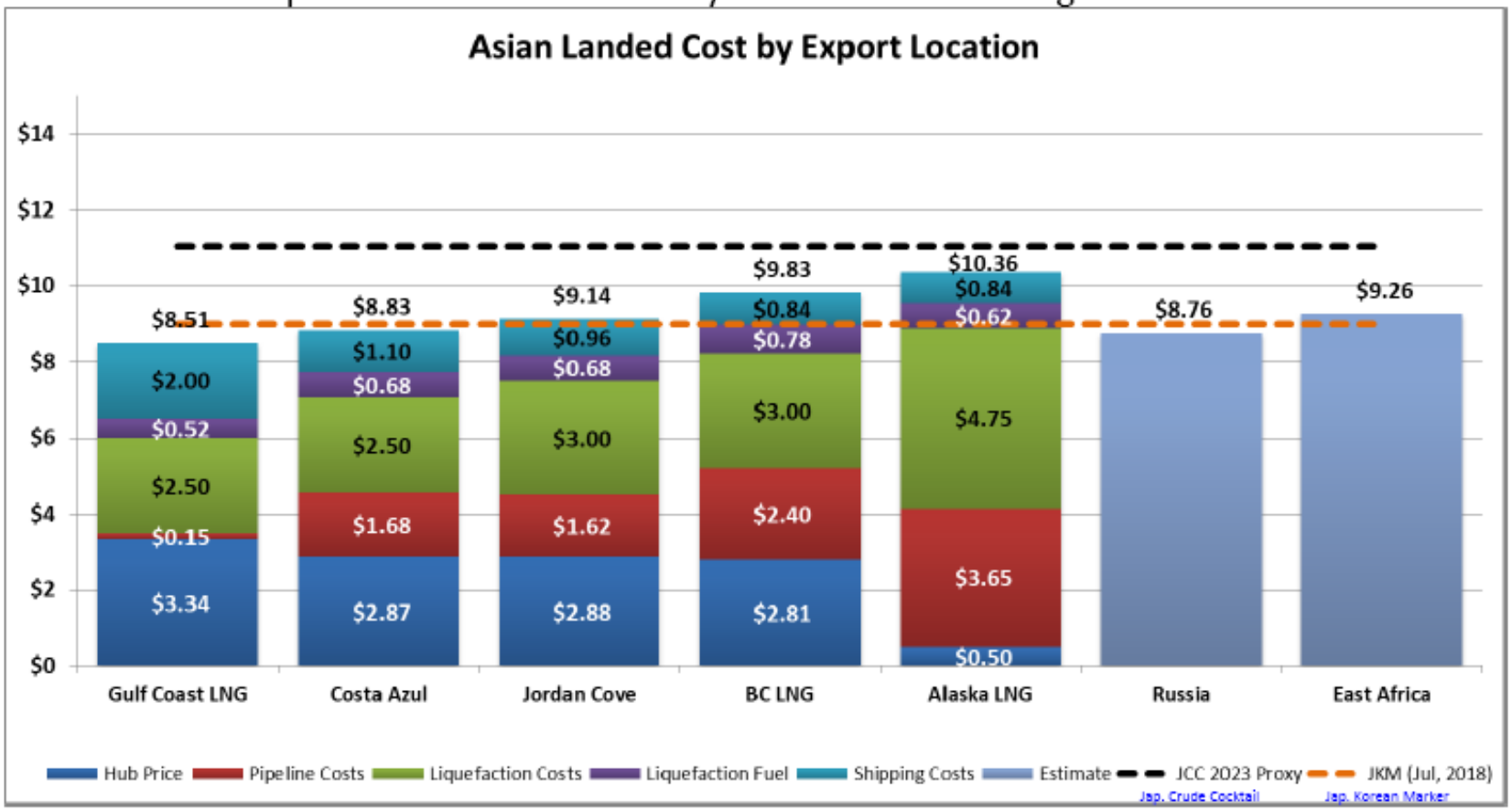


Source: S&P Global Platts Analytics

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

North America LNG Outlook

- North America LNG supply competitive with rest of world for delivery to Asia
- Deliveries to Europe are competitive but margins are thinner
- Cost competitiveness is not the only factor in determining market share

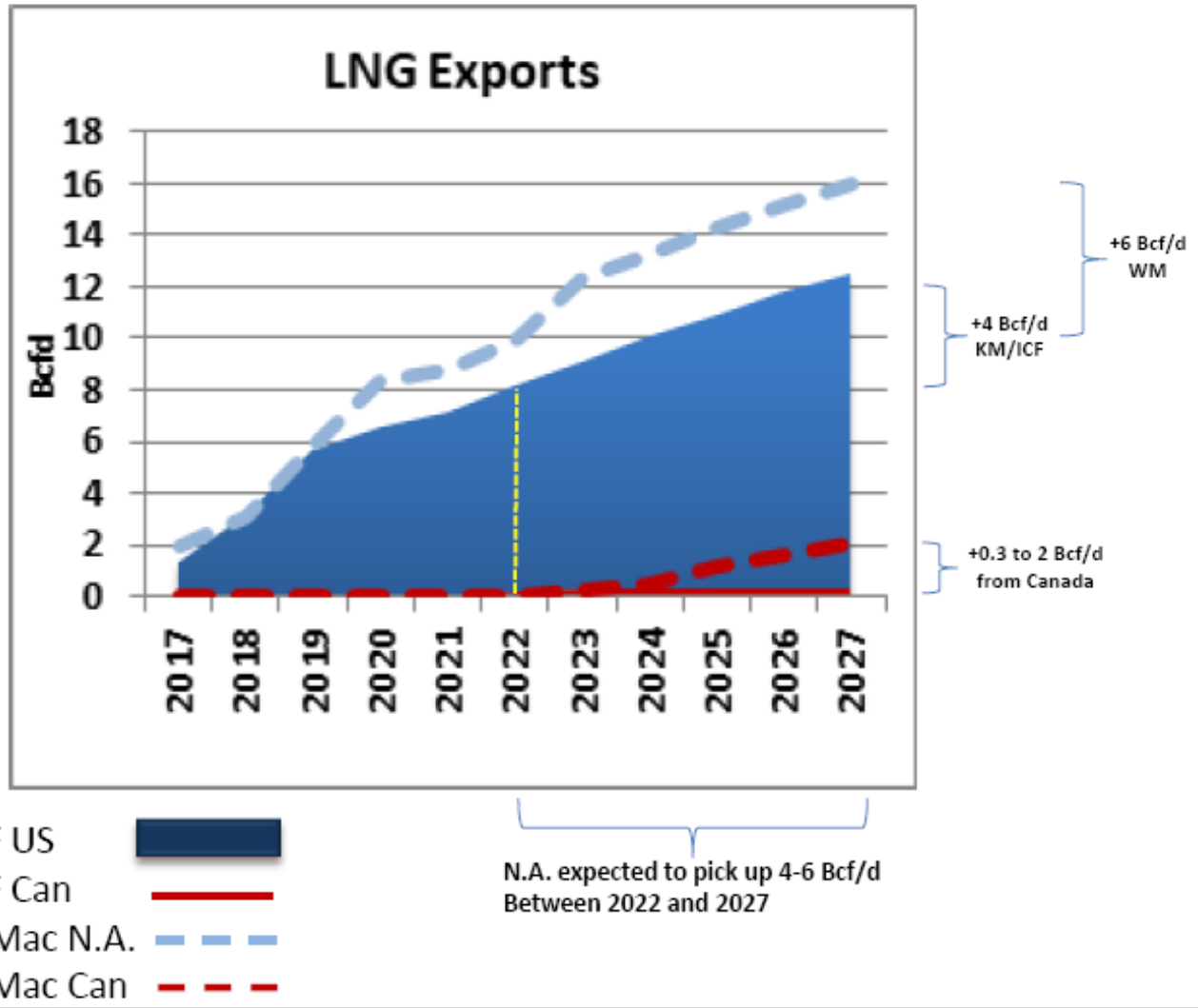


Note: Landed cost components are based on projected average 2023 prices.
SOURCE: Platts Gas/LNG Daily, KM Analysis

Source: Greg Ruben, KinderMorgan, Colorado Oil and Gas Association Trade presentation, August 21, 2018

KINDER MORGAN

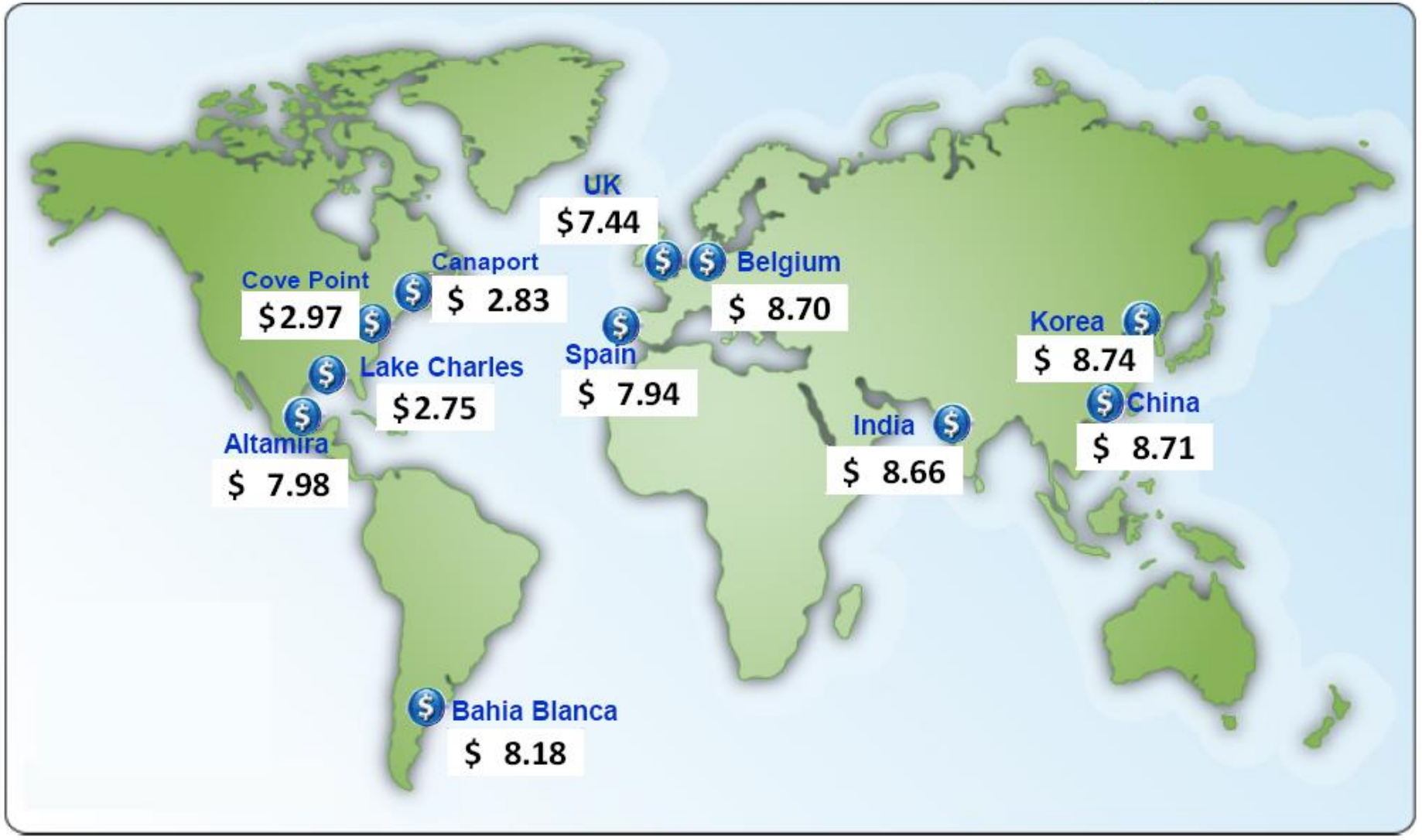
Projected Net North America LNG Exports



Source: Greg Ruben, KinderMorgan, Colorado Oil and Gas Association Trade presentation, August 21, 2018

Mercator Energy

World LNG Estimated Landed Prices: May-18



Source: *Waterborne Energy, Inc.* Data in $US/MMBtu.

Note: Includes information and Data supplied by IHS Global Inc. and its affiliates ("IHS"); Copyright (publication year) all rights reserved. Prices are the monthly average of the weekly landed prices for the listed month. Landed prices are based on a netback calculation

Updated: Jun-18

Key Questions

- It is all about efficiency. Is the independent publically traded North American Energy company more efficient than a foreign state-run energy group?
- If you are a foreign buyer of a 20-year supply of natural gas, how meaningful is the security that emanates from a country that supports the rule of law?
- Can any other country mimic the efficiency of a system that allows for the private ownership of mineral interests?
- Can the renewable energy industry significantly undermine the market share of the oil and gas industry?

Mercator Energy

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

Key Takeaways

- Forecasted North American **production growth is highly dependent on global export markets**; more exports to Mexico and LNG (10.3 Bcf/d) than organic demand growth in Canada and US (5.7 Bcf/d)
- Global **demand for LNG continues growing**; expect a "second wave" of U.S. LNG liquefaction capacity
- Gas **infrastructure development is required** to connect supply centers with emerging demand
- U.S. natural gas producers are dependent upon export growth

Source: Rick Allen, S&P Global Platts, *The Energy Summit – COGA 2018* presentation, August 22, 2018

Key Takeaways About You

- The Shale workforce of the future will require the following abilities related to statistics, mathematics, computer science, data processing, data science and artificial intelligence:
  - Industry knowledge
  - Analyze large quantities of data to draw conclusions
  - Produce usable data for analyses from unstructured "messy" real-world sources
  - The theoretical and applied study of algorithms, equations, functions, etc.
  - Program computers to perform defined tasks (ie – analyze, optimize)
  - Simulation of human intelligence by machines (ie – machine learning, natural language processing, machine vision, robotic processing automation

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Source: *Shale's radically changing workforce*, Paul Goydan and Jamie Webster, Boston Consulting Group

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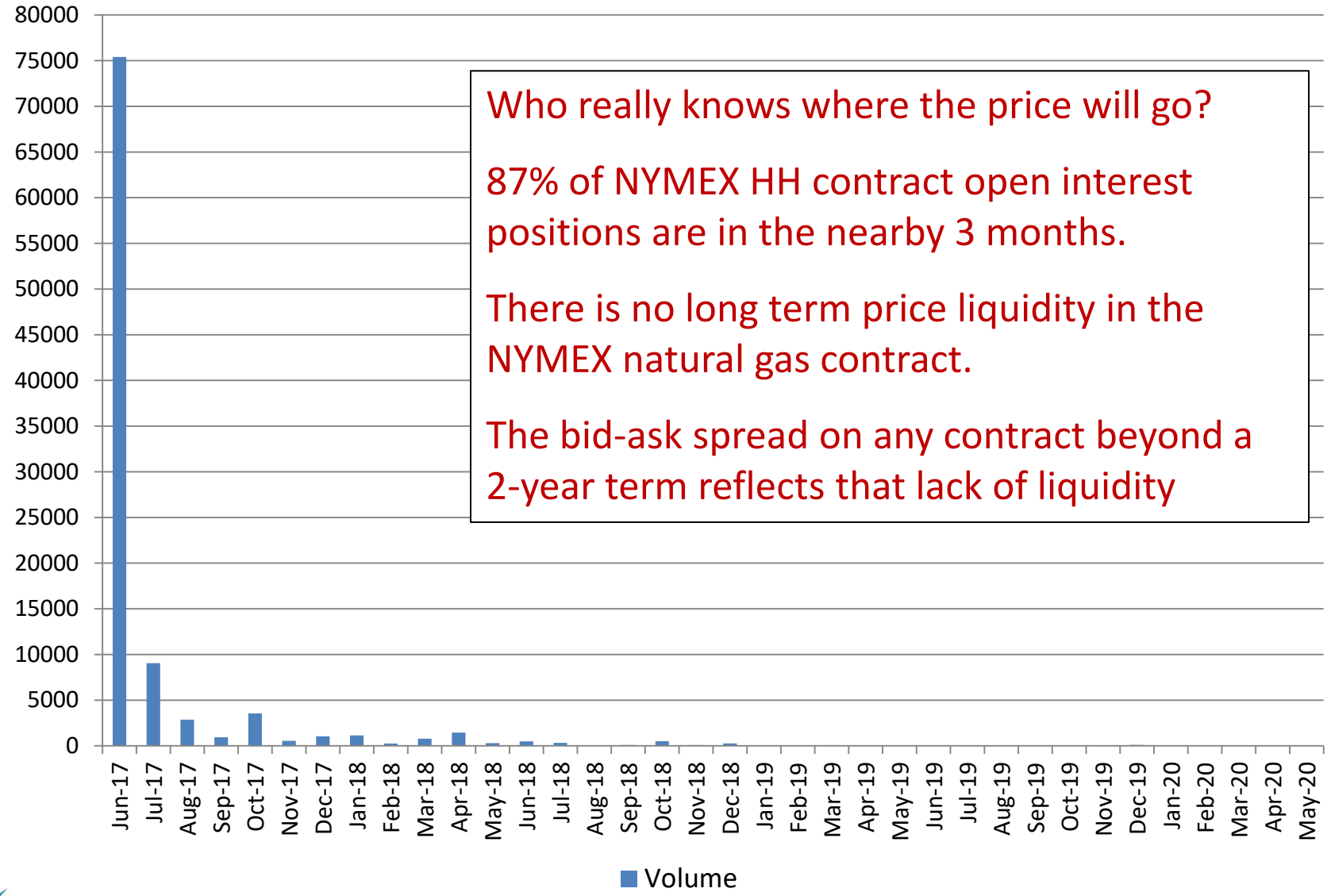
NYMEX Henry Hub Gas Futures Contract Open Interest Position



Who really knows where the price will go?

87% of NYMEX HH contract open interest positions are in the nearby 3 months.

There is no long term price liquidity in the NYMEX natural gas contract.

The bid-ask spread on any contract beyond a 2-year term reflects that lack of liquidity

Source: *NYMEX Henry Hub Gas Futures Contract, May 1,* S&P Platts Gas Daily, May 2, 2017