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Sector of Natural gas

Martin Jirušek, PhD.

Natural Gas in US – A History

- Known from the times of the first settlers – no major use
- 1st gas well 1821(1825?) – Fredonia, NY
  - Col. Drake also hit gas reservoir as he was drilling for oil in Titusville
  - Pipeline from this field was supplied to nearby settlements
- The first gas well was drilled into shale formation (!)
- Fredonia Gas Light Company 1857 – 1st gas company in the US
- Limited use within a close distance to wells
  - limited means of transport


THE SITE OF THE FIRST GAS WELL
IN THE UNITED STATES
LIGHTED
IN HONOR OF GENERAL LAFAYETTE'S VISIT
JUNE 4, 1825
PLACED BY BENJAMIN PRESCOTT CHAPTER
DAUGHTERS OF THE AMERICAN REVOLUTION
JUNE 4, 1925

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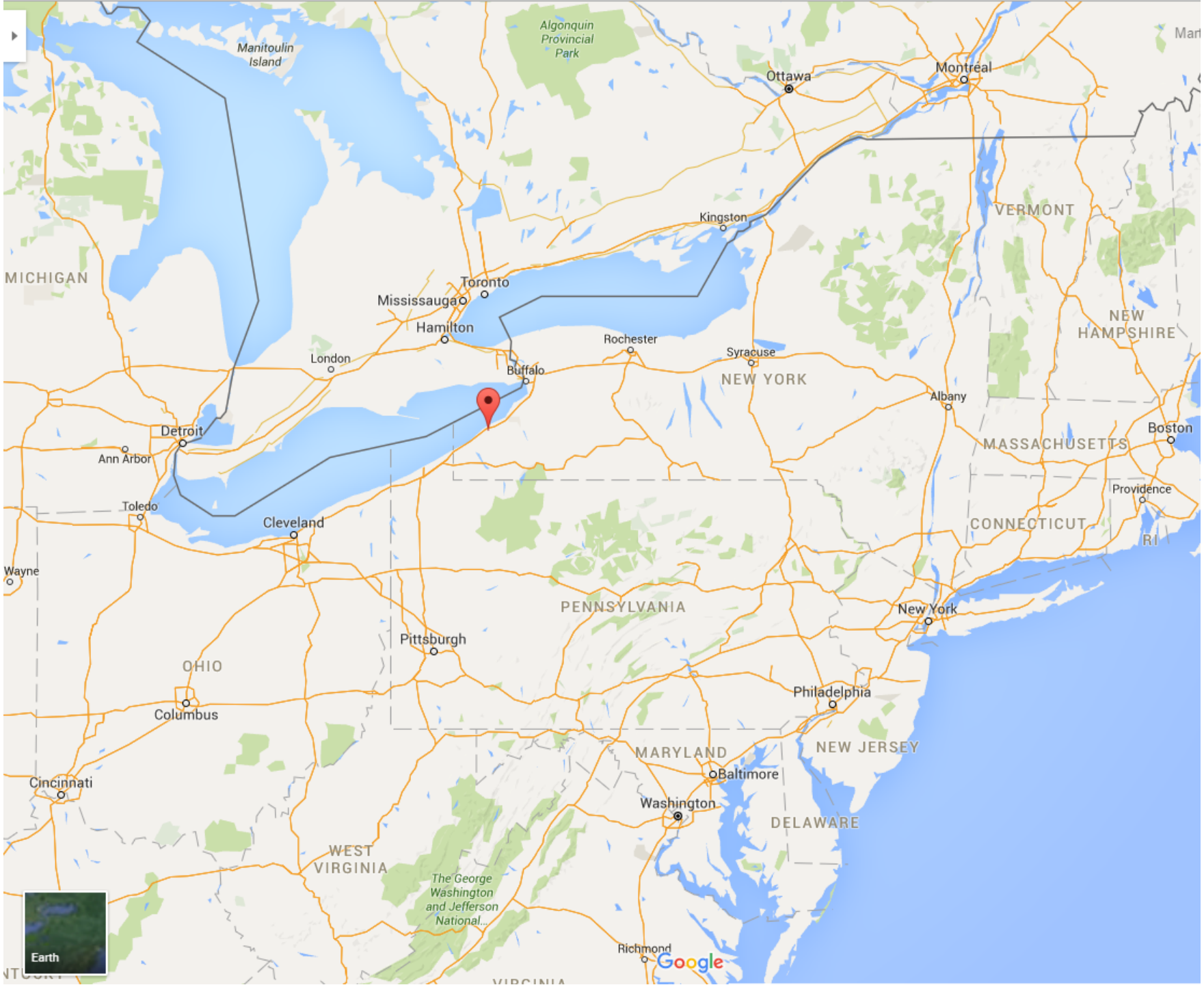
Manitoulin Island
Algonquin Provincial Park
Ottawa
Montreal
Kingston
VERMONT
MICHIGAN
Toronto
Mississauga
Hamilton
NEW HAMPSHIRE
Rochester
Syracuse
London
Buffalo
NEW YORK
Albany
Detroit
Boston
Ann Arbor
MASSACHUSETTS
Providence
Toledo
Cleveland
CONNECTICUT
RI
Wayne
PENNSYLVANIA
New York
Pittsburgh
OHIO
Philadelphia
Columbus
NEW JERSEY
MARYLAND
Baltimore
Cincinnati
Washington
DELAWARE
WEST VIRGINIA
The George Washington and Jefferson National...
Richmond
Earth
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Natural Gas in US – A History

- Natural gas was closely bound to the oil industry
  - By-product of oil extraction – associated gas, usually burned (flared) (gas flare)
  - NW of the US
- The associated (petroleum) gas initially covered the rather limited demand
- Extraction of non-associated gas started later
- Temporarily used for lighting

Natural Gas in US – A History

- 1854 – Bunsen burner
  - enabled use of gas for cooking and heating
- Complicated transportation - 1891 first long-distance gas pipeline
- Used in close proximity to gas wells
- Coordinated building of pipelines since 1920s
- The need for infrastructure limited the development, so did the lack of storage capacity

Natural Gas in US – A History

- Highly concentrated sector – early 1900s
- Rockefeller as an important player – owned significant part of transportation
- Partitioned market – situation cemented by major players´ unwillingness to develop infrastructure and interstate transportation
  - Transborder tariffs + rigid infrastructure prevented the market from developing
- Public opposition against market concentration – previous experiences with industrial trusts
- Efforts to regulate prices on federal level unsuccessful
- Natural Gas Act of 1938 – regulation of prices charged on interstate transport

General Remark on Natural Gas Sector

- Limited means of transport
- Requires high initial investments
- Investors seek for return of their initial investments
- Market naturally tends to be partitioned (due to above mentioned reasons), at least at the beginning

- Partitioning of a market and aiming to the highest capitalization possible – a common strategy in the sector

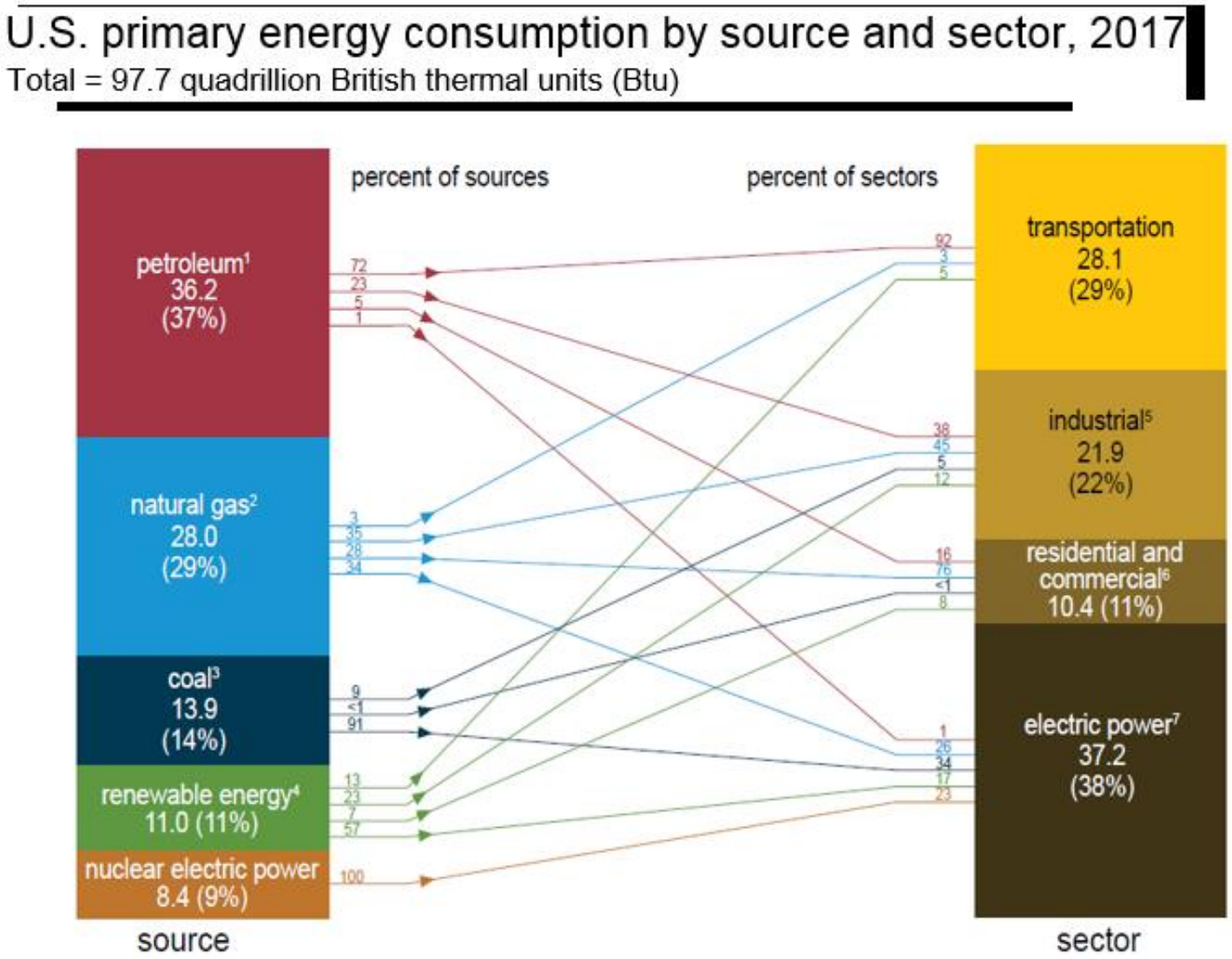
Natural Gas in US – A History

- The development of pipelines was spurred after the WW I, WW II until 1960s
  - the pipeline construction expanded thanks to improved technology of welding
  - gas used for heating and cooking
- Natural gas extraction expanded to the South and Southwestern part of the US (the Gulf of Mexico)
- Market regulation on a federal level
- Use of natural gas in decline in 1960s and 1970s – electric appliances
- Increase in late 1970s, early 1980s, mainly due to
  - Oil shocks – demand for substitute sources
  - Tightening environmental measures
  - Cold winters in the late 1970s

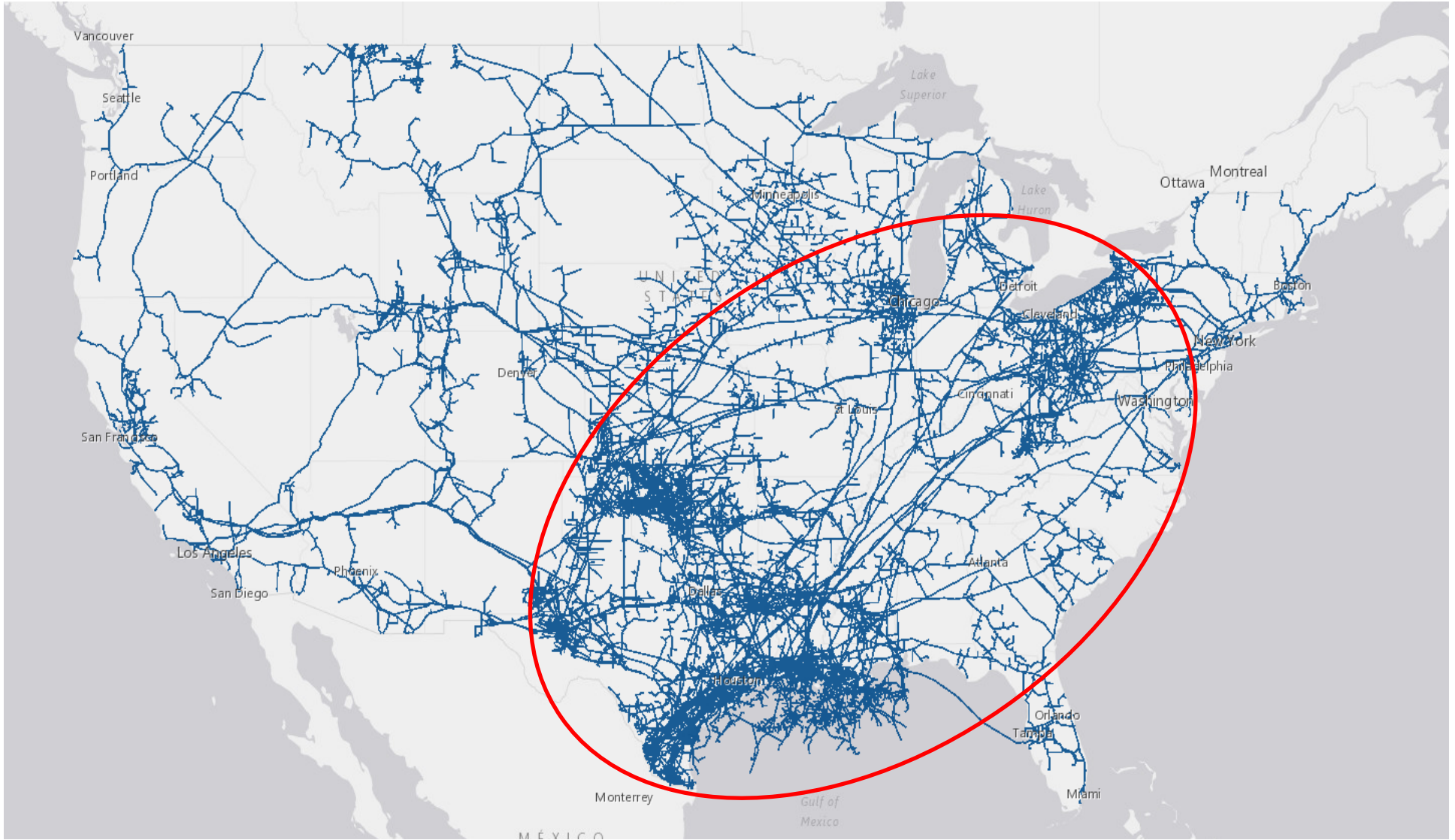
Natural Gas in US – A History

- However, demand was still rather low – economic downturn, nature of contracts, high prices (offsetting high initial costs)
- Deregulation in 1980s and early 1990s – weakened the influence of federal government
  - Supply shortages indicated that regulated sector struggles to serve all customers adequately
  - Deregulation spurred competition and development
  - Abolition of T-o-P contracts (1984 by FERC)
- Unbundling – the choice of free selection of supplier (not bound to a specific transporter or storage capacity owner) – 1992 by FERC
- Interstate affairs (transit, storage, wholesale/interstate market) – FERC
- Intrastate (storage, LNG, distribution, retail) - state

Natural gas in the US TPES



Natural Gas Infrastructure



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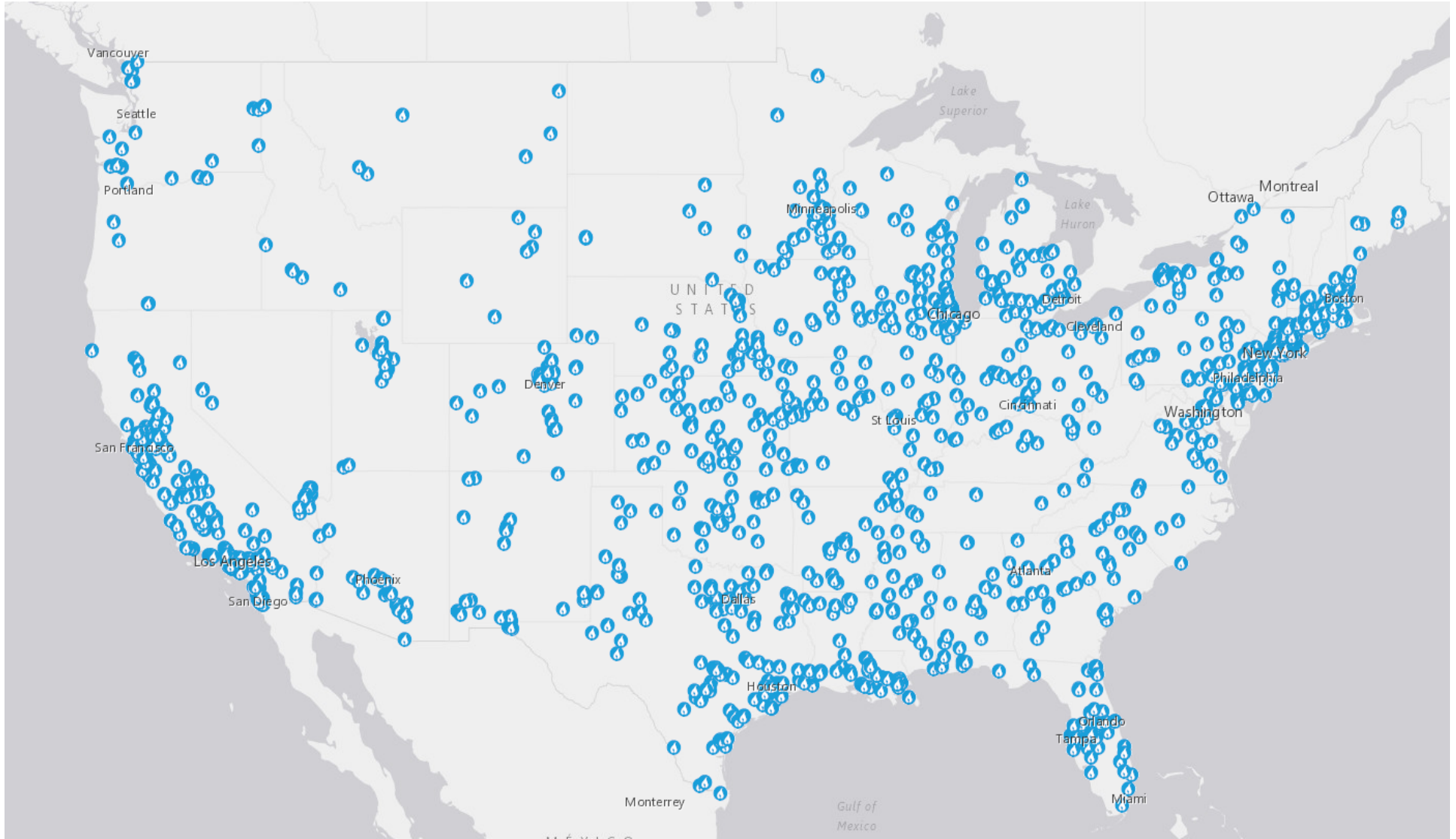
Gas Power Plants



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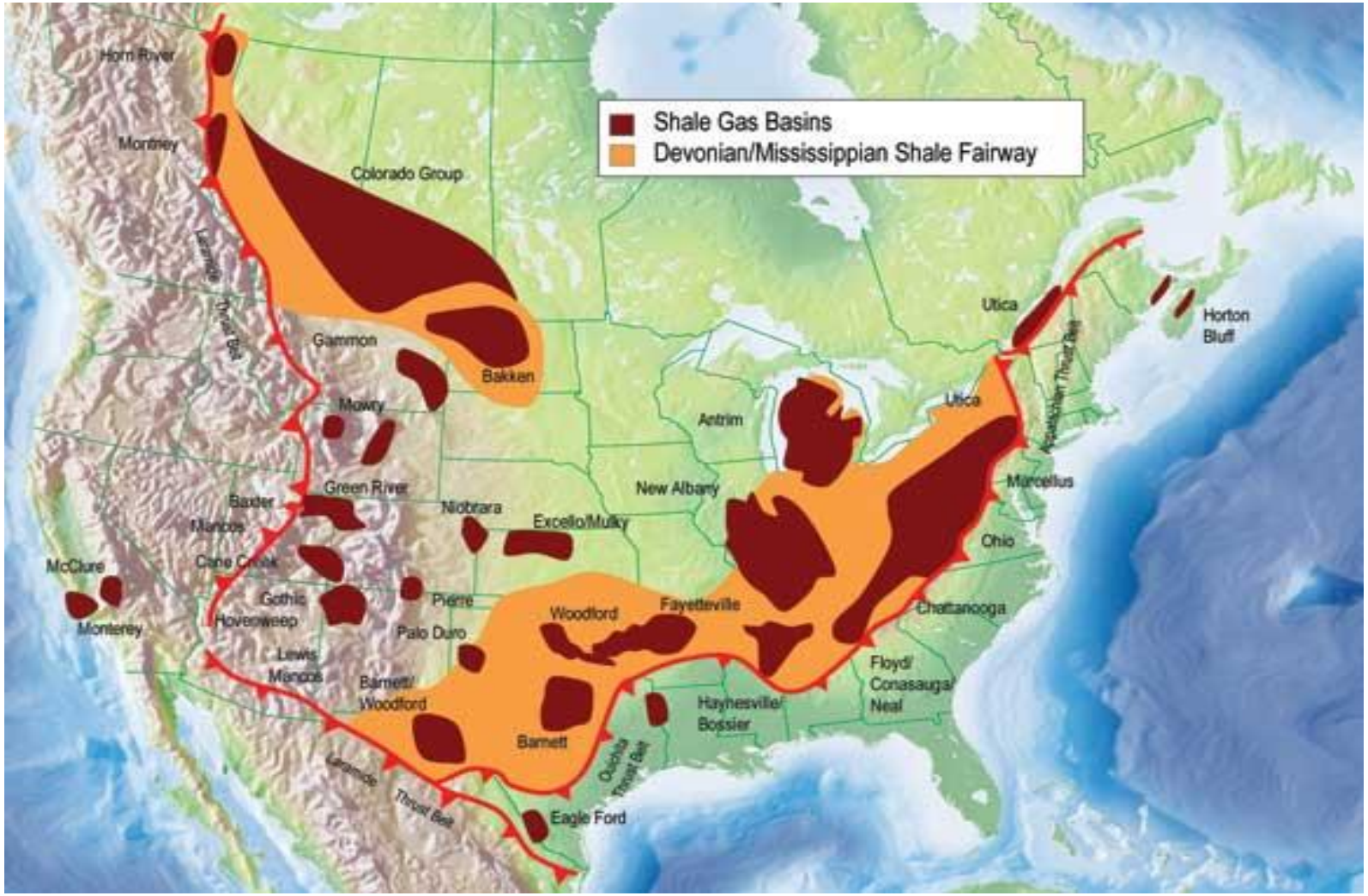
Major Shale Gas Plays in the US



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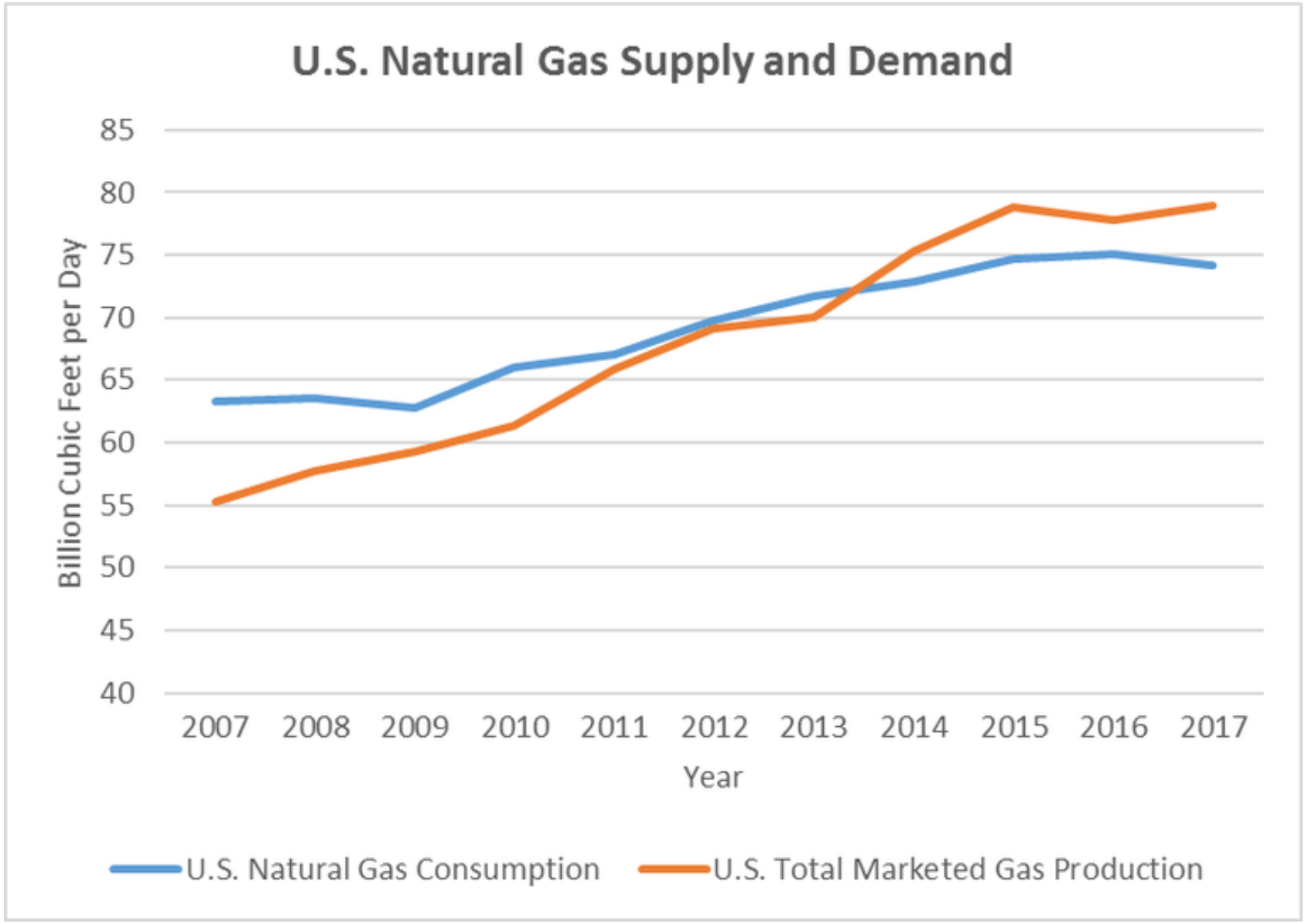
U.S. Natural Gas Supply and Demand
Billion Cubic Feet per Day
85
80
75
70
65
60
55
50
45
40
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Year
U.S. Natural Gas Consumption
U.S. Total Marketed Gas Production

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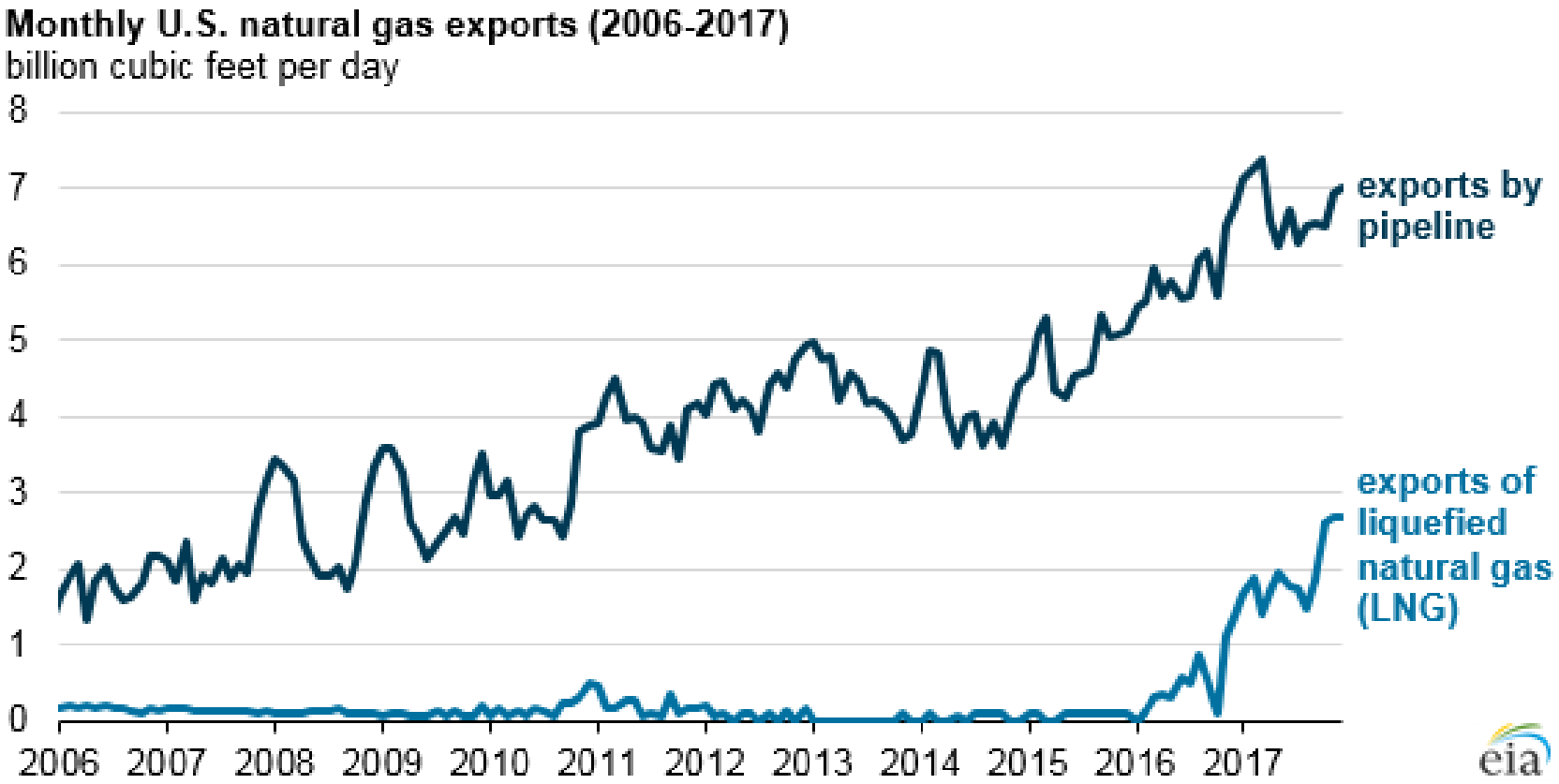
Monthly U.S. natural gas exports (2006-2017)
billion cubic feet per day
8
7
6
5
4
3
2
1
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
exports by pipeline
exports of liquefied natural gas (LNG)
eia

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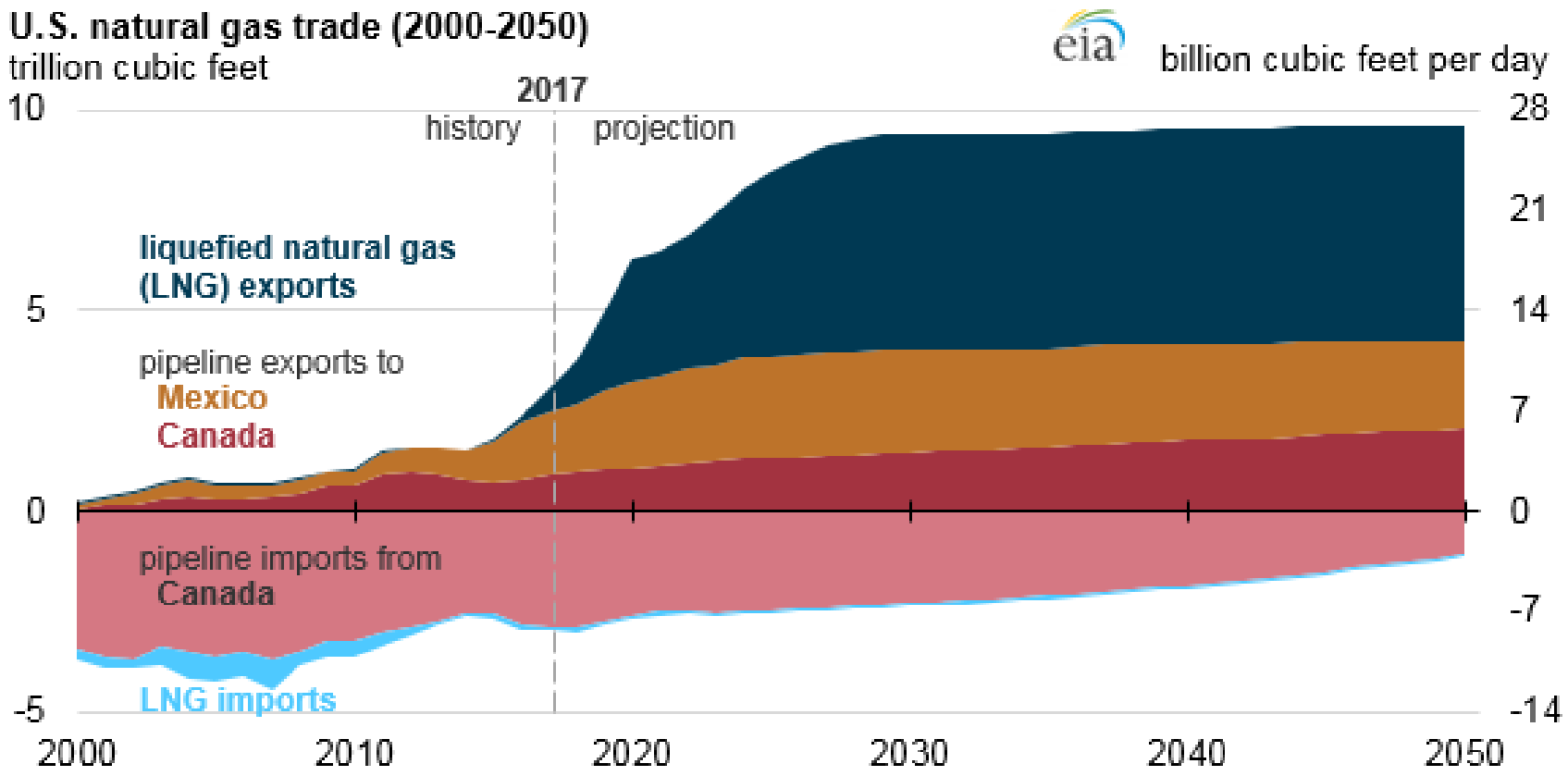
Natural gas Trade



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Natural Gas in the US - Expectations vs. Reality

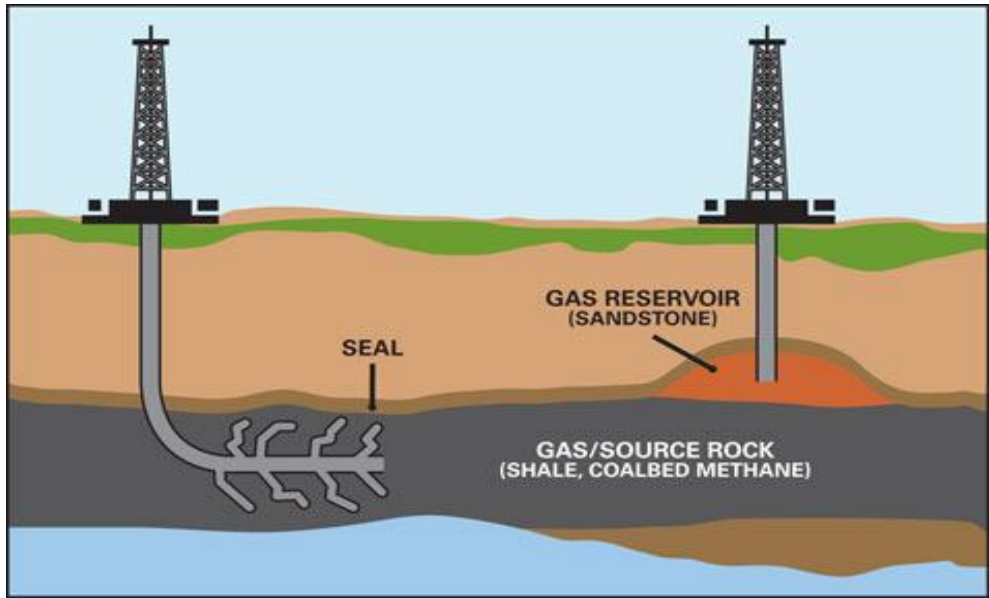
- Significant decrease of domestic production in 1980s and 1990s signaled future need for imports
- Decrease of imports from Canada and Mexico
- Increase of LNG imports (10% annually)
- Expectations that the US will become the biggest importer of LNG

Vs.

- In mid 2000s a major turnover took place – ‘The Quiet Revolution’of shale gas
- US as the world´s biggest shale gas producer
- LNG demand fell to 0
- The trend was reversed, USA among the biggest gas producers and exporters

‘A Quiet Revolution’

- Advent of natural gas extracted from unconventional sources (plays) - mostly shale
- Combination of two known technologies – horizontal drilling and hydraulic fracturing
- Both known technologies, their combination became economically viable thanks to the economy of scale and technological advancements and optimization
- Rapid increase of prices in 2005 ignited the ‘revolution’ (2002 USD 4/MMBtu vs. 2005 USD 9/MMBtu)



‘A Quiet Revolution’

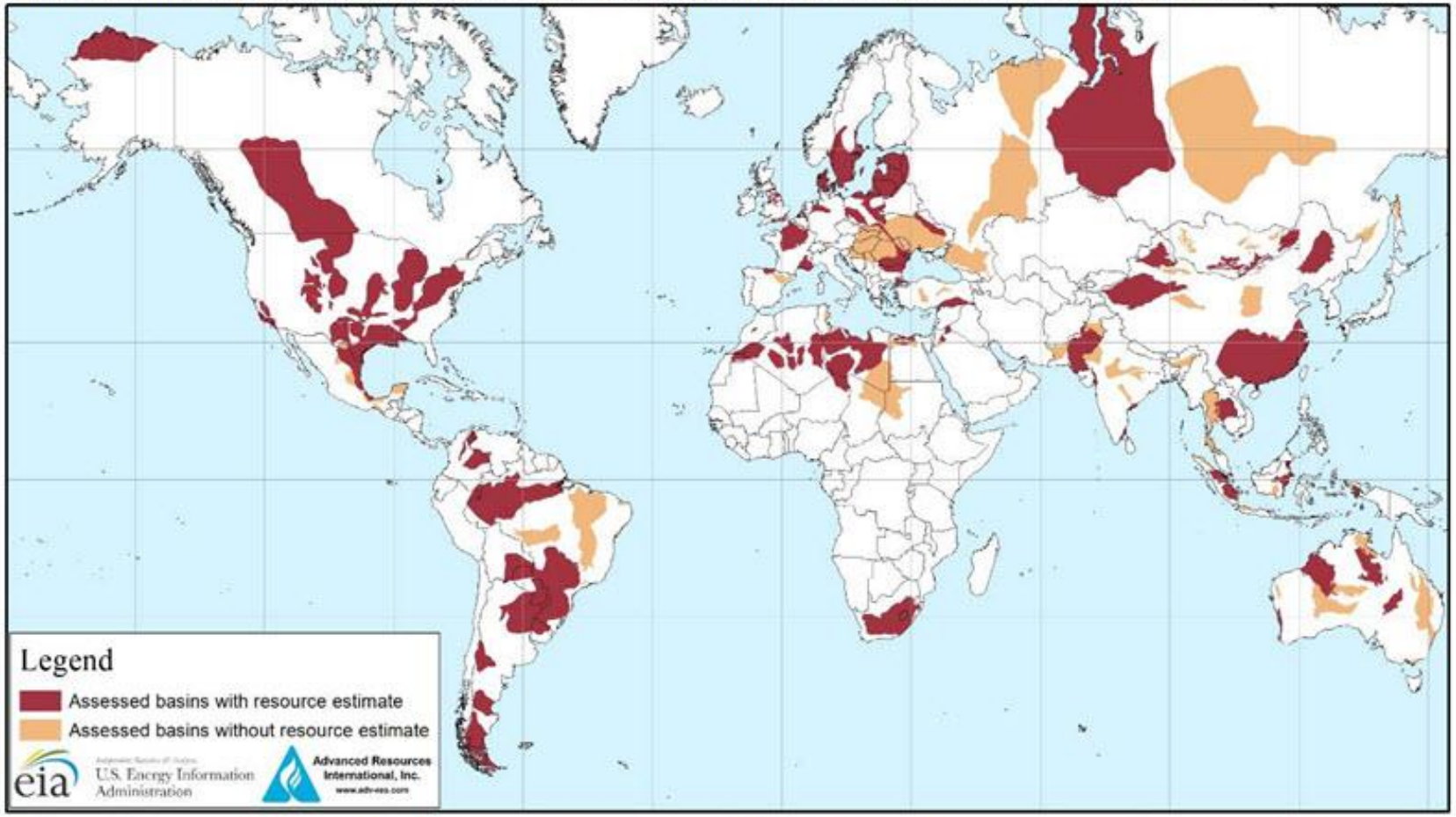
- Activities ignited by ‘independents’, mid-sized and big players joined later
- The revolution has not been replicated in other parts of the world (S America, Europe) despite large worldwide reserves
- Steep increase of estimated resources/reserves
- Substantial impact on energy sector/electricity generation – competing with traditional/base-load sources (coal, nuclear), beneficial in terms of emissions
- Changes in US position on global level in energy trade

‘A Quiet Revolution’

- Caused and accelerated seminal shifts in the energy sector
- GDP growth and GHG emissions have decoupled thanks to additions of gas-based power generation (coal - gas swap)
- Put a pressure on dirtier and less profitable sources of (electric) energy – mainly coal and nuclear
- Discussion about environmental impacts has shifted – from impacts of fracking to emission footprint and climate change in general
  - methane leakage

World Shale Gas Resources

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies.

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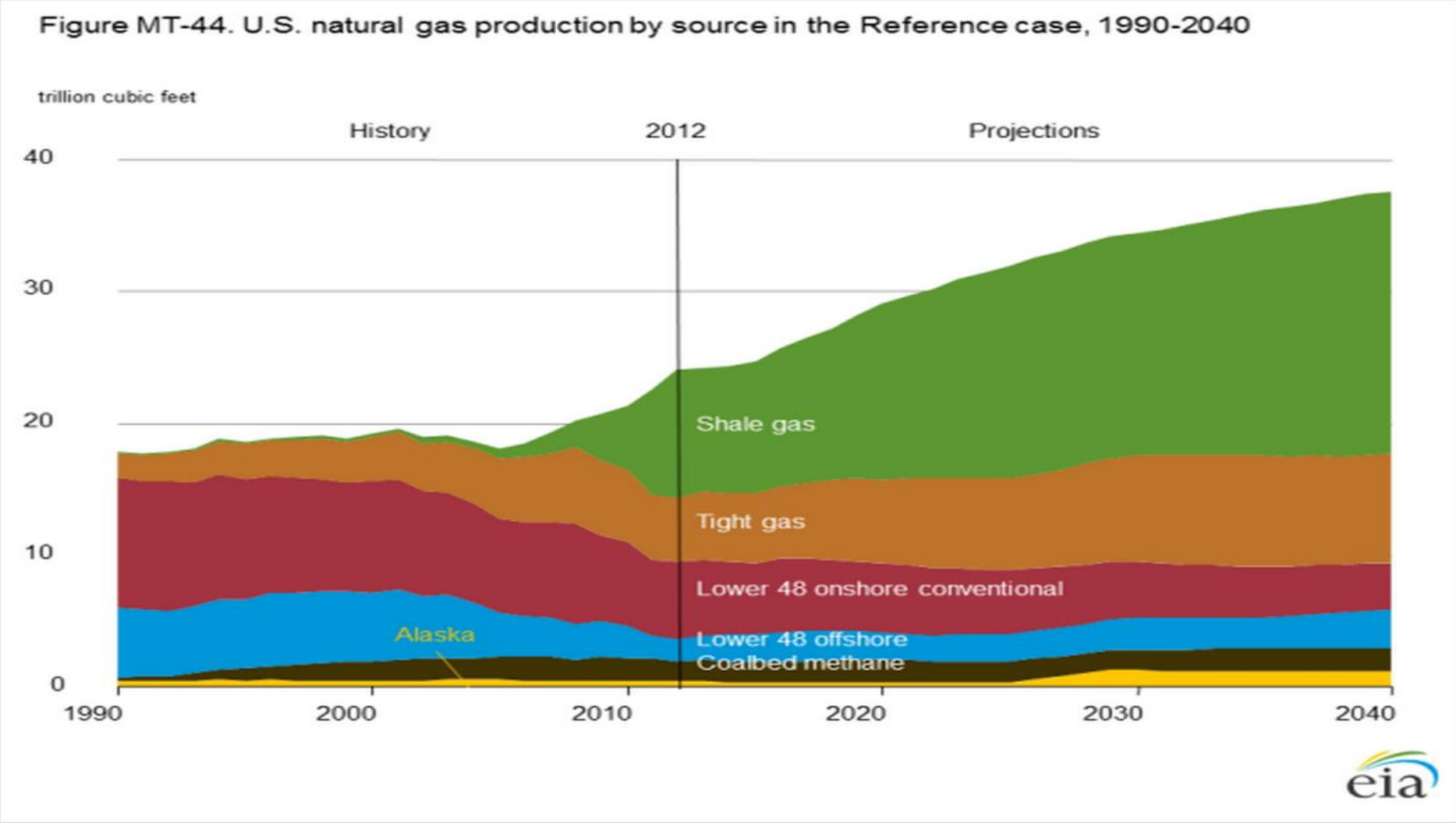
US Natural Gas Sources – A Prediction



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Natural gas and LNG

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US in A New Position

- Predictions of massive increase of LNG imports until cca 2007
- Applications to build LNG import terminals
- The quiet revolution changed the situation
- Abundance of natural gas, demand for imported LNG decreased to 0
- Qatari gas redirected
- The advent of unconventionals affected the whole energy sector
- US among the top world´s producers
- 2018 first whole year of US as a net gas exporter
- From a major prospective importer to a major prospective exporter
- Determining factors
  - oil price
  - export infrastructure – parts of infrastructure already built – still a comparative advantage

US LNG Exports

- Delusional image of gas prices on the US level – production costs + price of liquefaction + transport + regasification
- CEE: perceived as a mitigation of dependence on Russian supplies
  - Economy? Infrastructure? Sufficiency?
- Potentially beneficial for gas prices
  - Puts a pressure on landfall markets
- LNG exports to Europe would obviously benefit from a FTA
- TTIP negotiated between2013 – 2016 (stalled)
- Unclear outlook amid current tense economic relations

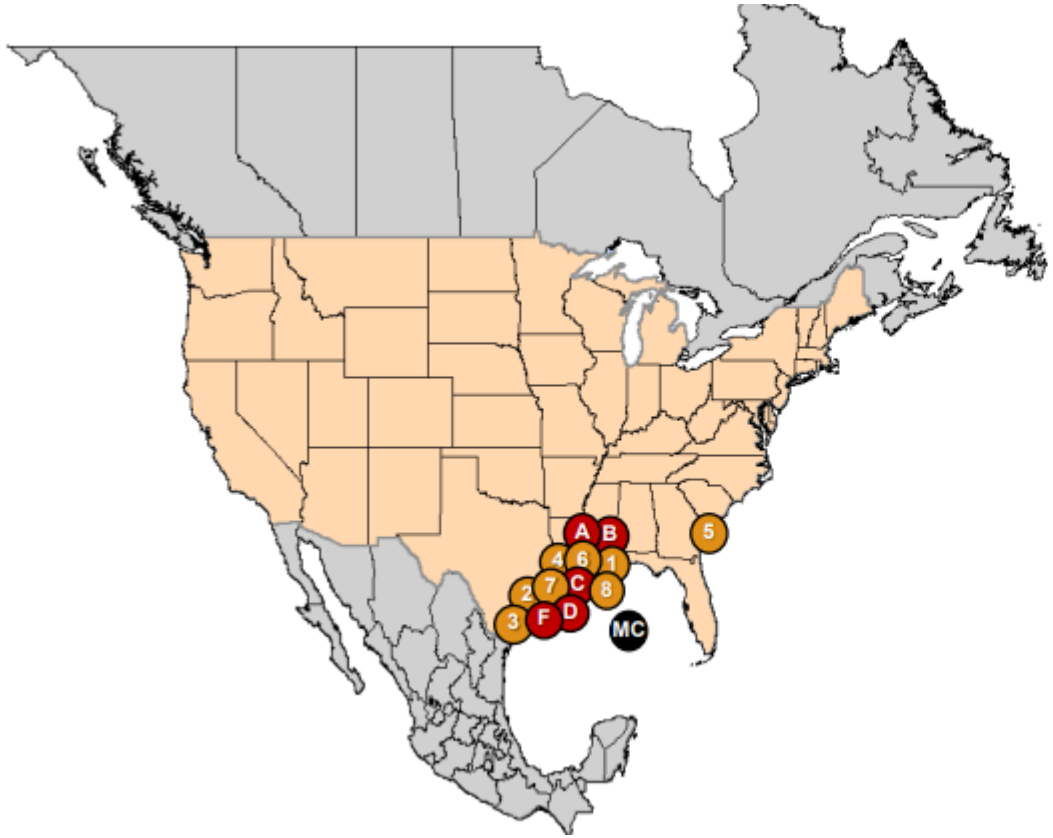
US LNG Exports

- LNG export application proces
  - A) FTA countries - routinely processed without delays
  - B) No FTA countries - more scrutiny, proof of ‘public interest’ required
    - Permission process has been streamlined as a result of pressure by exporters
    - Timeframe limited to 45 days
    - The ‘ end use’ reporting provision softened

US LNG Exports – operating terminals

- LNG terminals
  - Kenai (AK) – operating
  - Sabine Pass (LA) – operating
  - Cove Point (MD) – operating
  - Corpus Christi (TX) – operating
  - Cameron (LA) – operating
  - Freeport (TX) – expected in Q3-Q4/2019
  - Elba Island (GA) – delayed

US LNG Exports – Terminals Approved/Under Construction



Export Terminals

UNITED STATES

APPROVED - UNDER CONSTRUCTION - FERC

1. **Hackberry, LA:** 2.1 Bcfd (Sempra–Cameron LNG) (CP13-25)
2. **Freeport, TX:** 2.14 Bcfd (Freeport LNG Dev/Freeport LNG Expansion/FLNG Liquefaction) (CP12-509) (CP15-518)
3. **Corpus Christi, TX:** 1.4 Bcfd (Cheniere – Corpus Christi LNG Trains 2 & 3) (CP12-507)
4. **Sabine Pass, LA:** 0.7 Bcfd Train 6 (Sabine Pass Liquefaction) (CP13-552)
5. **Elba Island, GA:** 0.35 Bcfd (Southern LNG Company) (CP14-103)
6. **Cameron Parish, LA:** 1.41 Bcfd (Venture Global Calcasieu Pass) (CP15-550)
7. **Sabine Pass, TX:** 2.1 Bcfd (ExxonMobil – Golden Pass) (CP14-517)
8. **Calcasieu Parish, LA:** 4.0 Bcfd (Driftwood LNG) (CP17-117)

APPROVED – NOT UNDER CONSTRUCTION - FERC

- **A. Lake Charles, LA:** 2.2 Bcfd (Southern Union – Lake Charles LNG) (CP14-120)
- **B. Lake Charles, LA:** 1.08 Bcfd (Magnolia LNG) (CP14-347)
- **C. Hackberry, LA:** 1.41 Bcfd (Sempra - Cameron LNG) (CP15-560)
- **D. Port Arthur, TX:** 1.86 Bcfd (Port Arthur LNG Trains 1 & 2) (CP17-20)
- **F. Freeport, TX:** 0.72 Bcfd (Freeport LNG Dev) (CP17-470)

APPROVED – NOT UNDER CONSTRUCTION – MARAD/Coast Guard

- **MC. Gulf of Mexico:** 1.8 Bcfd (Delfin LNG)

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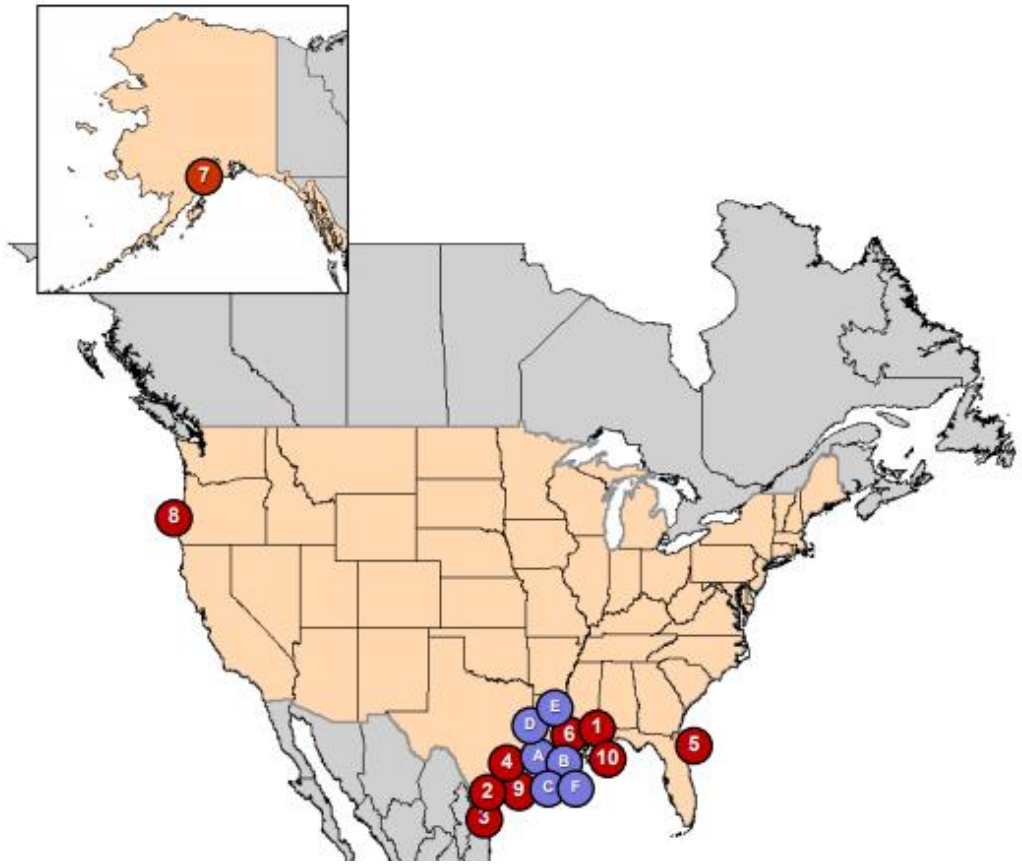
US LNG Exports – Terminals Proposed



UNITED STATES

PROPOSED TO FERC
Pending Applications:
1. **Pascagoula, MS:** 1.5 Bcfd (Gulf LNG Liquefaction) (CP15-521)
2. **Brownsville, TX:** 0.55 Bcfd (Texas LNG Brownsville) (CP16-116)
3. **Brownsville, TX:** 3.6 Bcfd (Rio Grande LNG – NextDecade) (CP16-454)
4. **Brownsville, TX:** 0.9 Bcfd (Annova LNG Brownsville) (CP16-480)
5. **Jacksonville, FL:** 0.132 Bcf/d (Eagle LNG Partners) (CP17-41)
6. **Plaquemines Parish, LA:** 3.40 Bcfd (Venture Global LNG) (CP17-66)
7. **Nikiski, AK:** 2.63 Bcfd (Alaska Gasline) (CP17-178)
8. **Coos Bay, OR:** 1.08 Bcfd (Jordan Cove) (CP17-494)
9. **Corpus Christi, TX:** 1.86 Bcfd (Cheniere Corpus Christi LNG) (CP18-512)
10. **Sabine Pass, LA:** NA Bcfd (Sabine Pass Liquefaction) (CP19-11)

Projects in Pre-filing:
A. **Cameron Parish, LA:** 1.18 Bcfd (Commonwealth, LNG) (PF17-8)
B. **LaFourche Parish, LA:** 0.65 Bcfd (Port Fourchon LNG) (PF17-9)
C. **Galveston Bay, TX**: 1.2 Bcfd (Galveston Bay LNG) (PF18-7)
D. **Plaquemines Parish, LA:** 0.9 Bcfd (Pointe LNG) (PF18-8)
E. **Plaquemines Parish, LA:** 2.76 Bcfd (Delta LNG - Venture Global) (FP19-4)
F. **Port Arthur, TX:** 1.86 Bcfd Port Arthur LNG Trains 3 & 4 – Sempra) (PF15-5)

CANADA
For Canadian LNG Import and Proposed Export Facilities:

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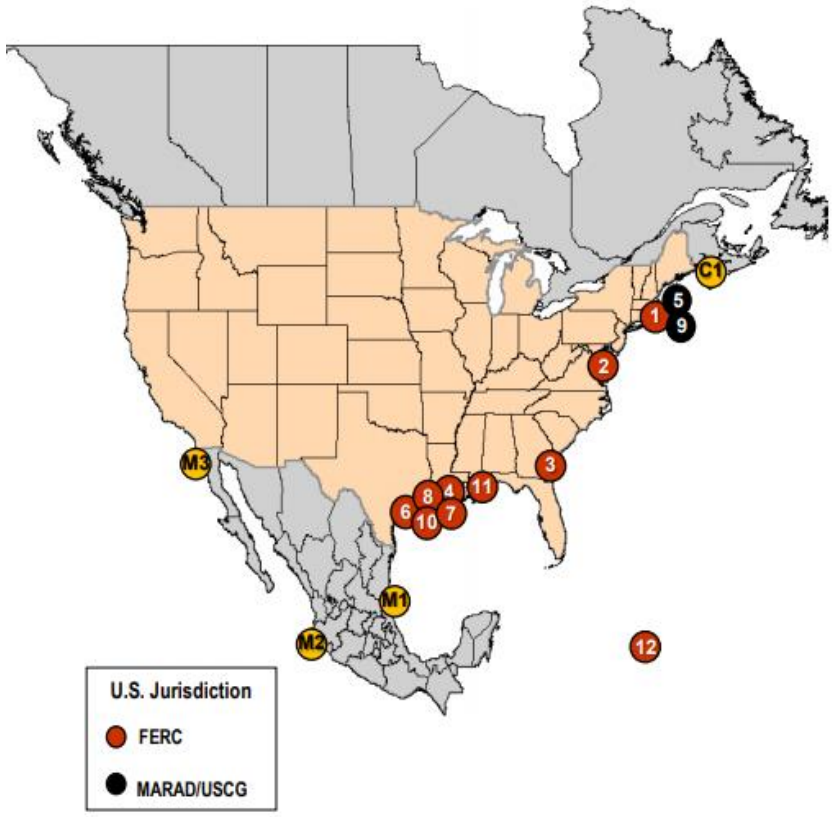
LNG Import Terminals



Import Terminals

UNITED STATES
1. **Everett, MA:** 1.035 Bcfd (GDF SUEZ - DOMAC)
2. **Cove Point, MD:** 1.8 Bcfd (Dominion - Cove Point LNG)
3. **Elba Island, GA:** 1.6 Bcfd (El Paso - Southern LNG)
4. **Lake Charles, LA:** 2.1 Bcfd (Southern Union – Corpus Christi LNG) ★
5. **Offshore MA:** 0.8 Bcfd (Excelerate Energy – Northeast Gateway)
6. **Freeport, TX:** 1.5 Bcfd (Cheniere/Freeport LNG Dev.) ★
7. **Sabine, LA:** 4.0 Bcfd (Cheniere/Sabine Pass LNG) ★
8. **Hackberry, LA:** 1.8 Bcfd (Sempra - Cameron LNG)
9. **Offshore MA:** 0.4 Bcfd (GDF SUEZ – Neptune LNG)
10. **Sabine Pass, TX:** 2.0 Bcfd (ExxonMobil – Golden Pass) (Phase I & II)
11. **Pascagoula, MS:** 1.5 Bcfd (El Paso/Crest/Sonangol - Gulf LNG Energy)
12. **Peñuelas, PR:** 0.3 Bcfd (EcoElectrica)

CANADA
C1. Saint John, NB: 1.0 Bcfd (Repsol/Fort Reliance - Canaport LNG)

MEXICO
M1. Altamira, Tamulipas: 0.7 Bcfd (Shell/Total/Mitsui – Altamira LNG)
M2. Baja California, MX: 1.0 Bcfd (Sempra – Energia Costa Azul)
M3. Manzanillo, MX: 0.5 Bcfd (KMS GNL de Manzanillo)

★ **Authorized to re-export delivered LNG**

- Under construction: 0
- Approved: 3
- Proposed: 1

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Destinations of US LNG Exports

- Europe, Mexico – top destinations for short-term/spot contracts
- LNG prices have been converging, market is getting flexible
- SE Asia – top destination for long-term contracts
  - Long-term contracts dominate (mainly due to cost returns)
- Competing suppliers coming in SE Asia (Australian LNG)
  - US exporters still falling behind
- Top destinations:
  - S. Korea
  - Mexico
  - Japan
  - China