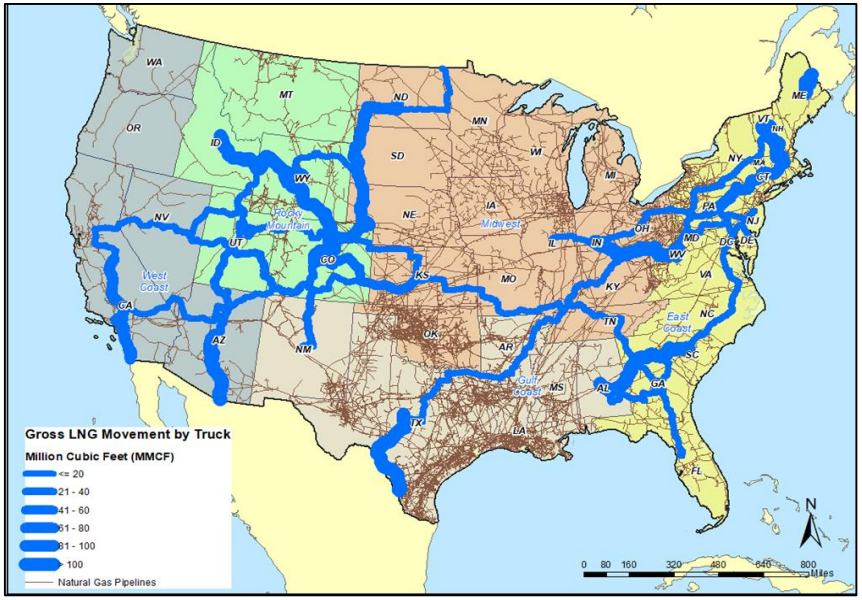

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Think Forward

The Dynamics of Energy Transport and Implications for Freight

presented to

TPB Freight Subcommittee

presented by

Cambridge Systematics, Inc.

David O. Willauer, Chair

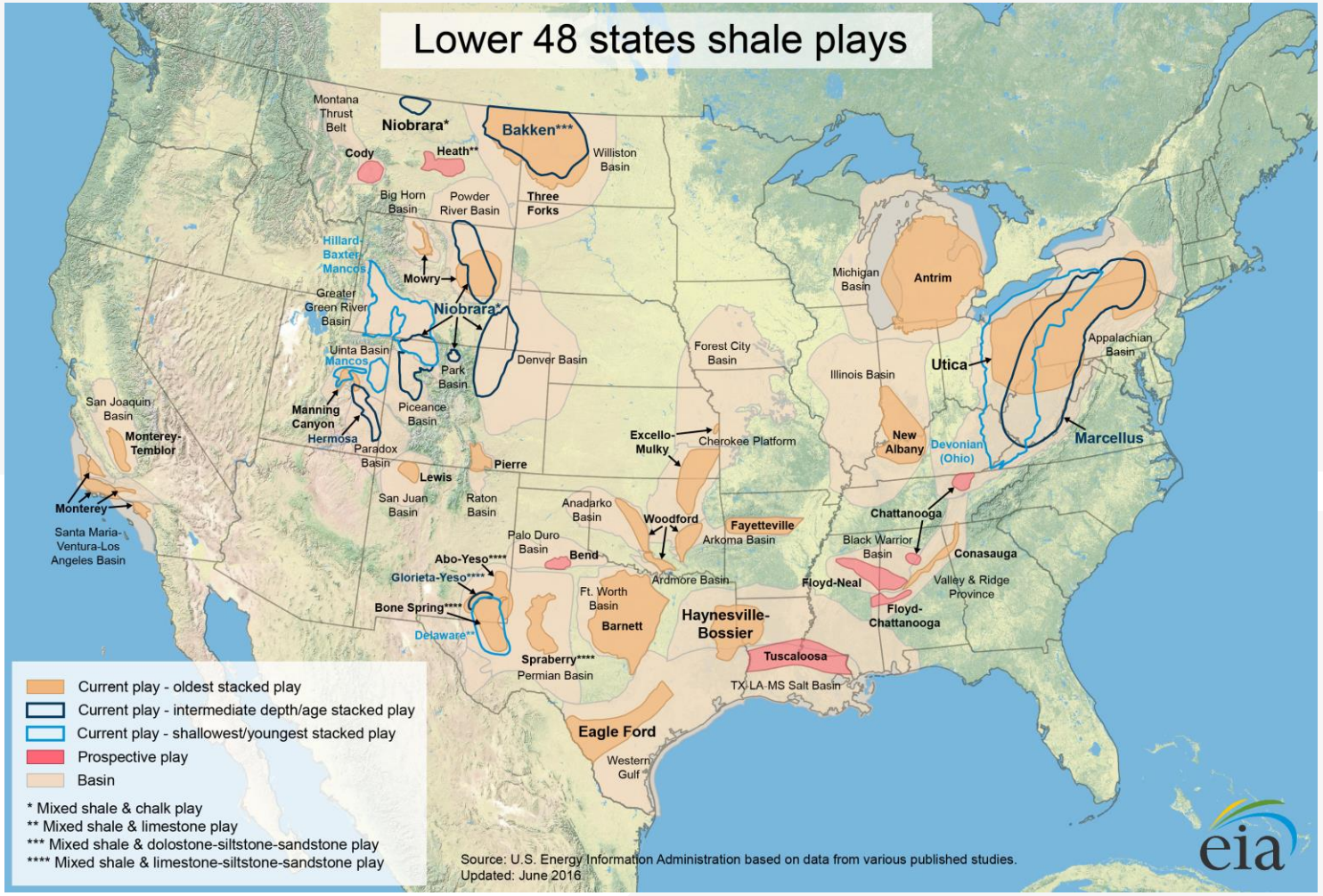
Transportation of Hazardous Materials

March 5, 2020

Presentation Overview

- The U.S. Energy Renaissance: Shale Oil and Gas Plays and New Production Technology
- Petroleum Commodities:
  - Crude Oil, Refined Petroleum, Natural Gas and Natural Gas Liquids (NGLs)
- Implications for Freight Transportation

US Oil and Gas Shale Plays



Source: EIA

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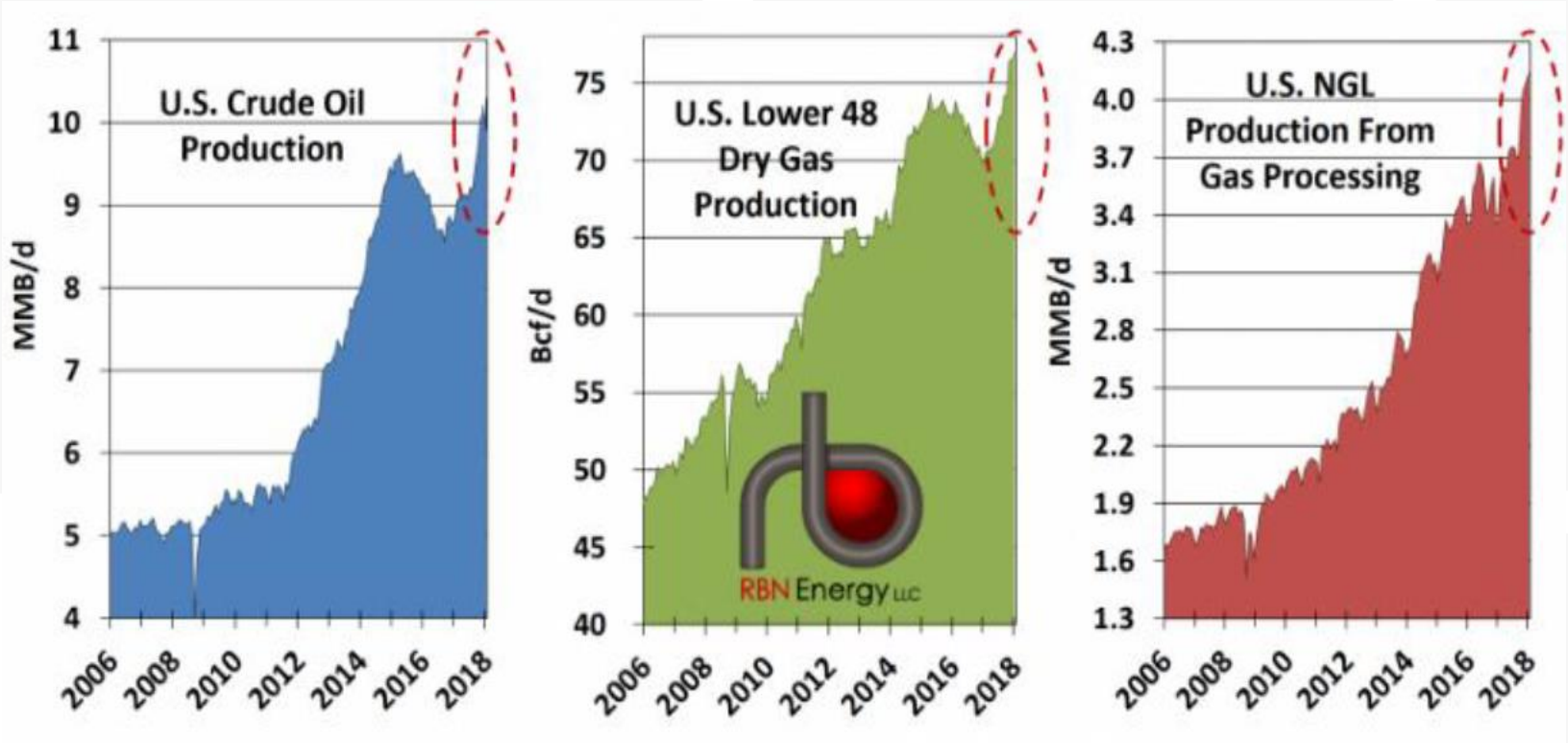
Results of More Shale Oil and Gas

- Refinery retrofits for shale crude processing
- Changing dynamics between Canada and Mexico markets
- Shift to natural gas-fired power plants (from coal, nuclear)
- Growth in LNG export terminals continues
- New crude oil, LNG and LPG infrastructure needed
- New steam crackers being built due to cheap ethane gas
- More chemical companies locating in the U.S.
- Crude oil production remains high at 13 MM b/d
- Crude price reduction of COVIS-19 benefits mid-streamers

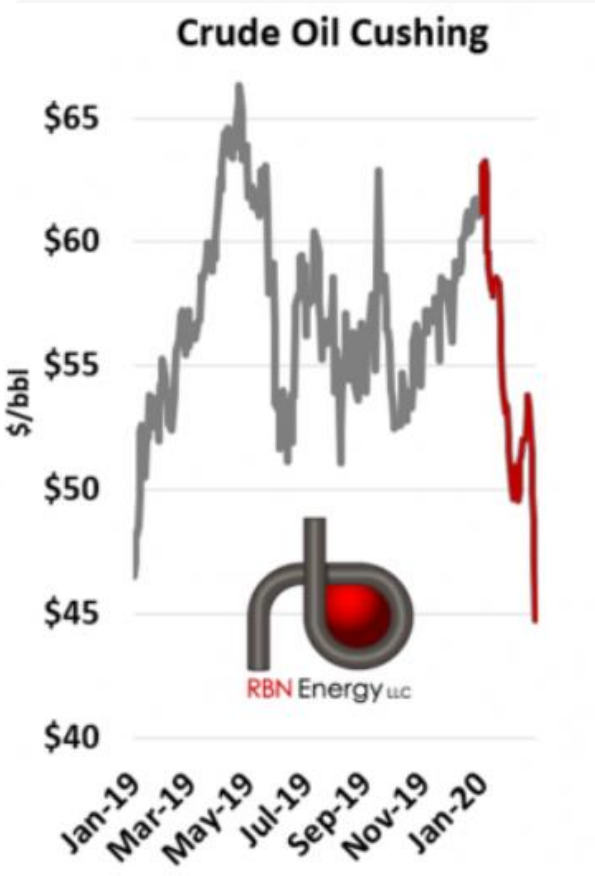
U.S. Hydrocarbon Production Trends



Crude Production at record highs 13 MM b/d despite corporate carbon caution

Sources: EIA and RBN Energy

U.S. Hydrocarbon Pricing Trends



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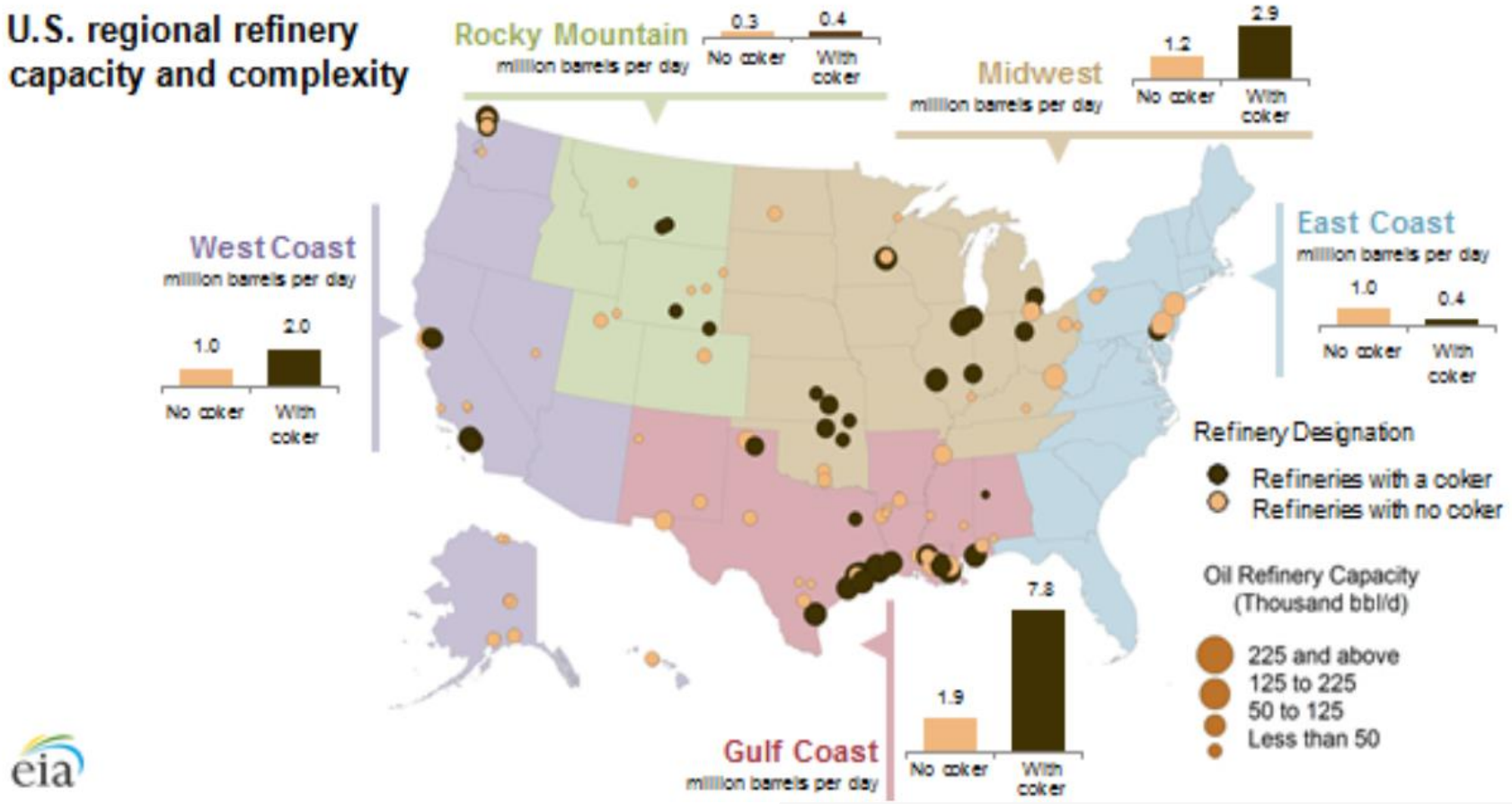
U.S. Petroleum Refinery Capacity



Source: EIA

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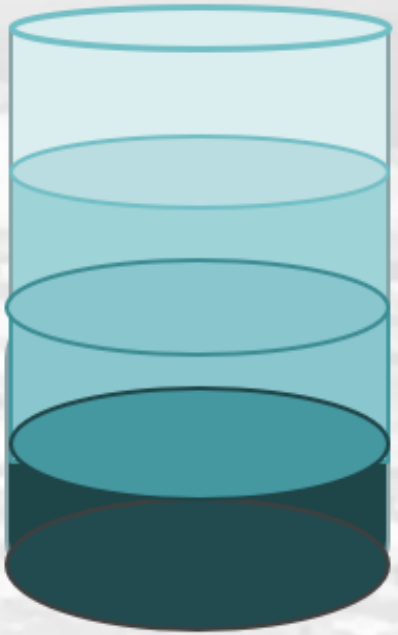
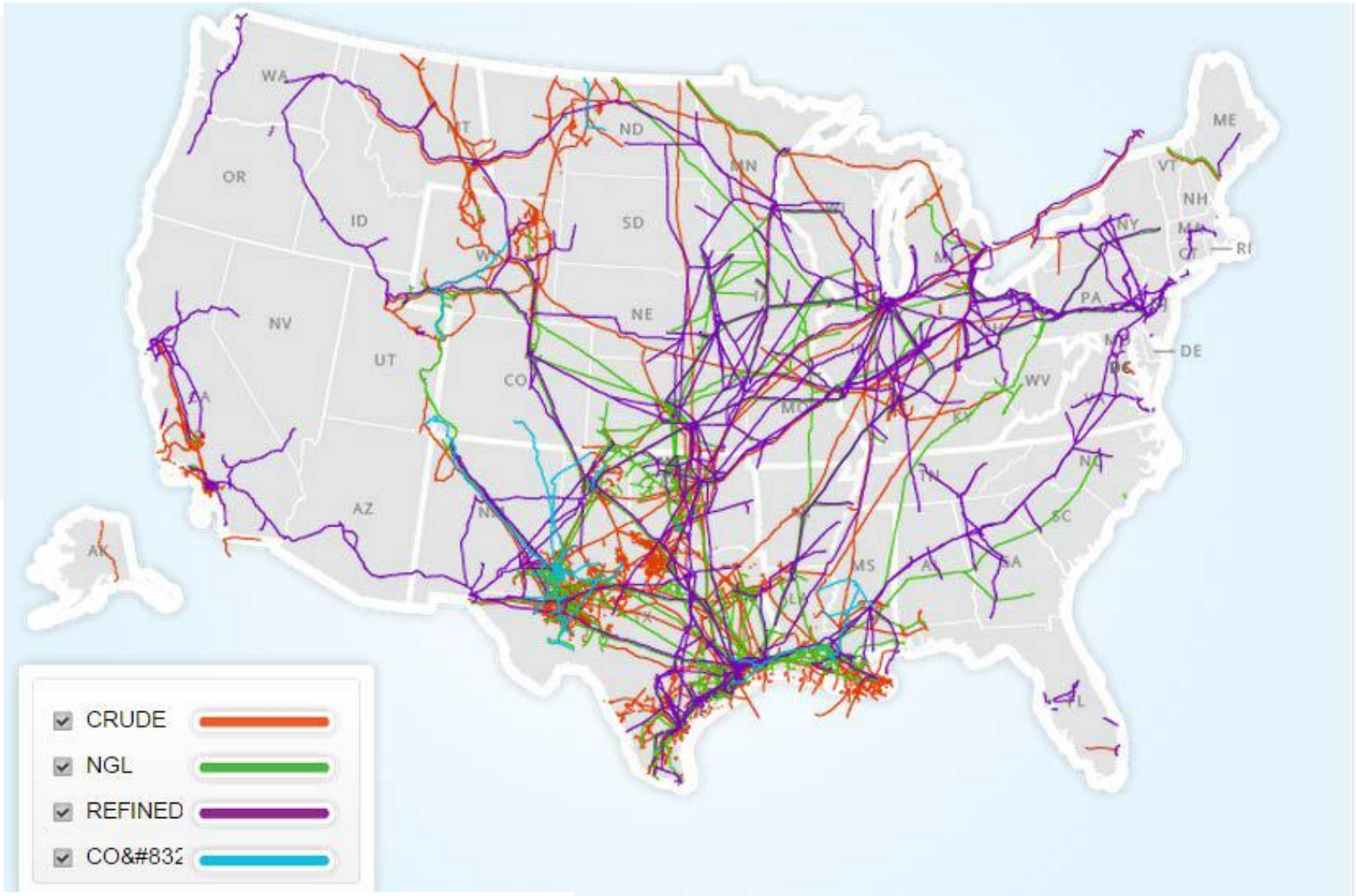
Crude Oil Classification

Classification	API Gravity	Sulfur	Type
Condensate	50°+	0%	Sweet
Light Oil	42°	1%	Med Sweet
Medium Oil	20°	3%	Med Sour
Heavy Oil	10°-	4%	Sour



Source: Cambridge Systematics and Transport Canada

Petroleum Product Pipelines



Source: American Energy Mapping, 2013

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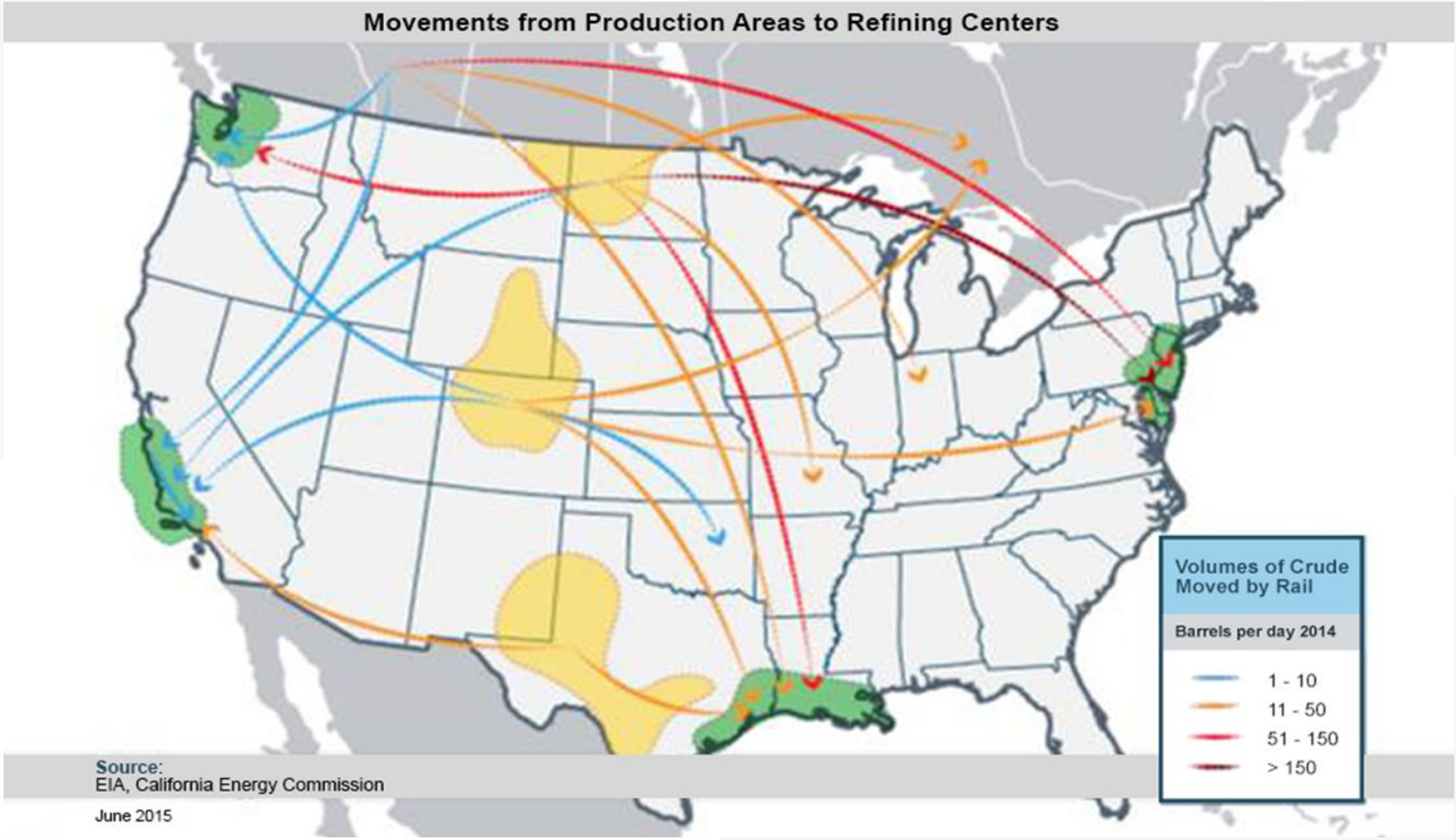
Capacity of Pipelines and Other Modes

1 major pipeline - 830,000 barrels per day	
13-14 unit trains per day - ~700 barrels per rail car on 100-car train	
1150+ trucks per day - ~714 barrels per tanker	

Source: State Dept Supplemental EIA Keystone XL, AOPL, TRB

Crude by Rail, Production to Refining



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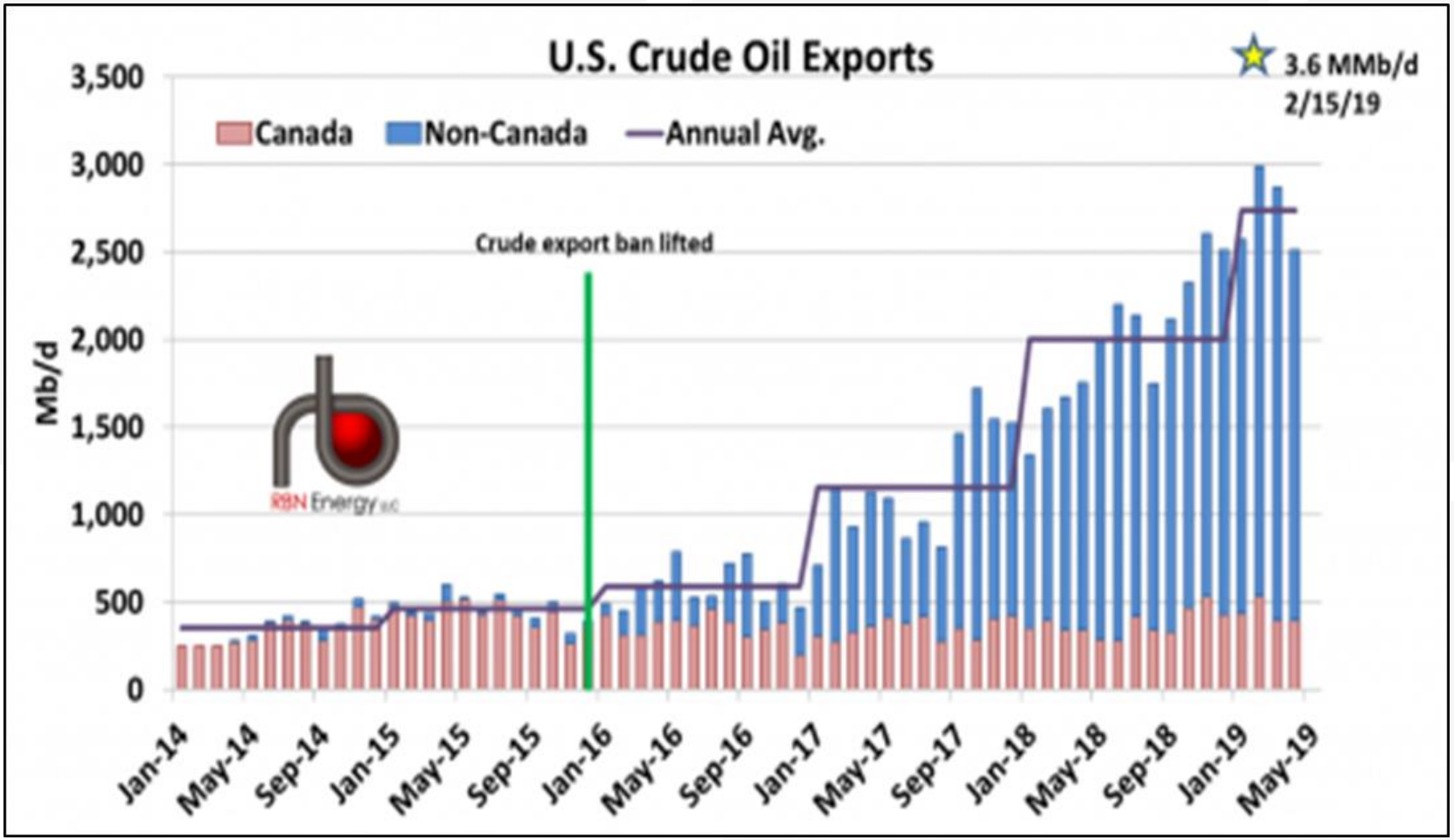
US Crude Oil Exports (2014-2019)



Source: EIA, RBN

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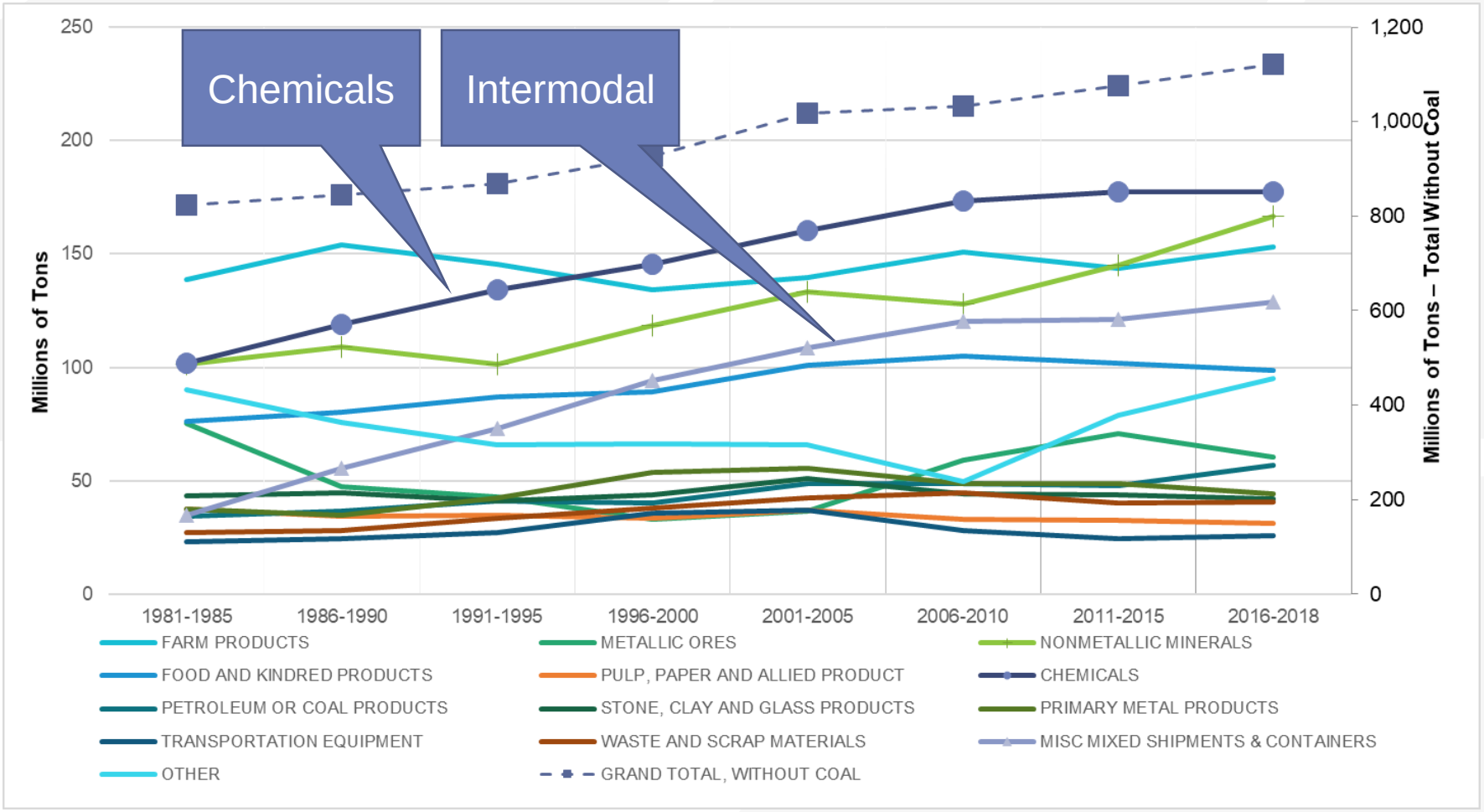
Petroleum and Chemicals by Rail

- Chlorine Gas (plastics and paper production, water treatment)
- Anhydrous Ammonia (fertilization and refrigeration)
- Crude Oil (feedstock for petroleum refining), now able to export
- Propane and Butane (fuel and fuel blending) 60% LPG is exported
- Ethanol (biofuel, fuel blending, exports)

Tank Car Developments (111, 112, 113, 117) High Hazard Flammable Trains

Class I Annual Tonnage without Coal



Source: AAR and Cambridge Systematics

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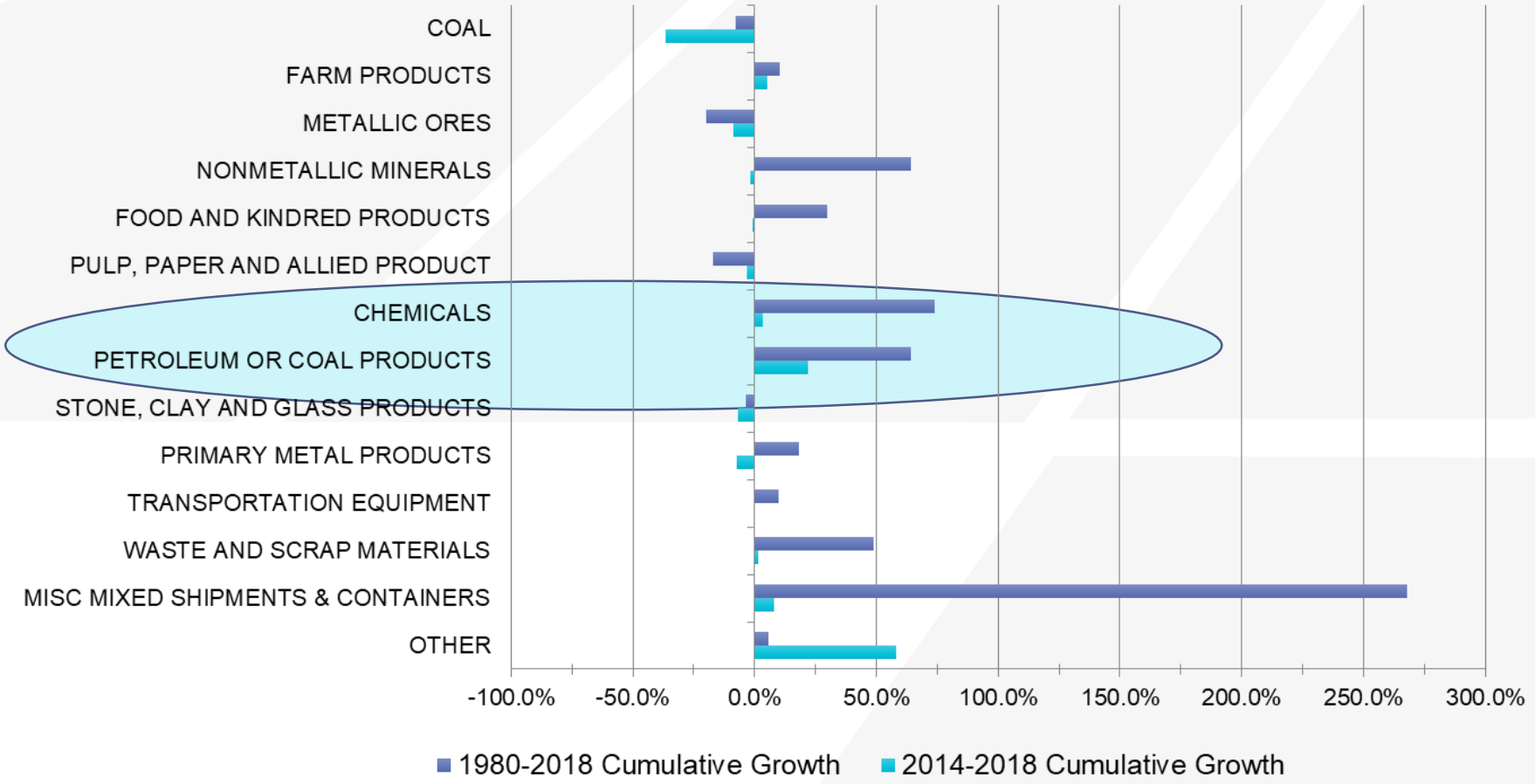
Sources of Growth in Rail Tonnage



Source: AAR and Cambridge Systematics

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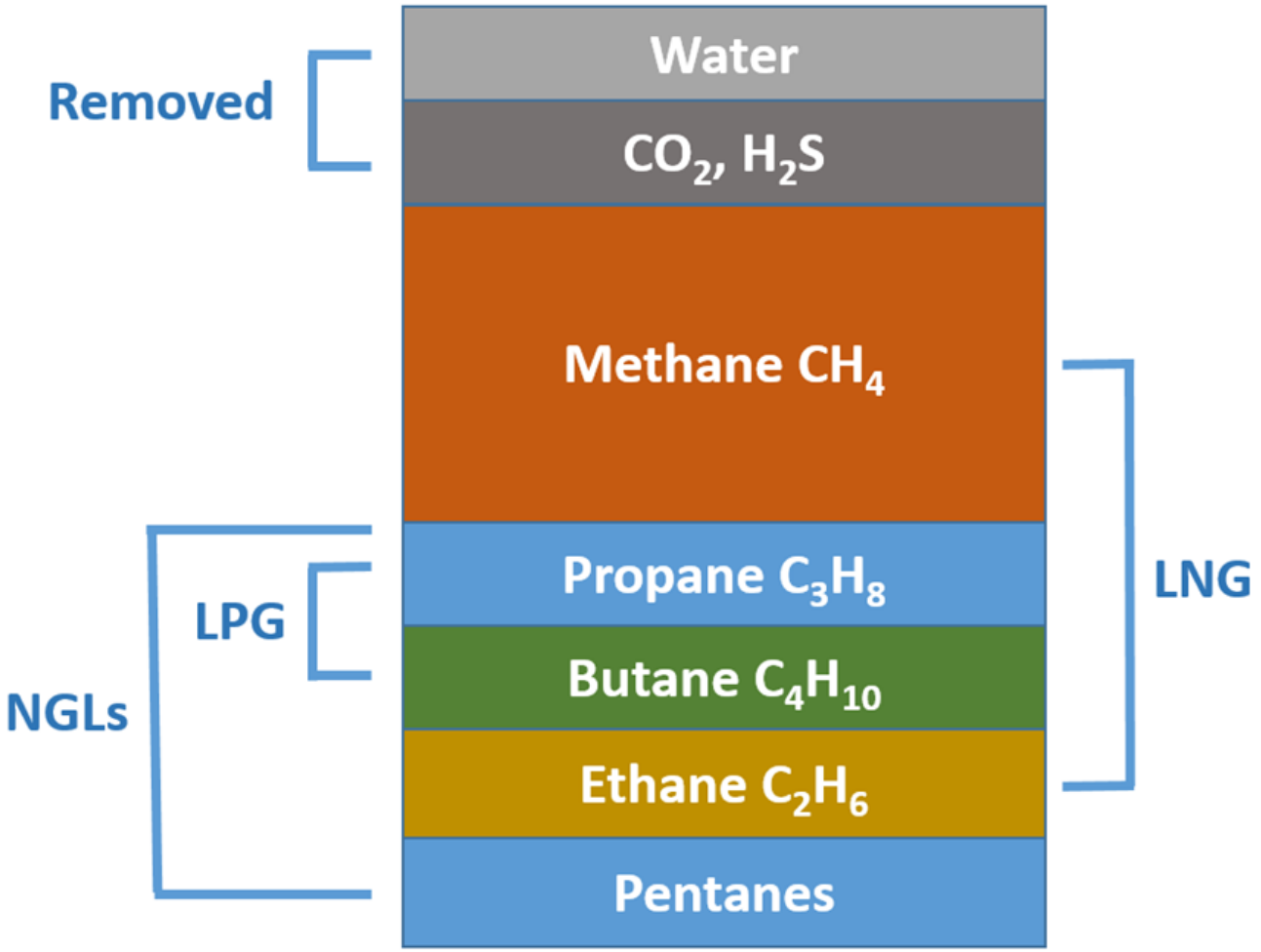
U.S. Holds Competitive Advantage in Natural Gas Industry

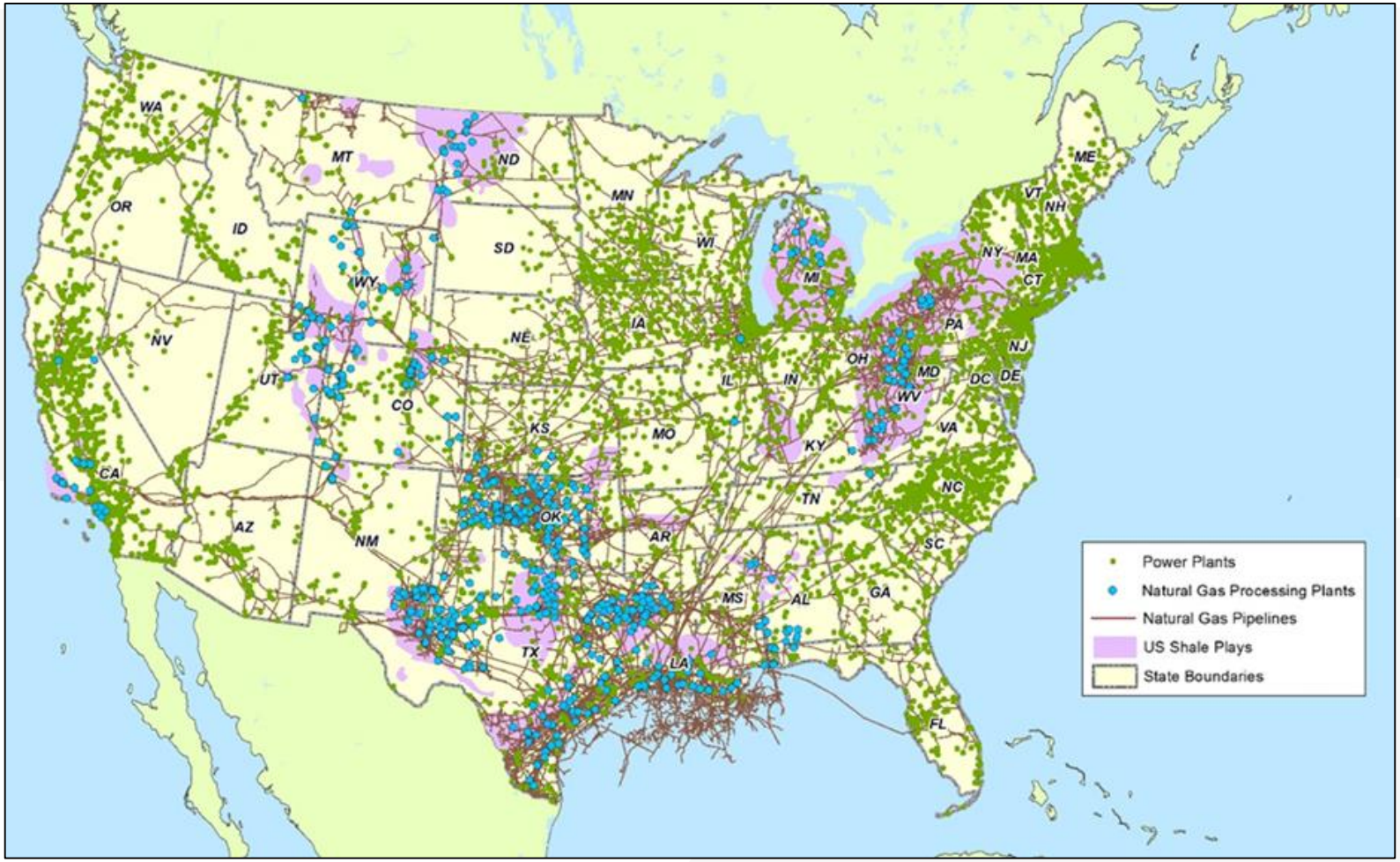
- Ample access to low-cost shale gas continues to attract foreign companies to the US, resulting in a pipeline of 340 chemical projects valued at $204 billion.
- Seventy percent of those projects involve a foreign investor and the majority of the investments involve natural gas and NGLs for export.

Source: American Chemistry Council

Natural Gas Properties



US Natural Gas Supply Chain



Source: EIA, CS

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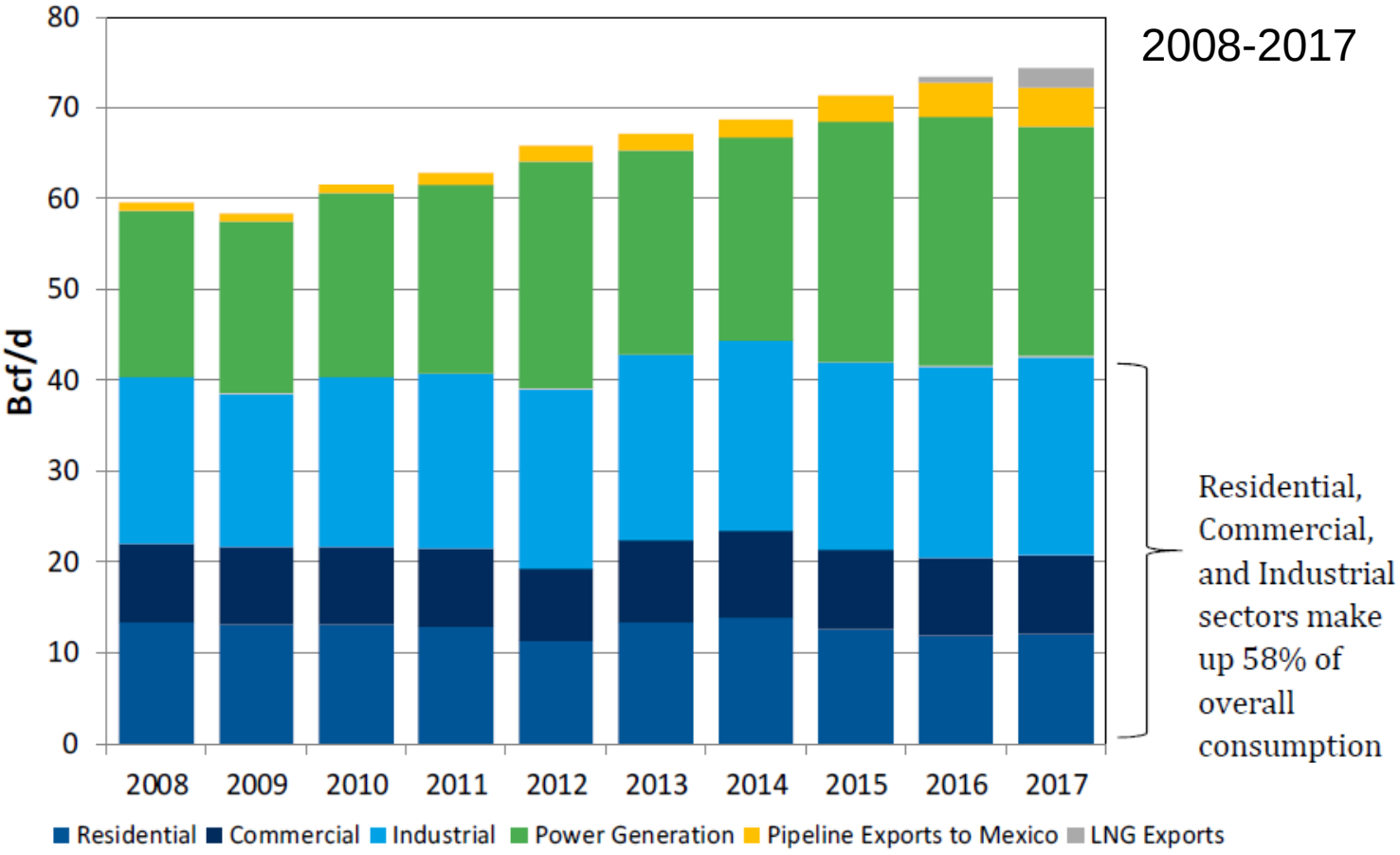
Historical Gas Consumption by Sector

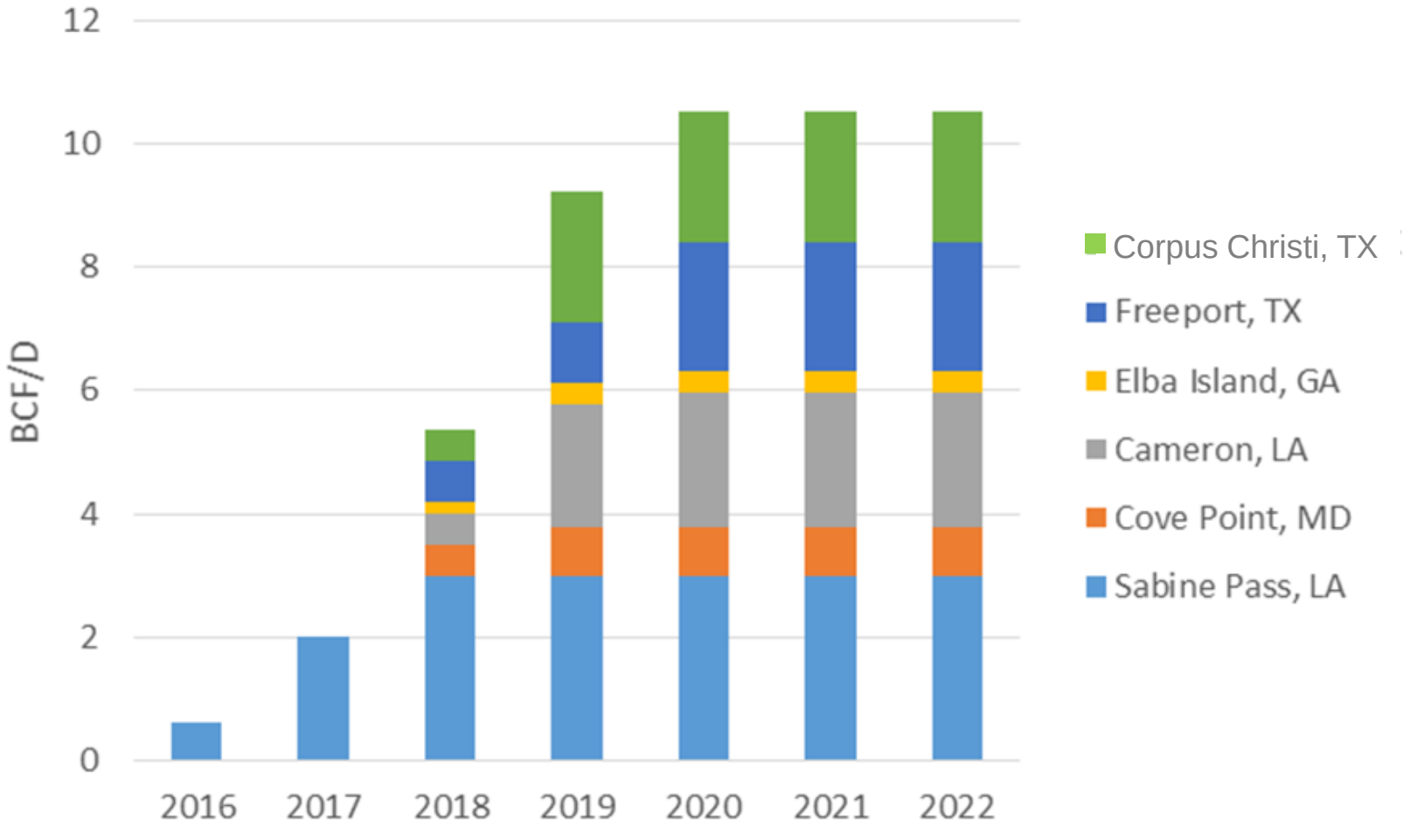


Source: FERC Website, Black & Veatch Analysis, EIA

Emerging Markets: LNG Fuel Applications

Sources: Chart Industries, FECR, Tote Marine, CN Railroad, CS

LNG Exports 2016-2022



Sources: EIA, FERC, CS, RBN

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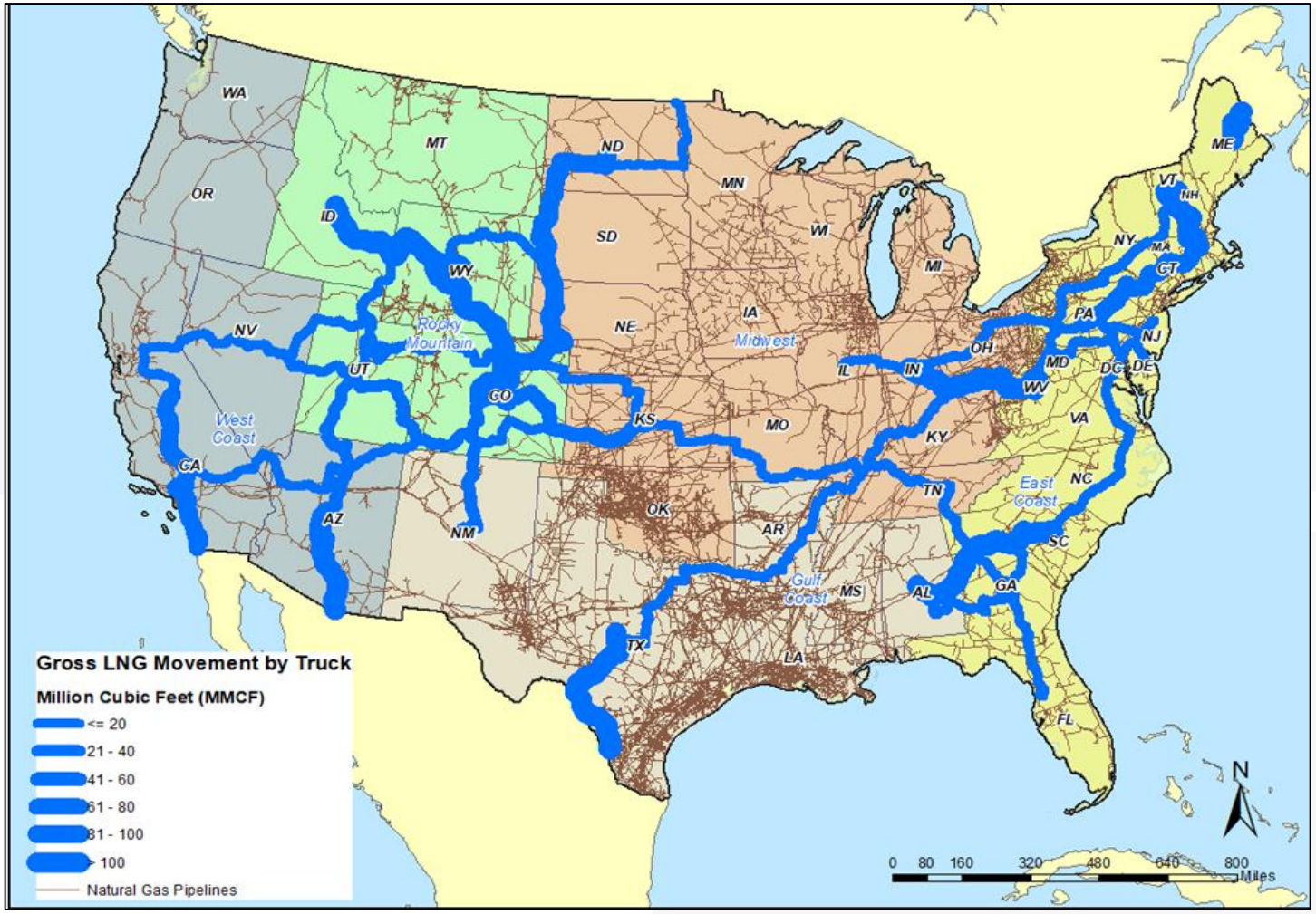
LNG Liquefaction Facilities

New Fortress Energy LNG Liquefaction Plant, Hialeah, FL

Cheniere LNG Liquefaction Plant, Sabine Pass, LA

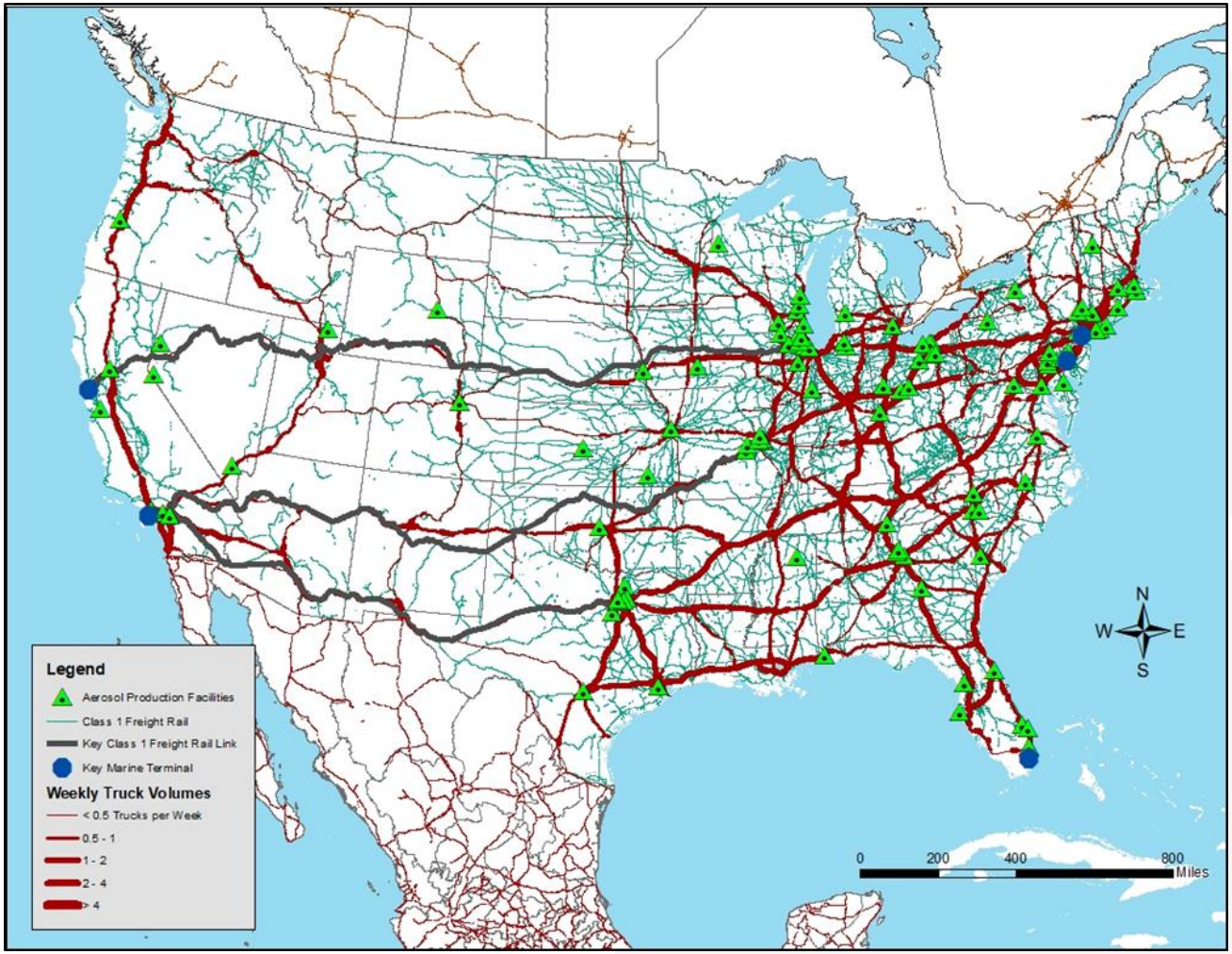
Source: Cheniere, New Fortress, Inc.

LNG Truck Movements, 2016 in BCF



Sources: EIA, CS

Aerosol Production Case Study



Source: Cambridge Systematics

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Energy Implications for Freight

- **Pipeline trends**: Oil, gas, NGL pipeline construction, reversals, permitting delays
- **Maritime trends**: Crude oil imports continue, exports begun 2015, LNG imports to exports, NGL exports
- **Rail trends**: Ethanol leading crude oil volumes, more propane and butane by rail, crude by rail still provides flexibility in areas not served by pipelines
- **Truck trends**: Increase in crude by truck from production areas, more butane for fuel blending, propane by truck, refined petroleum distribution, more ethanol blends for motor fuels

Implications for Freight Planning

- **Statewide Freight Plans**
  - Changing rail and truck shipment profiles
  - Modal profiles to include pipelines
  - Energy supply (push) states (TX, LA, PA, OH)
  - Energy demand (pull) states (Megaregions)
- **Freight Modeling Implications**
  - Out of Scope (OOS) commodities including petroleum represent 30% of FAF4
  - Improvements to estimate commodity flows can increase the quality of the FAF4.

Aging Transportation Infrastructure

- Changes in routing between new production and refining/processing capabilities
- Energy Trends Impact Infrastructure
  - New Liquid and Gas Pipeline Networks
  - National Highway System
  - Bridges, Tunnels
  - Intermodal Facilities
  - Railroads and Rail Terminals
  - Ports and Waterways
  - Transportation Fueling Systems

AT040 Hazmat Transportation Sessions

TRB Hazmat Transportation Committee 2020

- AT040 Full Hazmat Committee
- Session #1: Freight Day (Maritime)
- Session #2: Pipeline Solutions in a Changing Energy Landscape
- Subcommittee on Risk Assessments
- Subcommittee on the Transport of Energy Products

Discussion

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