



QUADRENNIAL ENERGY REVIEW

ENERGY TRANSMISSION, STORAGE, AND DISTRIBUTION INFRASTRUCTURE

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US-China Clean Coal Industry Forum – August 25, 2015



FUNDAMENTAL CHANGES IN THE U.S. ENERGY SECTOR

Increasing Energy Production

- Natural gas production growth
- Oil production growth
- Intermittent renewables
- Distributed generation/energy resources
- Increased generation/production/demand efficiency

Policy Developments

- CAFE
- Clean Air Act -111 (d), other
- Clean Water Act/other
- RFS
- RPS (state)
- RGGI (regional)

Technology Advances

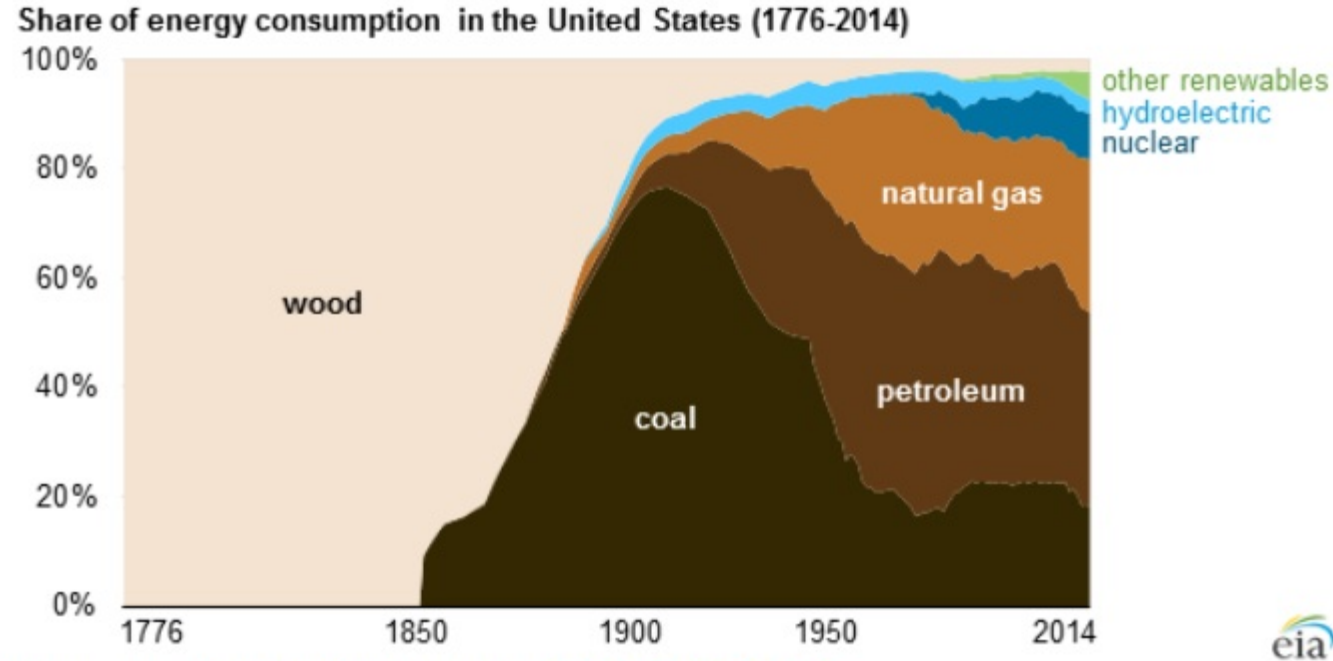
- Solar (central and rooftop)
- Wind
- Demand-side
- Hydraulic fracturing

Energy Security Changes

- Decreased N. American energy imports
- Climate change impacts
- Vulnerabilities more evident, including aging infrastructures, physical and cyber threats
- Increased interdependencies
- Increased energy support required by allies



HISTORICAL TRENDS

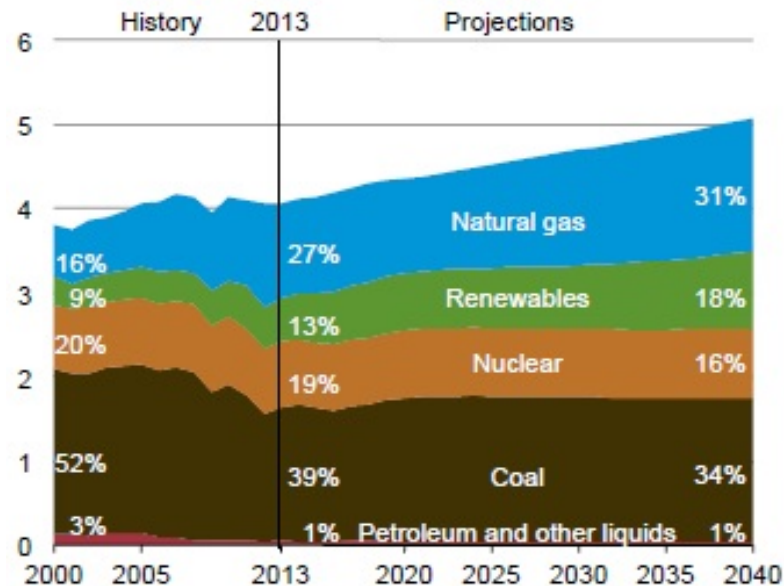


- Petroleum, natural gas, and coal have made up at least 80% of total U.S. energy consumption for more than 100 years
- Coal became dominant in the late 19th century before being overtaken by petroleum products in the middle of the 20th century
- Since the mid-20th century, use of coal increased again (mainly as a primary energy source for electric power generation)

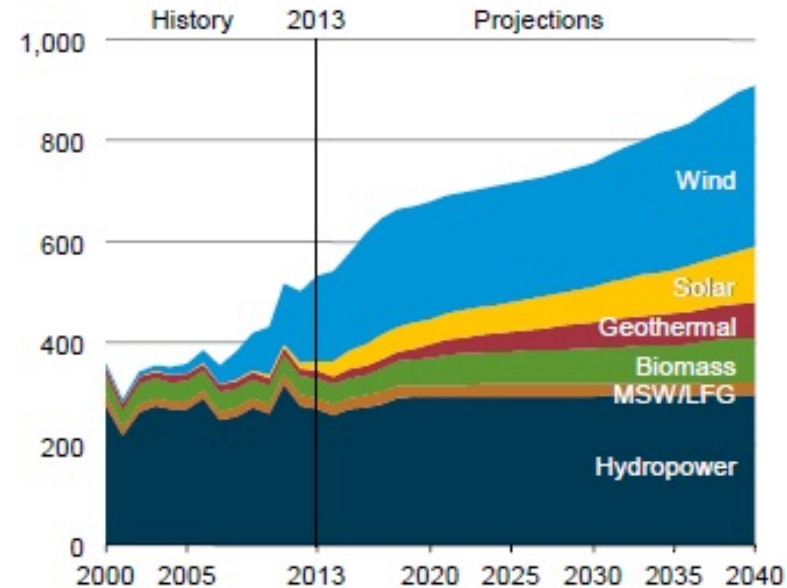


PROJECTED OVERALL TRENDS

Electricity Generation by Fuel 2000-2040
(Trillion Kilowatthours)



Renewable Electricity Generation by Fuel Type
2000-2040
(Trillion Kilowatthours)

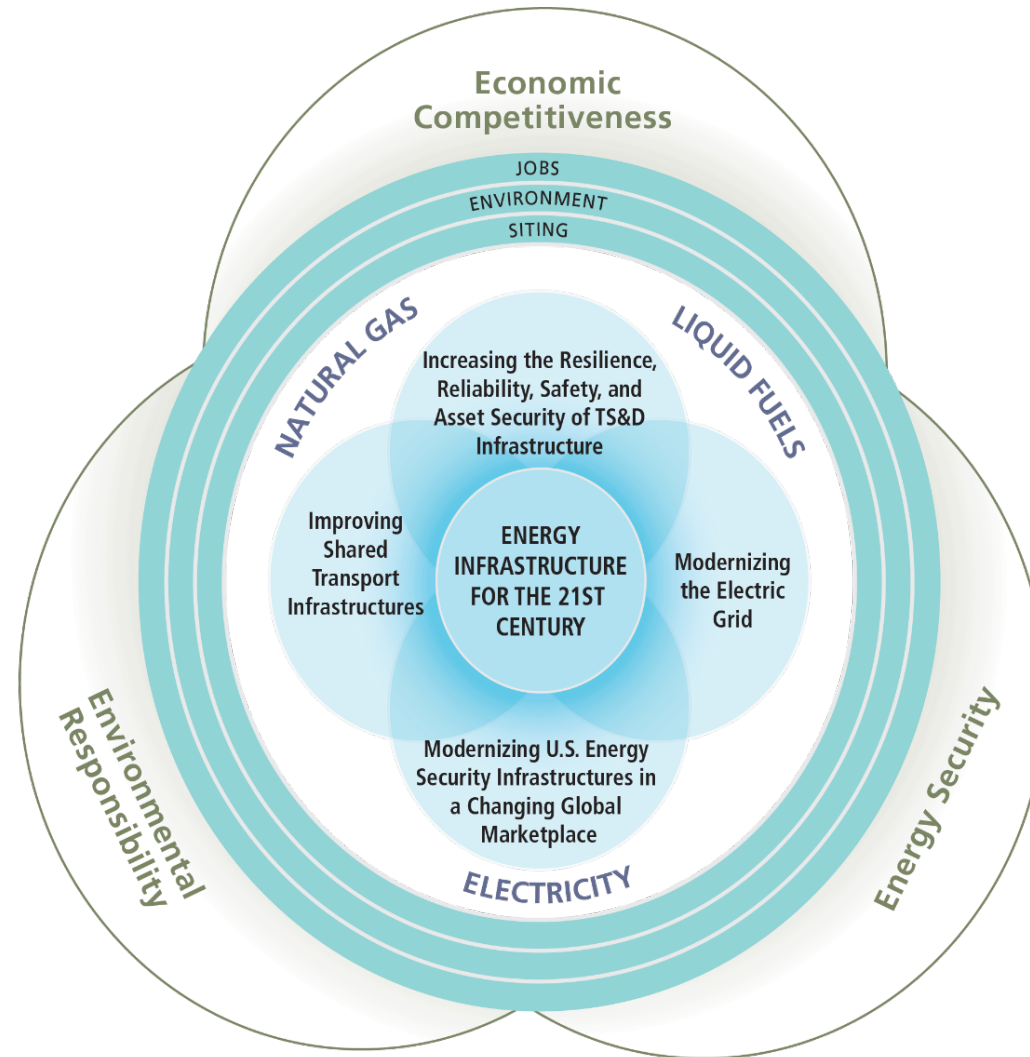


In 2014, major energy sources and percent share of total U.S. electricity generation included:

- Coal - 39%
- Natural gas - 27%
- Nuclear - 19%
- Petroleum - 1%
- Other gases < 1%
- Renewables - 13%
 - Hydropower - 6%
 - Biomass - 1.7%
 - Geothermal - 0.4%
 - Solar - 0.4%
 - Wind - 4.4%



FRAMING TS&D INFRASTRUCTURE



High Level Goals



Energy Infrastructure Objectives

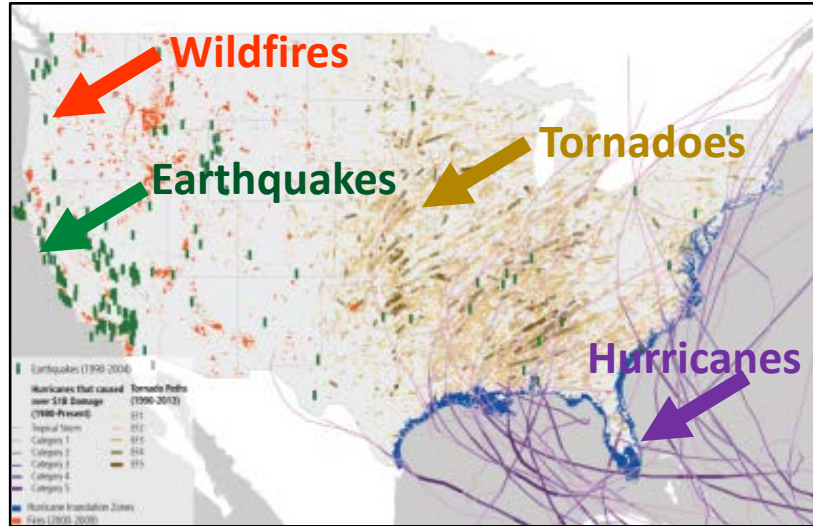


Crosscutting Issues

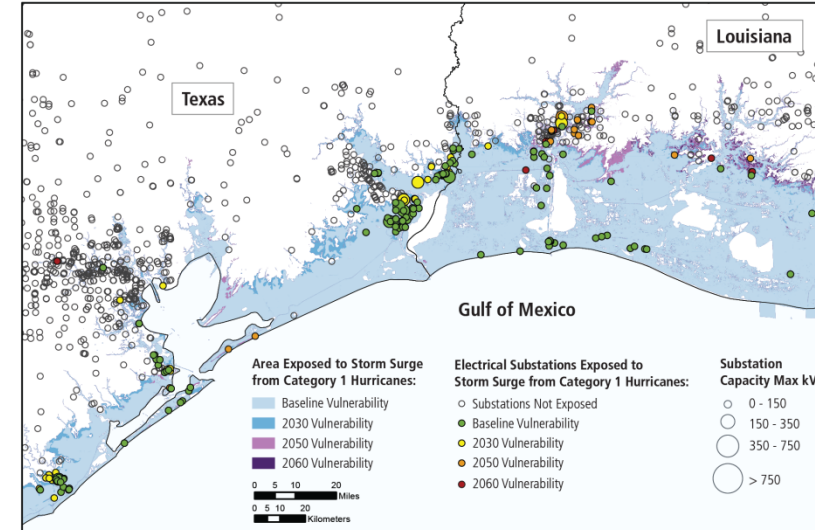


VULNERABILITIES AND DISRUPTIONS: NATURAL DISASTERS

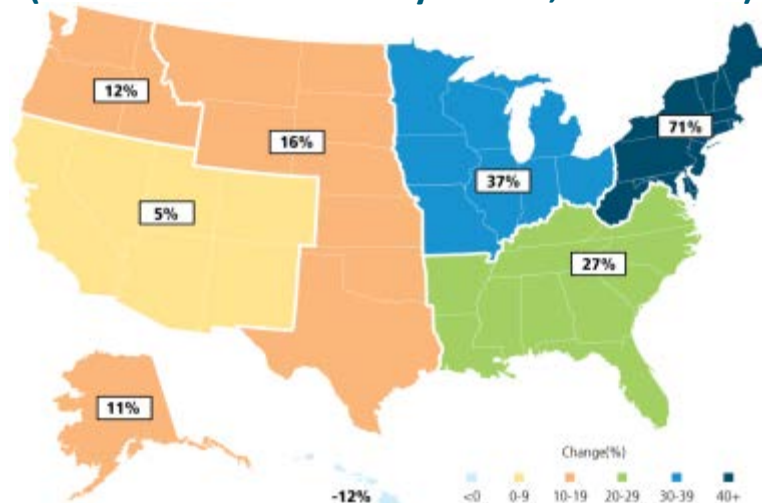
Tornado and Hurricane Tracks, Wildfires, Earthquakes, and Coastal Inundation



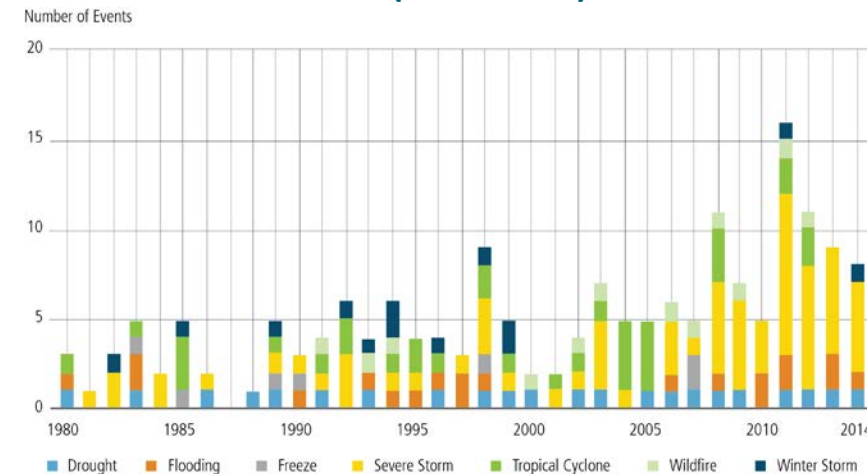
Gulf Coast Electricity Substation Facilities' Exposure to Storm Surge under Different Sea-Level Rise Scenarios



Increased Intense Precipitation Events (Heaviest 1% of All Daily Events, 1958-2012)

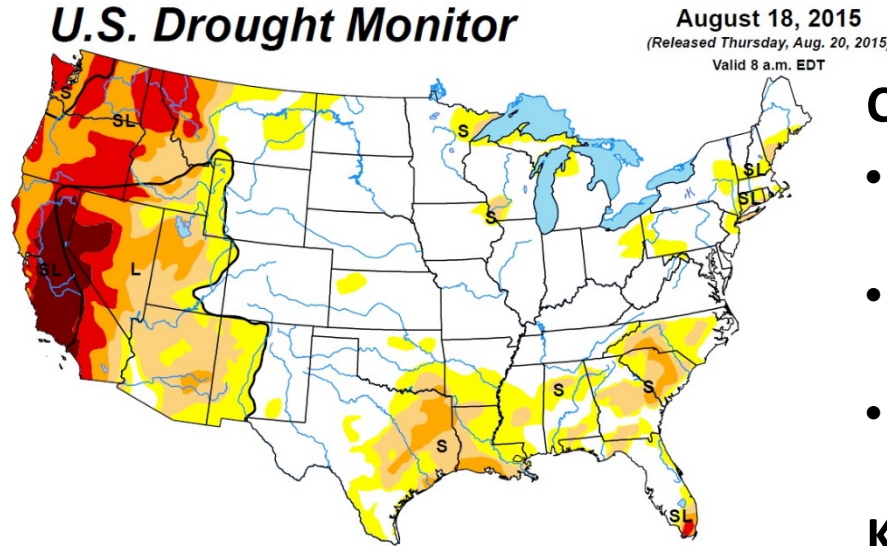


Billion-Dollar Disaster Event Types by Year (1980-2014)



VULNERABILITIES AND DISRUPTIONS: CLIMATE CHANGE

U.S. Drought Monitor



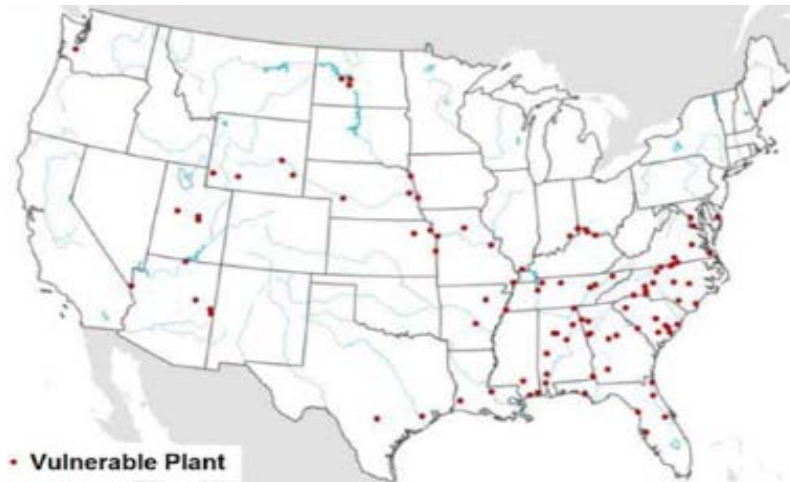
Climate Trends

- Changing precipitation patterns cause more frequent and severe droughts
- Snowpack levels have decreased, resulting in lower summer streamflows
- Ground and surface water levels have declined

Key Energy Sector Impacts

- Decreasing water availability for cooling at thermoelectric facilities reduces generation capacity
- Decreasing water availability impacts oil and gas production
- Reductions in river levels impedes barge transport
- Changes in precipitation/decreasing snowpack could decrease available hydropower generation capacity

Locations of the 100 Most Vulnerable Coal-fired Power Plants

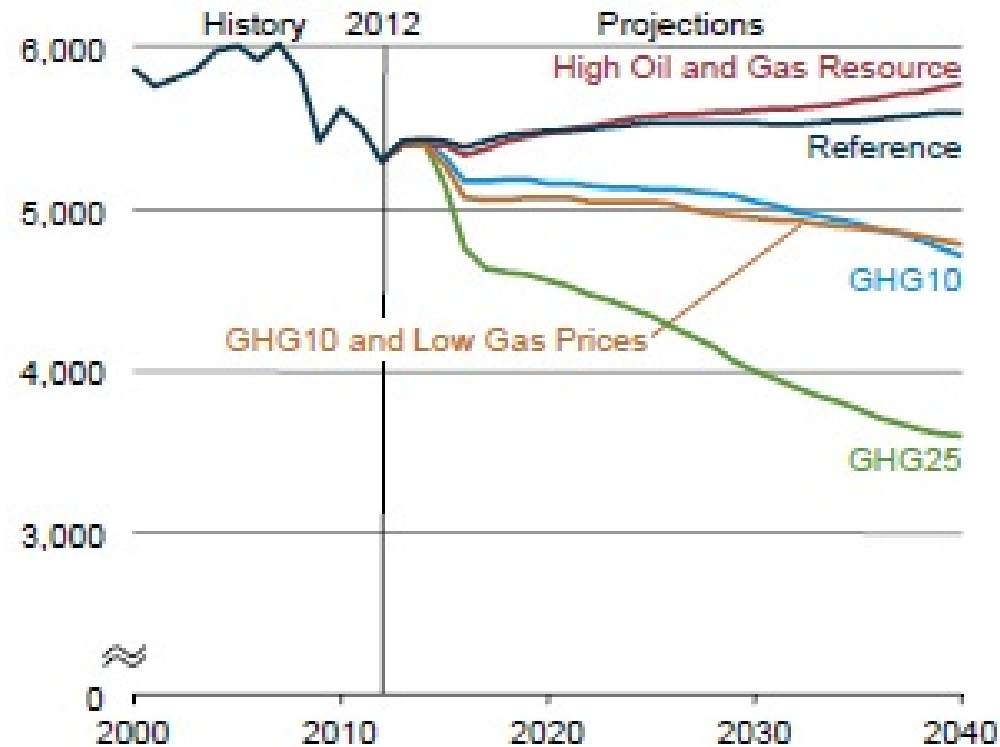


Source: NETL 2010b



GREENHOUSE GAS EMISSIONS

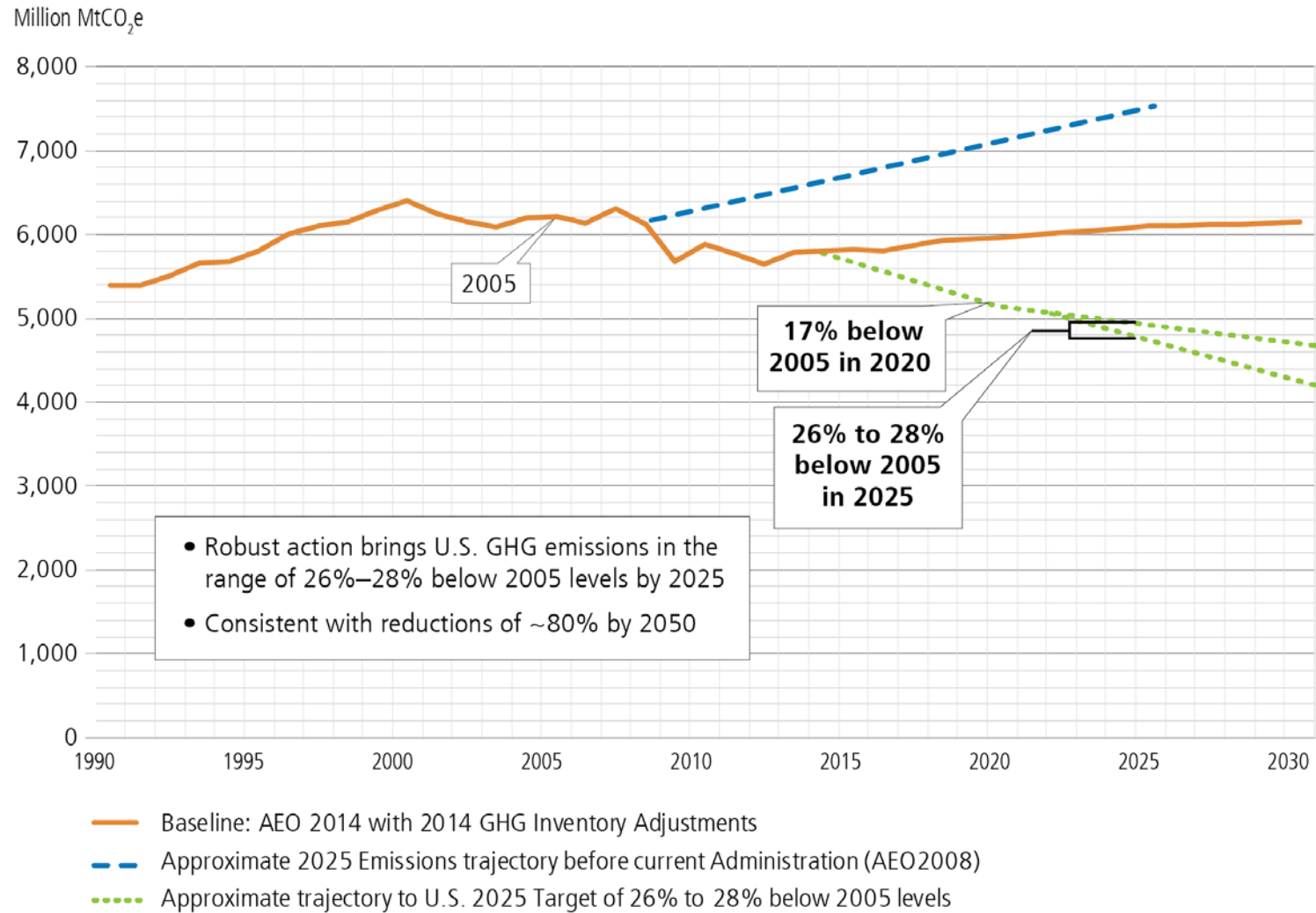
Energy-related Carbon Dioxide Emissions in Five Cases 2000-2040 (million metric tons)



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2014*

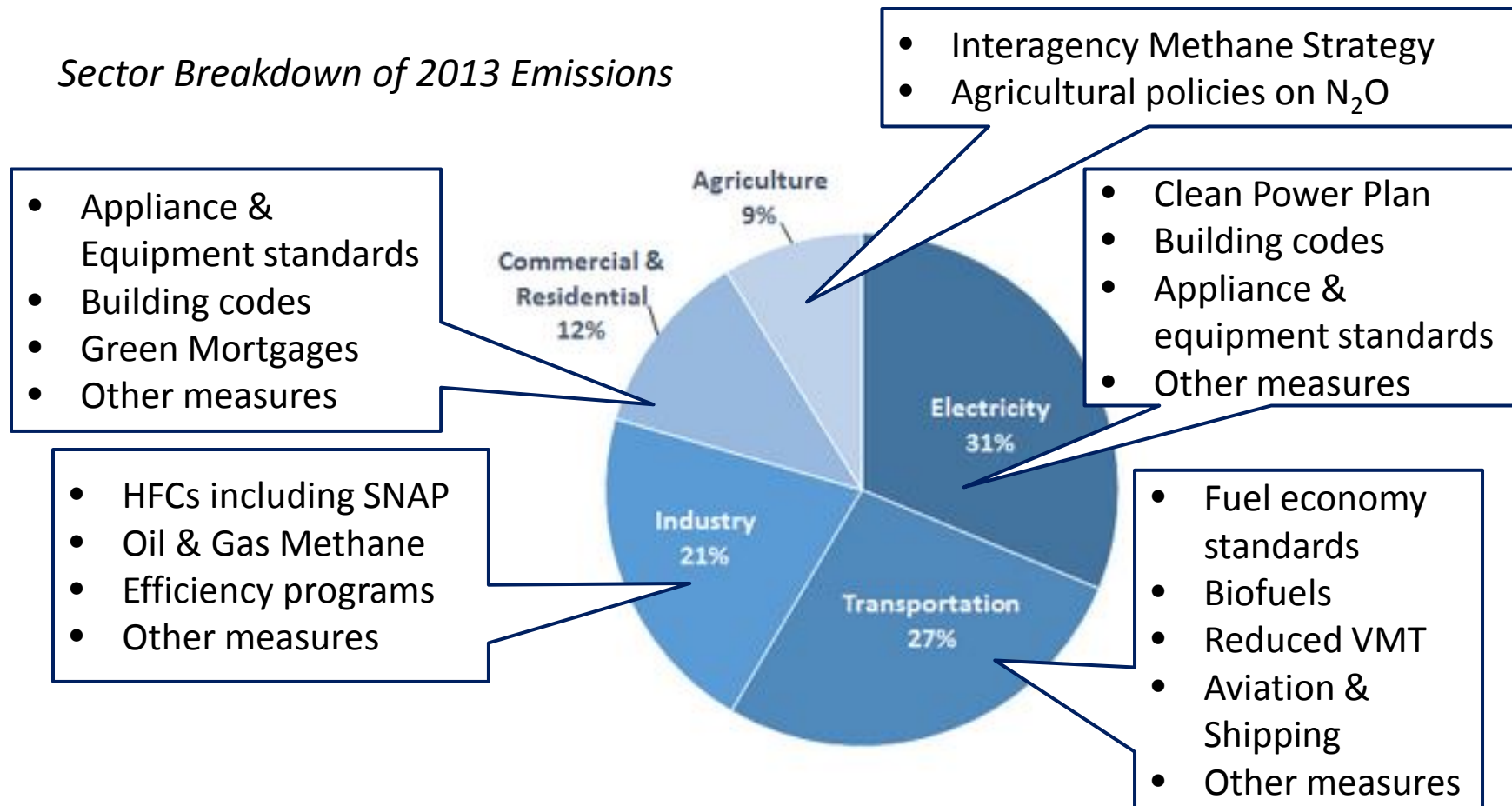


MEETING THE U.S. INDC



U.S. COMMITMENTS

Sector Breakdown of 2013 Emissions

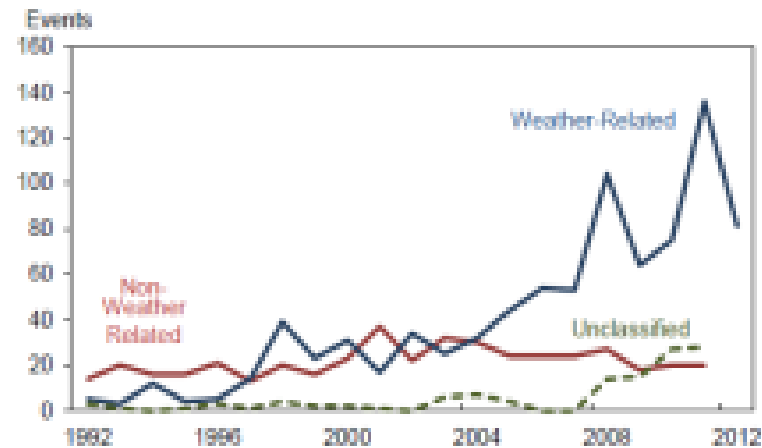


- The U.S. is driving substantial reductions in all sectors and gases through existing and new policies
- Enhanced policies to bolster sinks through reforestation and conservation will further contribute to reaching our 2025 goal



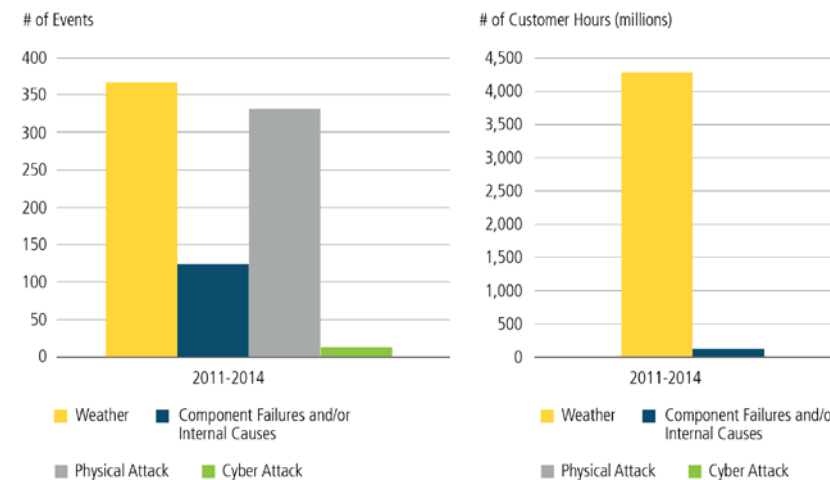
VULNERABILITIES AND DISRUPTIONS: ELECTRICITY OUTAGES

Observed Outages to the Bulk Electric System (1992-2012)



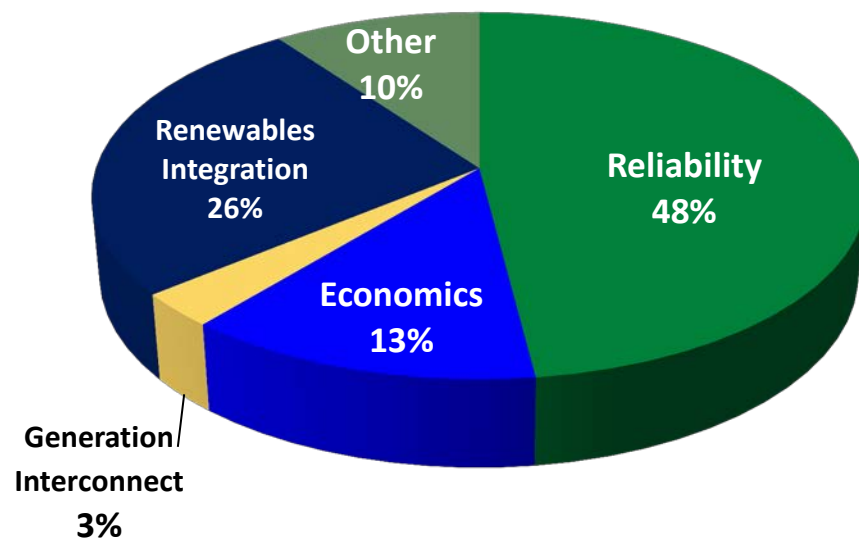
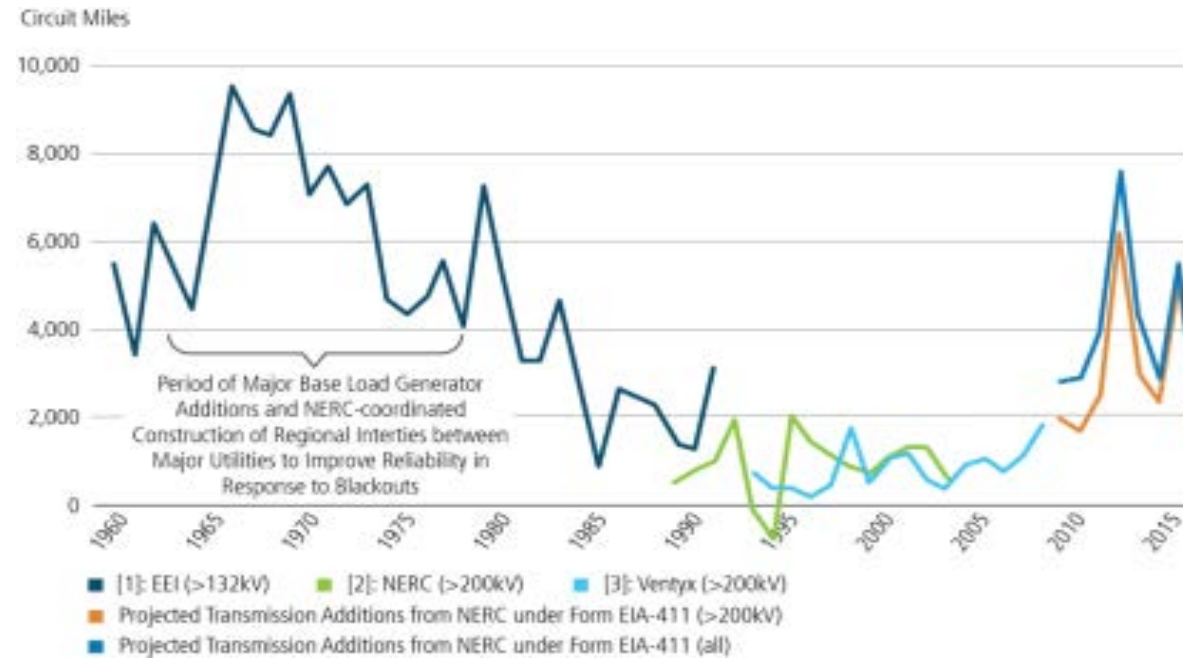
Source: Energy Information Administration

Electricity Outages by Type of Event and Lost Customer Hours



NEW INVESTMENT: ELECTRICITY

Historic and Projected Expansion of Net Transmission Circuit Miles (1960-2015)

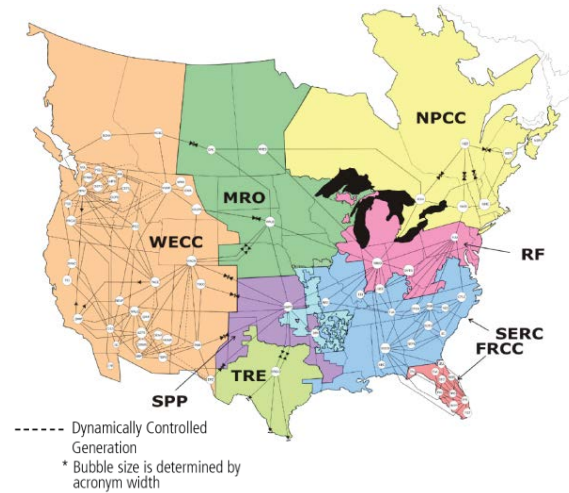


Reported Drivers of Projected Transmission Addition (2011-2015)

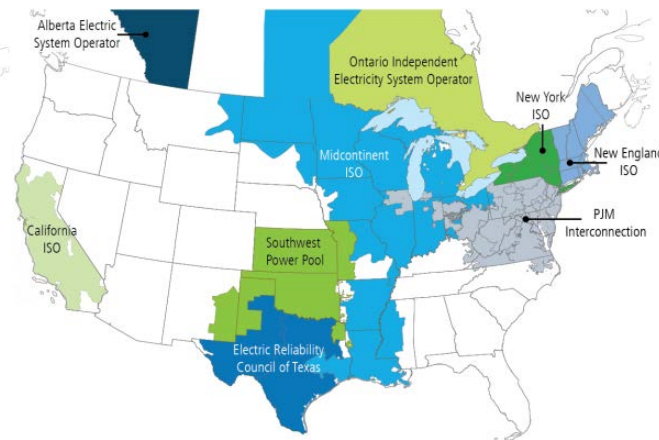


JURISDICTIONAL LANDSCAPE

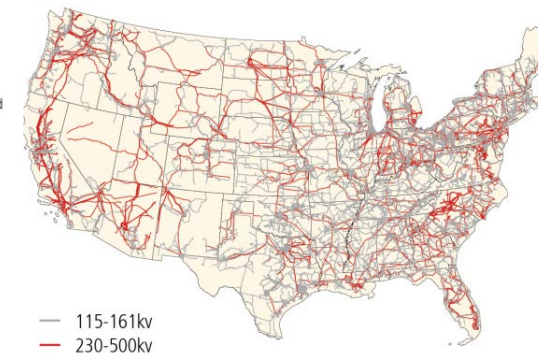
NERC Regional Entities and Balancing Authorities



Regional Transmission Organizations (RTO)/ Independent System Operators (ISO)

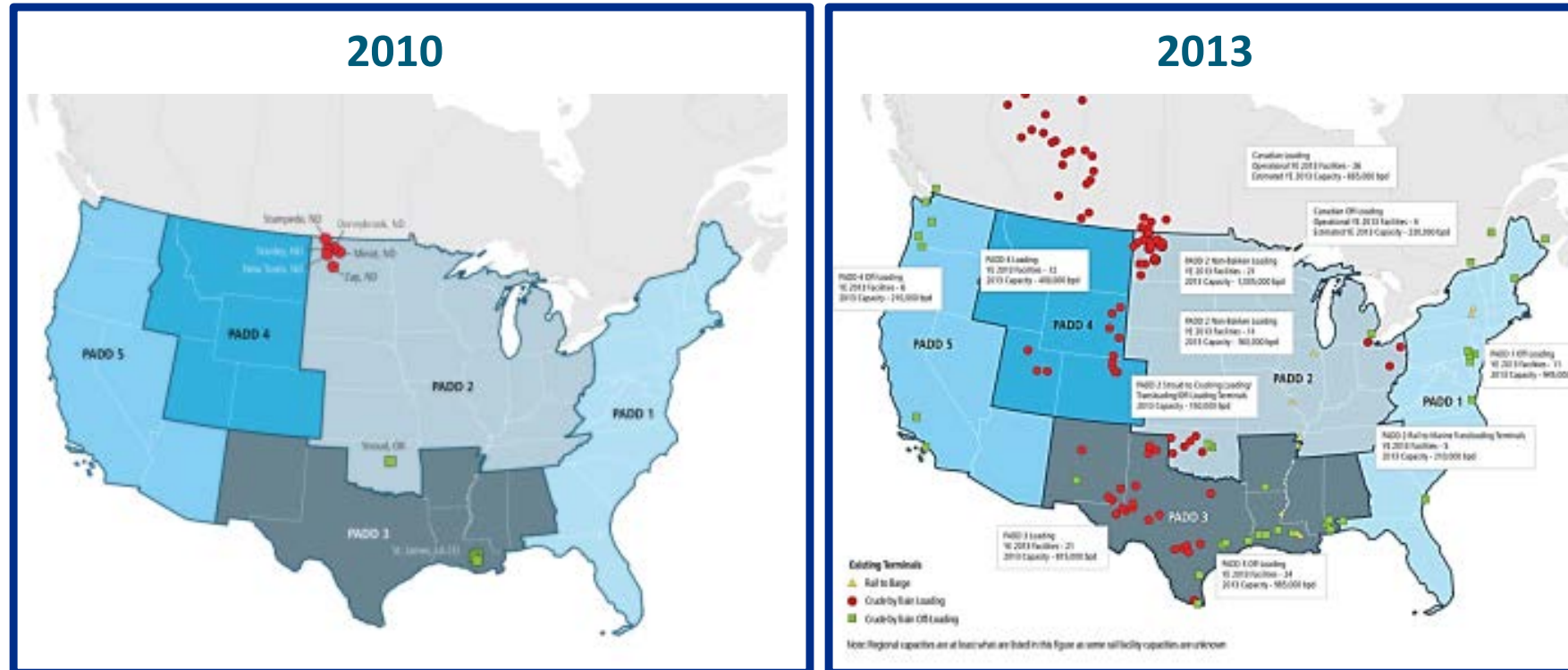


Federally Regulated Power Lines



SUPPLY/INFRASTRUCTURE: RAIL

Crude Oil by Train Loading (red) and Offloading (green) Facilities



DEVELOPMENT AND DISTRIBUTION OF INDIGENOUS SUPPLIES

2010

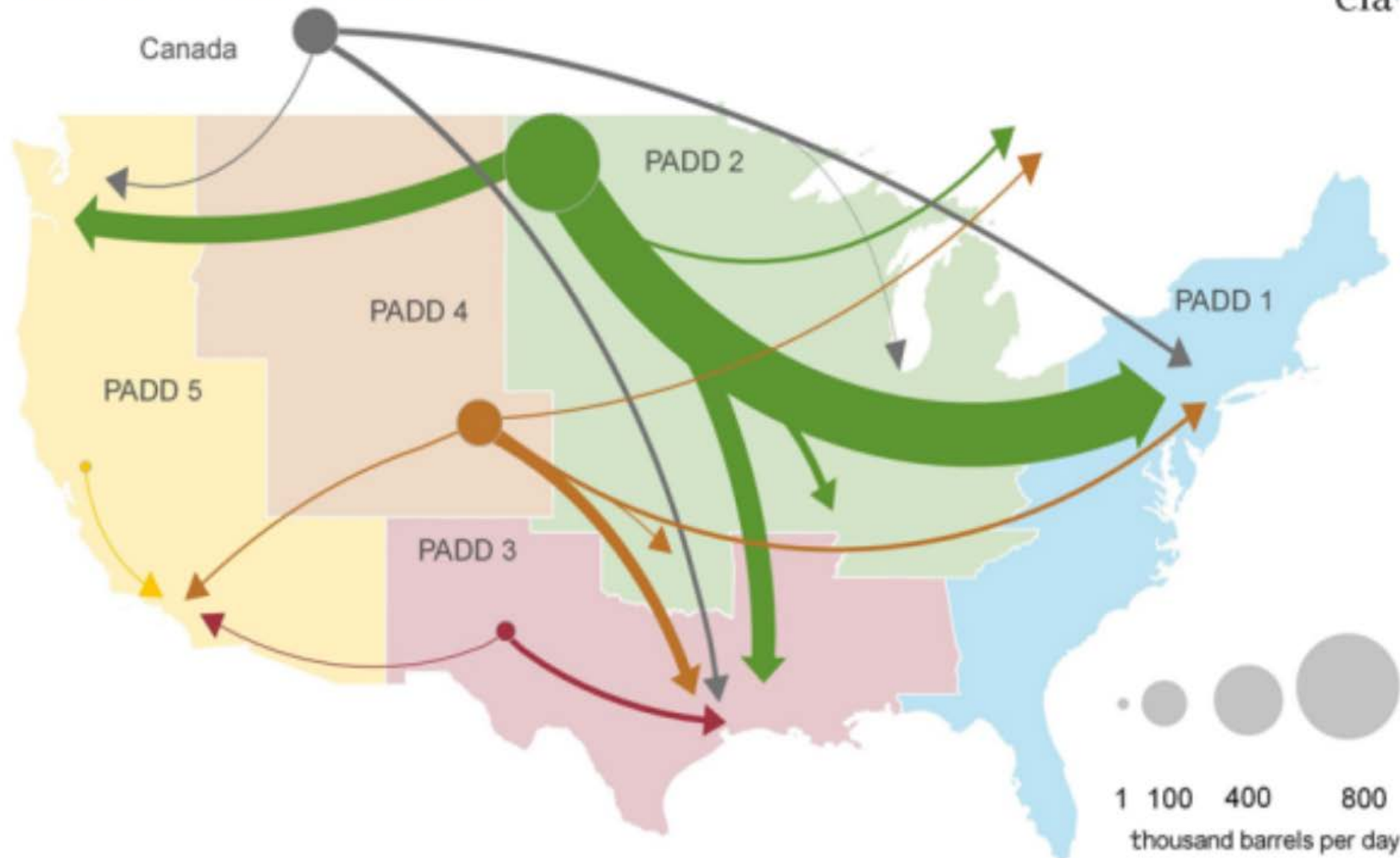
2011

2012

2013

2014

Crude-by-rail movements (2014)

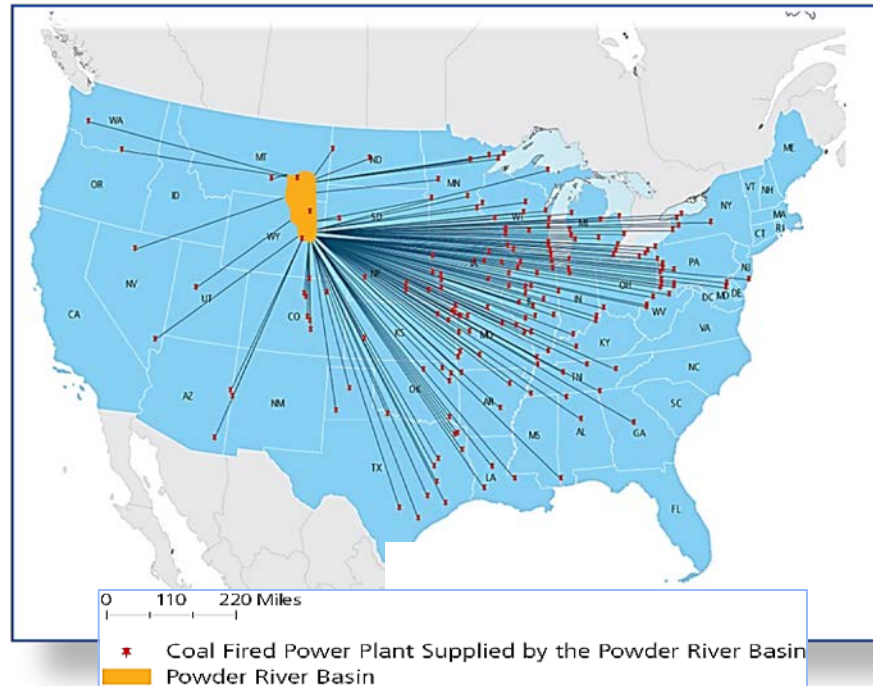


Crude by Rail Shipments, 2010-2014



RAIL TRENDS

Coal-Fired Power Plants Supplied by the Powder River Basin



A study by USDA's Agricultural Marketing Service concluded that, for the period from August 2013 through August 2014,

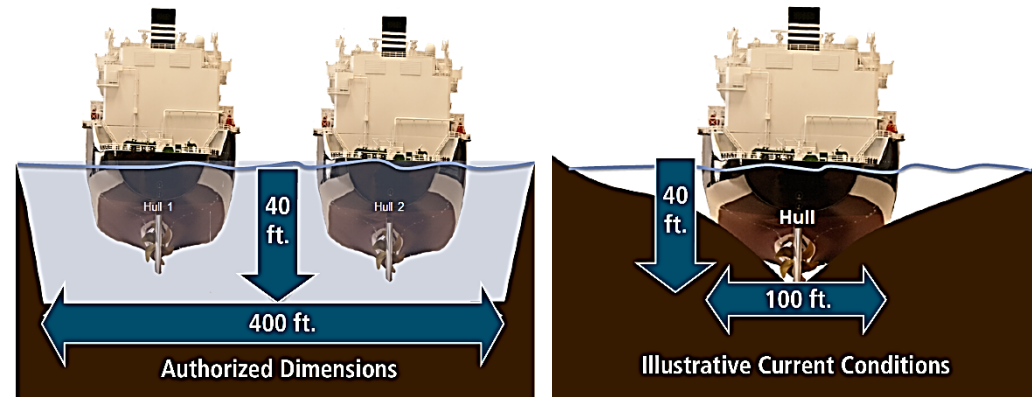
“the magnitude and duration of recent unexpected shifts in supply and demand for ... rail service... have exceeded previous events in terms of both magnitude and duration, including Hurricane Katrina, which caused major disruptions throughout the entire agricultural transportation network.”

Key Rail Findings

- Oil is an attractive commodity for railroad as it is not seasonal
- On average, roughly 1 million barrels of oil were moved by rail per day in 2014—nearly 12 percent of U.S. domestic crude oil production
- 34 states get coal for power generation from the Powder River Basin in Wyoming, almost all by rail. Eight states obtain more than 90 percent of their domestic coal from Wyoming. It is largely transported through regions of rail congestion where much of our oil and agriculture also originate.



PORTS AND WATERWAYS TRENDS



Calcasieu River Ship Channel – Lake Charles, LA - designed for two tankers to pass

Shoaling can force vessels to reduce cargos, idle until high-tide, or, be subject to one-way traffic restrictions

Top 10 Port Systems by Total Energy Commodity Shipments (2013, millions of short tons)

Port Channel System	Crude and Petroleum Products	Coal	Total Energy	Energy as a Percentage of Shipments
Lower Mississippi (LA)	161	47	208	48%
Houston/Galveston (TX)	200	3	203	69%
Beaumont/Port Arthur (TX)	115	-	115	89%
Port of NY/NJ	80	<1	80	59%
Delaware River	62	-	62	82%
Corpus Christi (TX)	58	-	58	77%
Port of Virginia	2	50	52	66%
Lake Charles (LA)	49	-	50	88%
LA and Long Beach (CA)	46	2	47	33%
Huntington - Tristate (WV)	8	32	41	87%



SELECT RECOMMENDATIONS

