



# ELECTRICITY RELATED PARTS OF THE QUADRENNIAL ENERGY REVIEW

ENERGY TRANSMISSION, STORAGE, AND DISTRIBUTION INFRASTRUCTURE

**Larry Mansueti**  
**DOE Electricity Advisory Committee**  
**June 29, 2015**



## Changing US Energy Landscape

### Increasing Energy Production

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

### Policy Developments

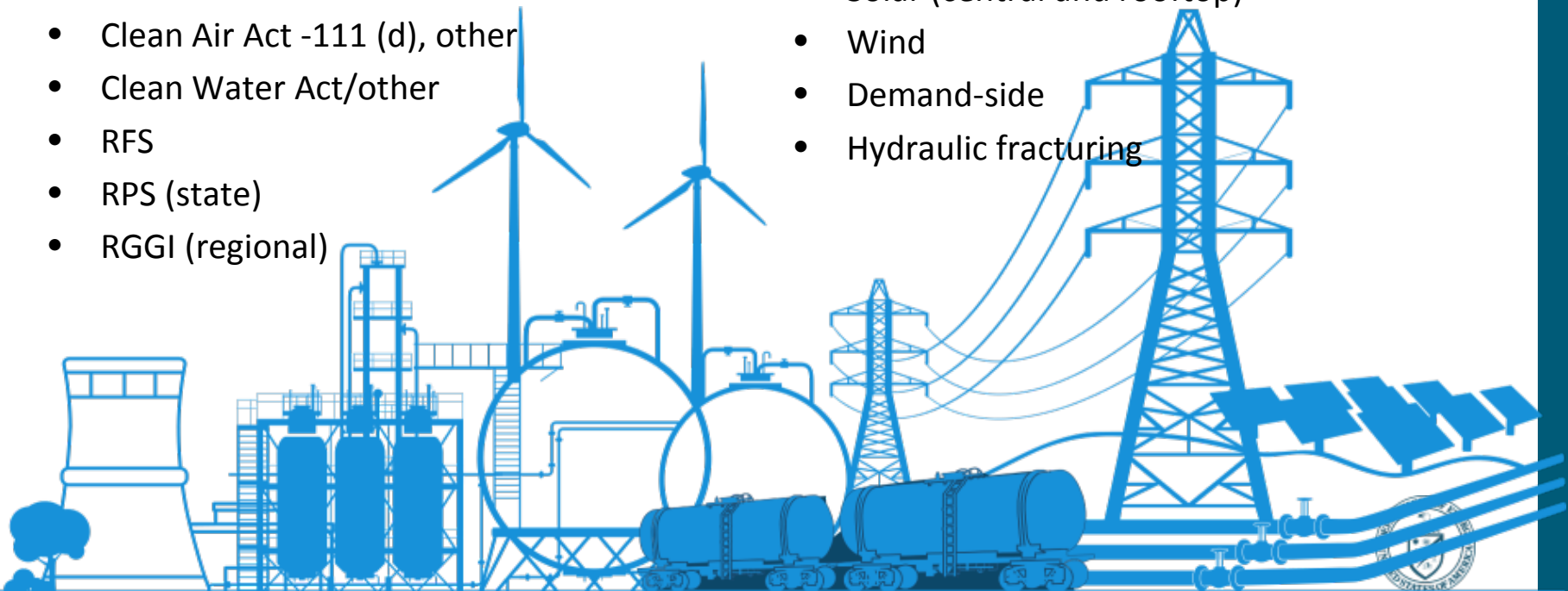
- CAFÉ
- Clean Air Act -111 (d), other
- Clean Water Act/other
- RFS
- RPS (state)
- RGGI (regional)

### 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

### Technology Advances

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





# Public Meeting North Dakota



ANALYSIS AND STAKEHOLDER PROCESS



## Stakeholder Input

Public Meetings	Location	Date	Chair
Vulnerabilities (Cyber, Physical, Climate, Interdependencies)	Washington, DC	4/11	Moniz
Infrastructure Constraints—New England	Hartford, CT Providence, RI	4/21	Moniz
Petroleum Product TS&D	New Orleans, LA	5/27	Moniz
Water-Energy Nexus	San Francisco, CA	6/19	Holdren
Electricity TS&D—West	Portland, OR	7/11	Poneman
Natural Gas TS&D	Pittsburgh, PA	7/21	Moniz
Gas-Electricity Interdependence	Denver, CO	7/28	Utech
Infrastructure Constraints—Bakken	Bismarck, ND	8/8	Moniz, Foxx, Holdren, Schneider
Rail, Barge, Truck Transportation	Chicago, IL	8/8	Moniz, Foxx, Holdren, Darcy
State, Local and Tribal Issues	Santa Fe, NM	8/11	Moniz, Jewell
Infrastructure Siting	Cheyenne, WY	8/21	Moniz, Schneider
Electricity TS&D - East	Newark, NJ	9/8	Moniz
Finance and Market Incentives	New York, NY	10/6	Moniz

[www.energy.gov/qer](http://www.energy.gov/qer)

- Briefing memo
- Agenda and speakers
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- 1. How to operate the system safely, fairly, efficiently**
- 2. Who should be responsible for reliability, security, safety (enforcement, new investment, standards)**
- 3. How to allocate costs of resilience measures**



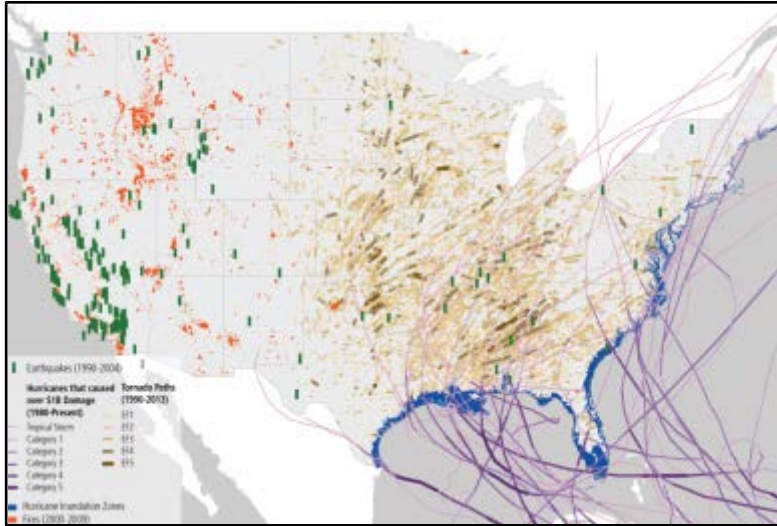
ROAD CLOSED

INCREASING THE RESILIENCE, RELIABILITY, SAFETY, AND ASSET SECURITY OF TS&D INFRASTRUCTURE



## Vulnerabilities and Disruptions

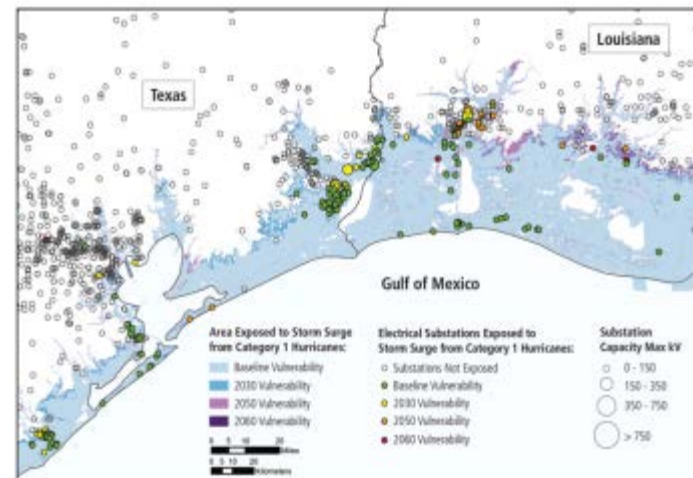
### Illustrations of Tornado and Hurricane Tracks, Wildfires, Earthquakes, and Coastal Inundation



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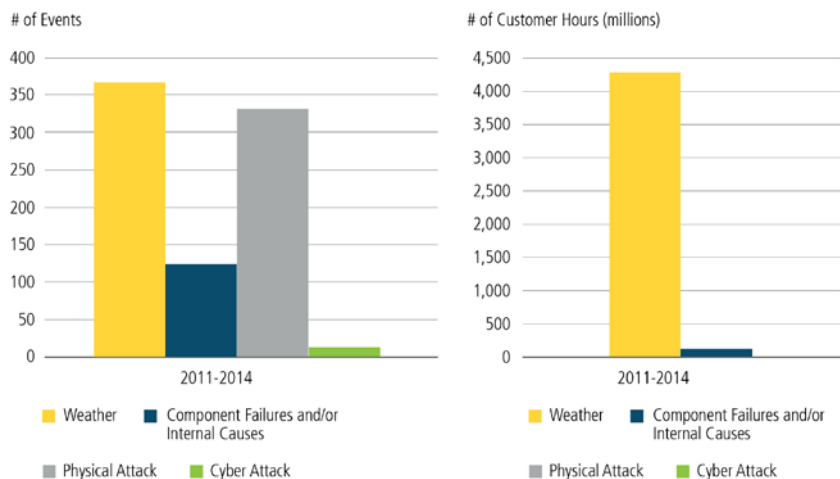
### Gulf Coast Electricity Substation Facilities' Exposure to Storm Surge under Different Sea-Level Rise Scenarios

- For example, sea-level rise increases the vulnerability of electricity substations to inundation caused by hurricane storm surge



## Recommendations

### Electricity Disturbances by Type of Event and Lost Customer Hours



### Selected Recommendations

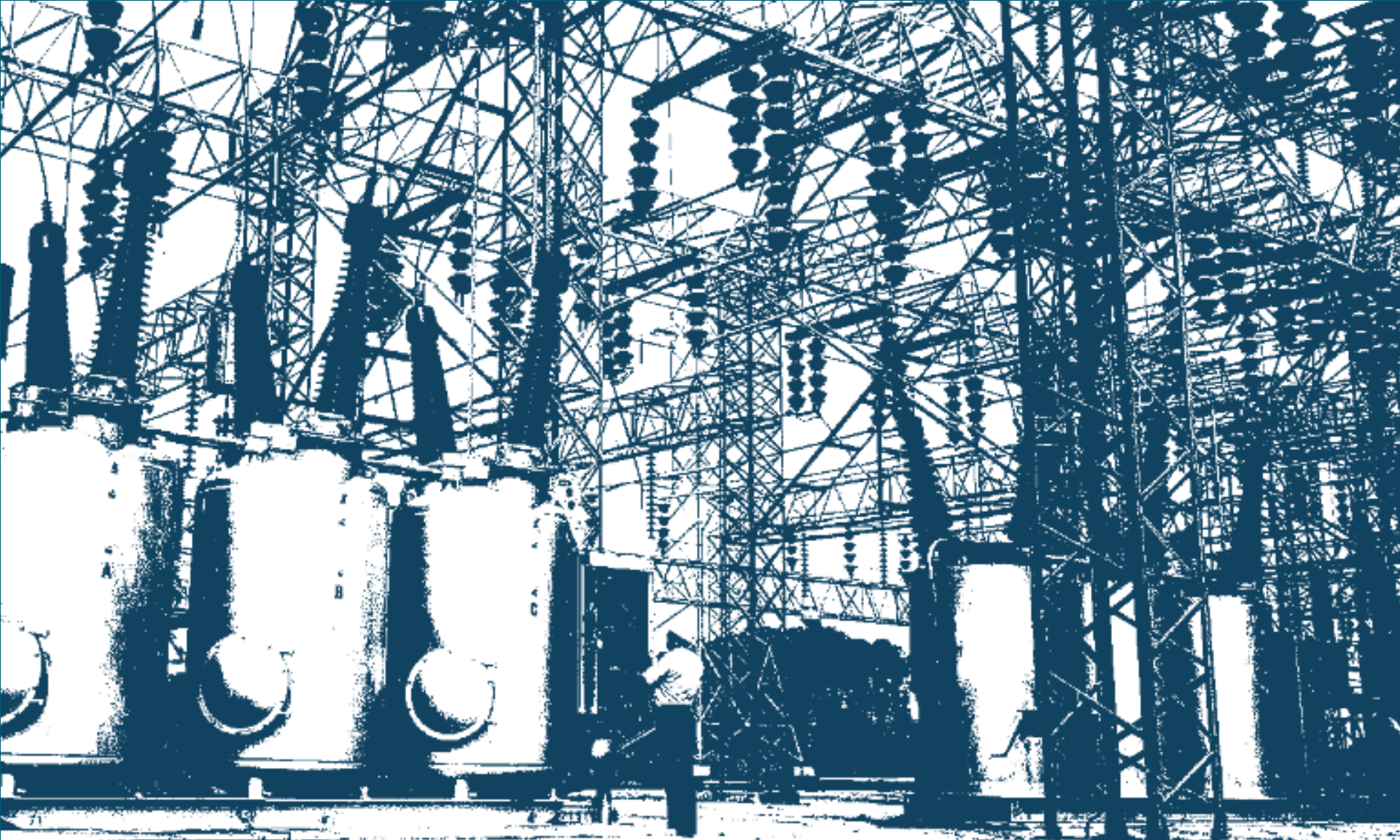
- Establish a \$2.5 - \$3.5 B competitive financial assistance program to accelerate pipeline replacement and enhance maintenance programs for natural gas distribution systems
- Provide \$350 - \$500 M in support for the updating and expansion of state energy assurance plans
- Establish a \$3-3.5 B competitive grant program to promote innovative solutions to enhance energy infrastructure resilience, reliability, and security
- Analyze the policies, technical specifications, and logistical and program structures needed to mitigate the risks associated with loss of transformers
- Analyze the need for additional or expanded regional product reserves
- Integrate the authorities of the President to release products from regional petroleum product reserves (RPPRs) into a single, unified authority

The Quadrennial Energy Review, April 2015

***“Building a resilient, reliable, safe, and secure energy infrastructure is a national priority and vital to American competitiveness, jobs, energy security, and a clean energy future.”***







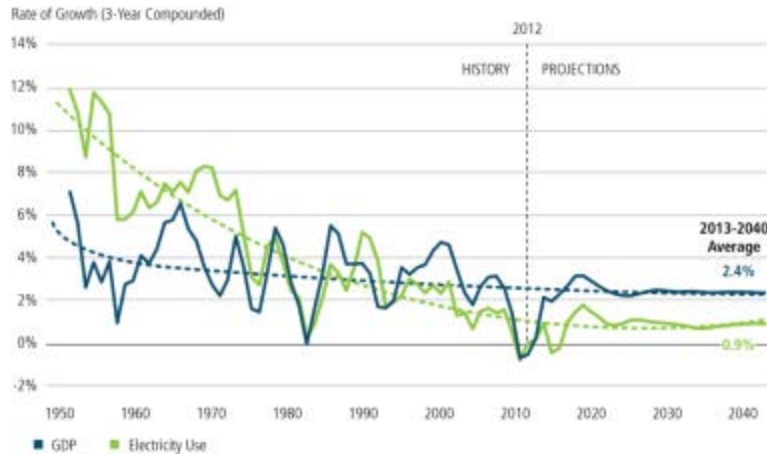
## MODERNIZING THE ELECTRIC GRID



Key Trends in Electricity

Selected Trends

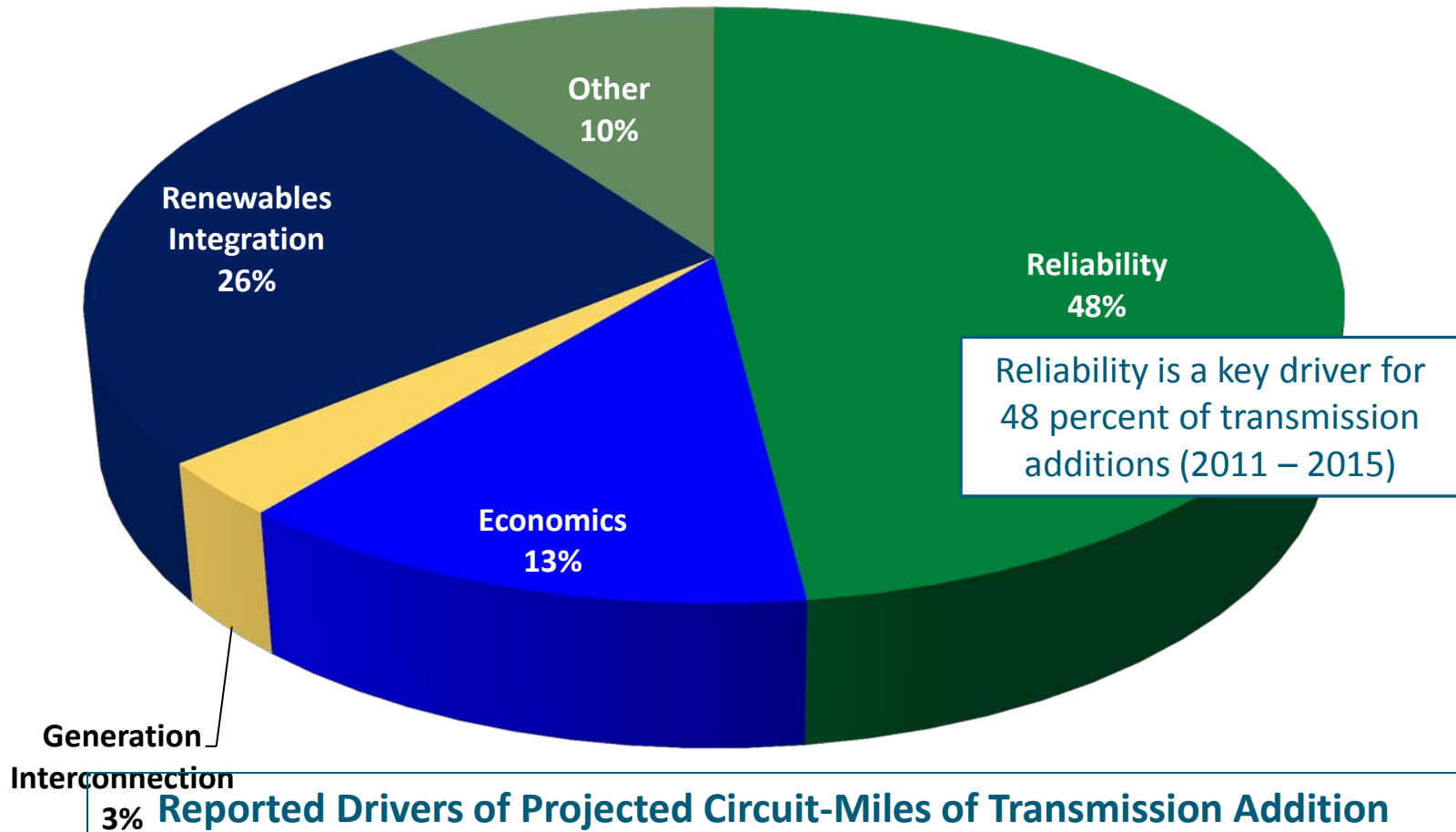
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- Growth in U.S. electricity demand is at its lowest level in decades
- Investments in transmission and distribution upgrades and expansions will grow
- There is increased use of distributed energy resources
- Lack of adequate information/tools impedes resilience



## Transmission Investment: Today's Drivers



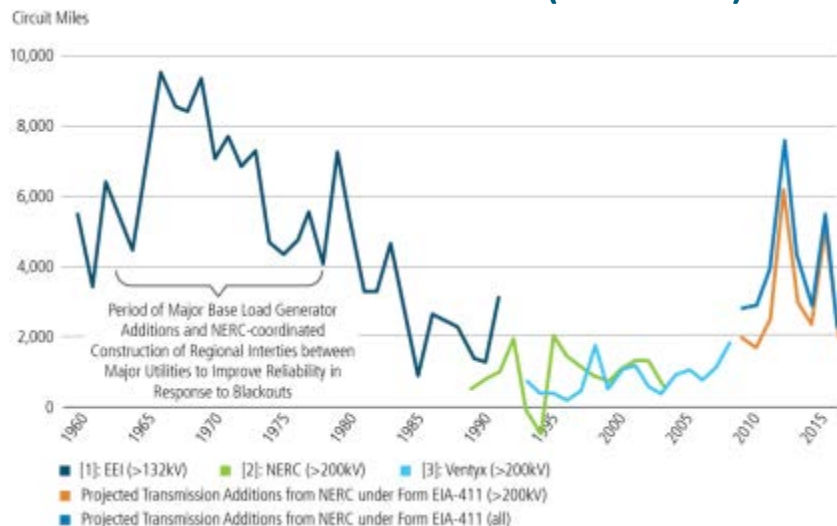
**Reported Drivers of Projected Circuit-Miles of Transmission Addition (2011-2015)**

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## Findings

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



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*“Innovative technologies and services are being introduced to the system at an unprecedented rate, often increasing efficiency, reliability, and the roles of customers, but also injecting uncertainty into grid operations, traditional regulatory structures, and utility business models.”*

### Selected Findings

- Investments in transmission and distribution upgrades and expansions will grow
- The potential range of new transmission construction is within historic investment magnitudes
- Flexible grid system operations and demand response can enable renewables and reduce the need for new bulk-power-level infrastructure
- Investments in resilience have multiple benefits
- Innovative technologies can have significant value for the electricity system
- States are the test beds for the evolution of the grid of the future
- Different business models and utility structures rule out “One-Size-Fits-All” solutions to challenges



## Selected Recommendations

- Provide \$3.5 B in grid modernization research and development, analysis, and institutional support
- Conduct a national review of transmission plans and assess barriers to their implementation
- Establish a framework and strategy for storage and grid flexibility
- Provide \$300-\$350 M in state financial assistance to promote and integrate transmission, storage, and distribution infrastructure investment plans for electricity reliability, affordability, efficiency, lower carbon generation, and environmental protection
- Coordinate goals across jurisdictions
- Value new services and technologies
- Improve grid communication through standards and interoperability

NERC Regional Entities and Balancing Authorities



Federally Regulated Power Lines



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





# IMPROVING SHARED ENERGY TRANSPORT INFRASTRUCTURES



### 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,

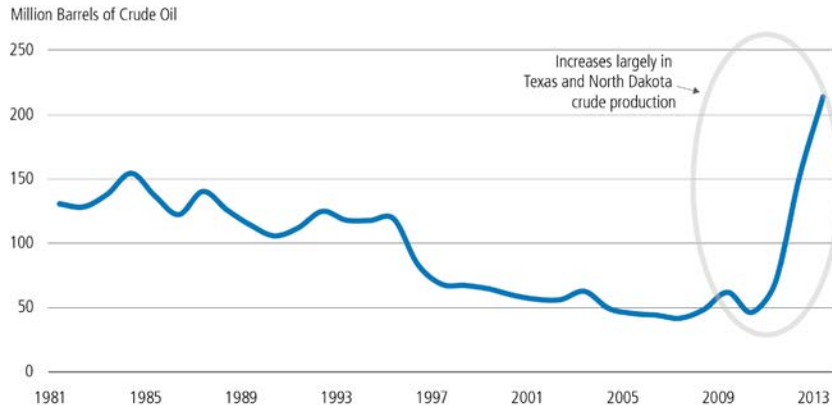
***“the magnitude and duration of recent unexpected shifts in supply and demand for ... rail service... have exceeded previous events in terms of both magnitude and duration, including Hurricane Katrina, which caused major disruptions throughout the entire agricultural transportation network.”***

### 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.

## Recommendations

### US crude oil production (1981-2013)



The Quadrennial Energy Review, April 2015

***“Changes in the U.S. energy marketplace are stressing the Nation’s infrastructures... particularly in the case of oil where the rapid increase in U.S. tight oil production is transforming conventional patterns and modes.”***

### Selected Recommendations

- Support a \$2 - \$2.5 B program of competitively awarded grants for shared energy transport systems
- Enhance the understanding of important safety-related challenges of transport of crude oil and ethanol by rail and accelerate responses
- Address critical energy data gaps in the rail transport of energy commodities and supplies
- Support alternative funding mechanisms for waterborne freight infrastructure
- Support public-private partnerships for waterborne transport infrastructure



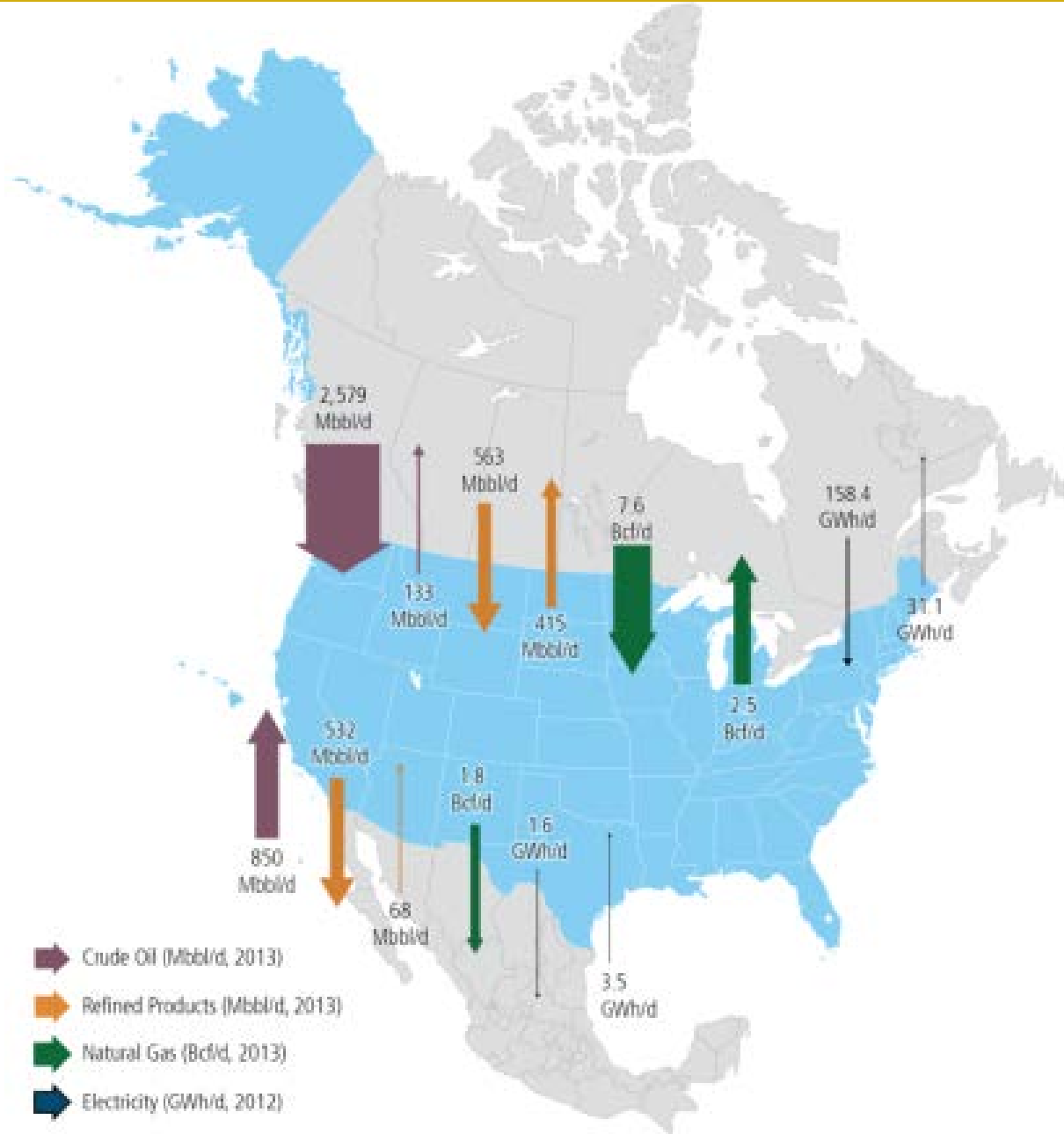




# INTEGRATING NORTH AMERICAN ENERGY MARKETS



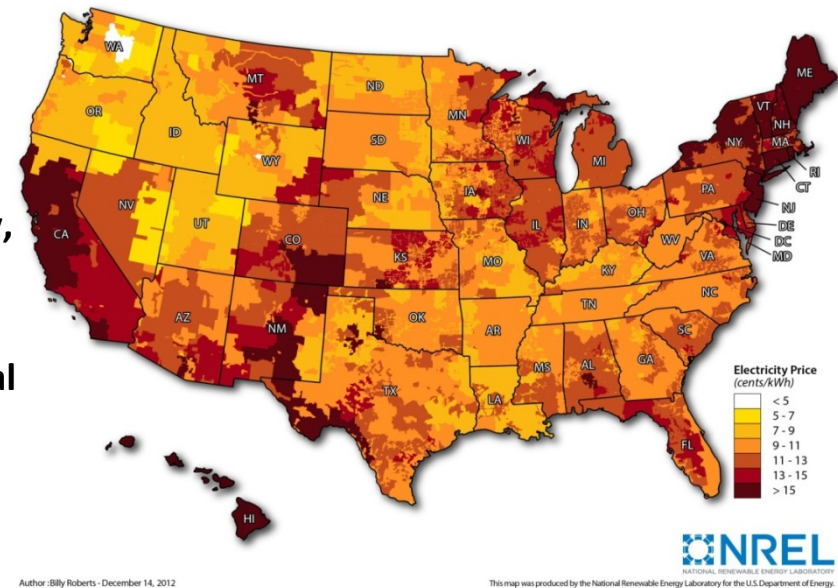
# North American Energy Flows

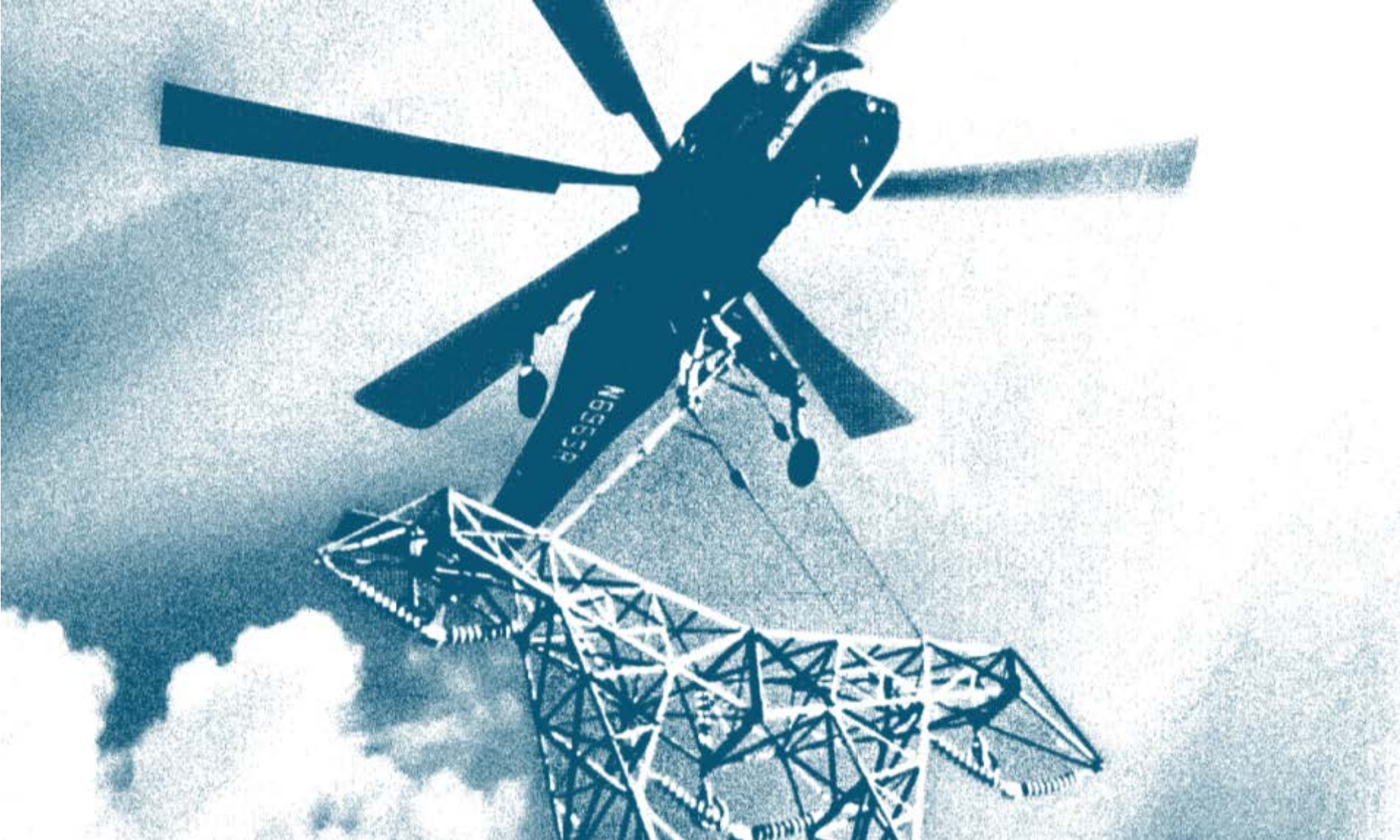


### Selected Recommendations

- Continue advances that have been made in the North American energy dialogue
- Increase the integration of energy data among the United States, Canada, and Mexico
- Undertake comparative and joint energy system modeling, planning, and forecasting
- Establish programs for academic institutions and not-for-profits to develop legal, regulatory, and policy roadmaps for harmonizing regulations across borders
- Coordinate training and encourage professional interactions
- Partner with Canada and the Arctic Council on Arctic energy safety, reliability, and environmental protection
- Partner with Canada and the Arctic Council on energy delivery to remote areas
- Promote Caribbean energy TS&D infrastructure

### Regional Variation in Electricity Prices





## SITING AND PERMITTING OF TS&D INFRASTRUCTURE



### Selected Findings

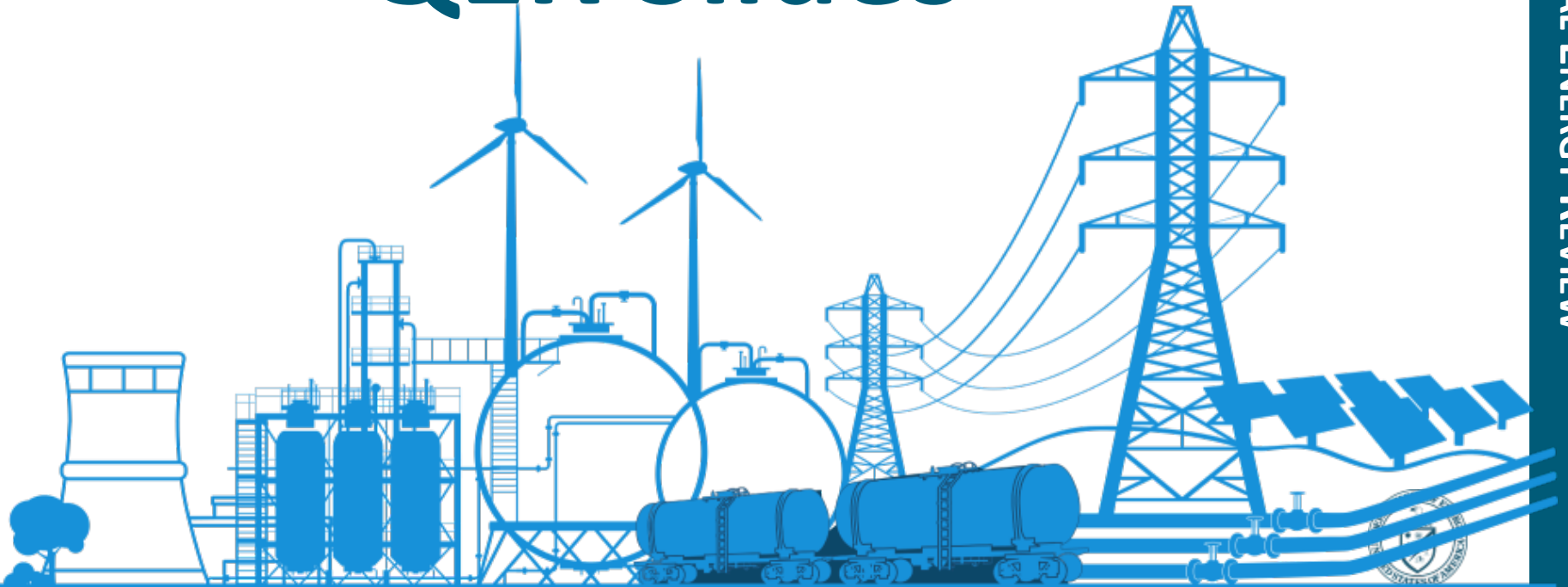
- Close collaboration with tribal, state, and local governments is critical to siting, permitting, and review of infrastructure projects
- Robust public engagement is essential for the credibility of the siting, permitting, and review process

### Selected Recommendations

- Enact statutory authorities to improve coordination across agencies
- Allocate resources to key Federal agencies involved in the siting, permitting, and review of infrastructure projects
- Adopt Administration proposals to authorize recovery of costs for review of project applications



# Appendix: Full Set of QER Slides



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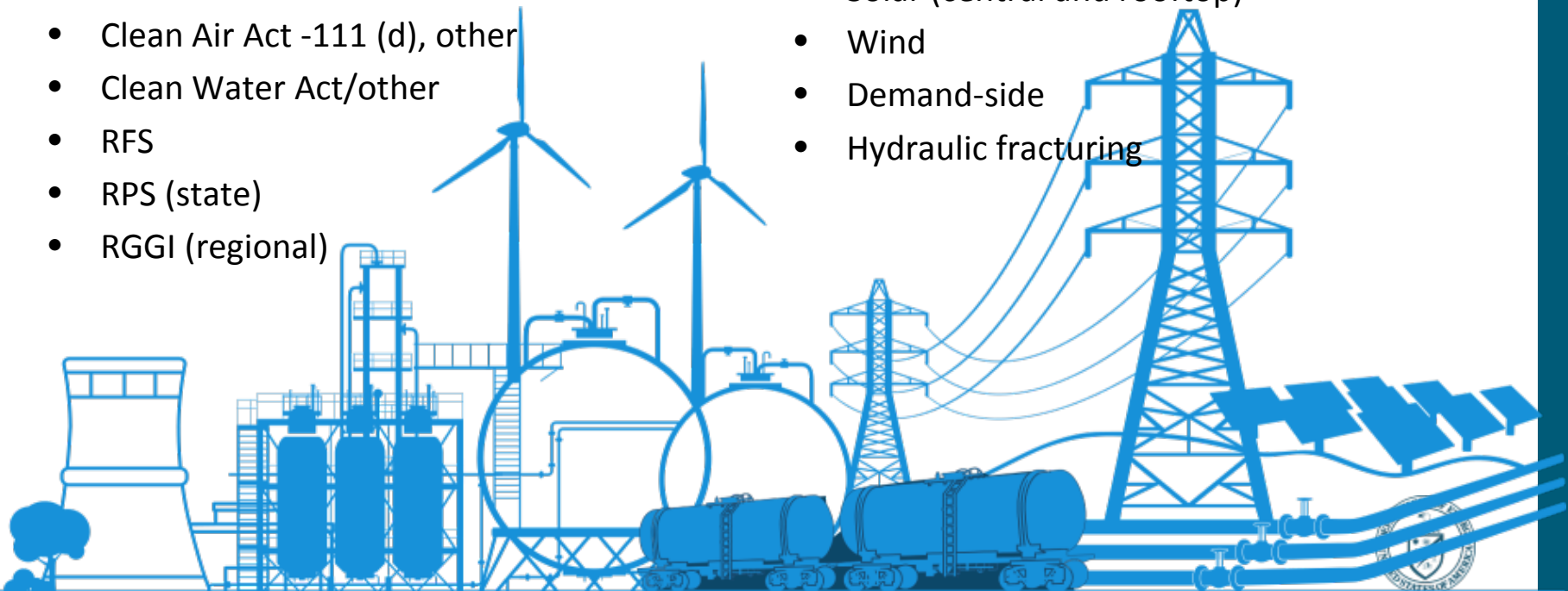
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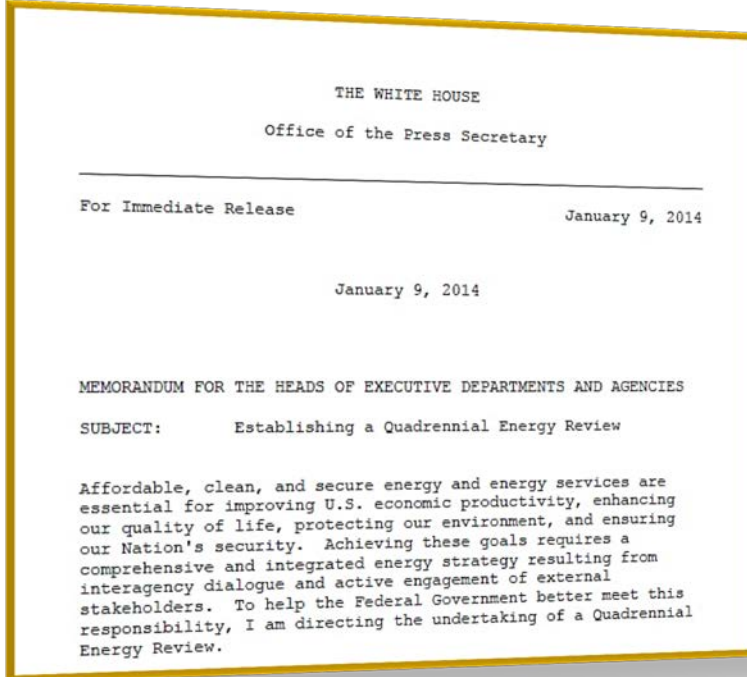
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## Presidential Memorandum



“Affordable, clean, and secure energy and energy services are essential for improving U.S. economic productivity, enhancing our quality of life, protecting our environment, and ensuring our Nation's security.

**Achieving these goals requires a comprehensive and integrated energy strategy** resulting from interagency dialogue and active engagement of external stakeholders.

To help the Federal Government better meet this responsibility, **I am directing the undertaking of a Quadrennial Energy Review.”**

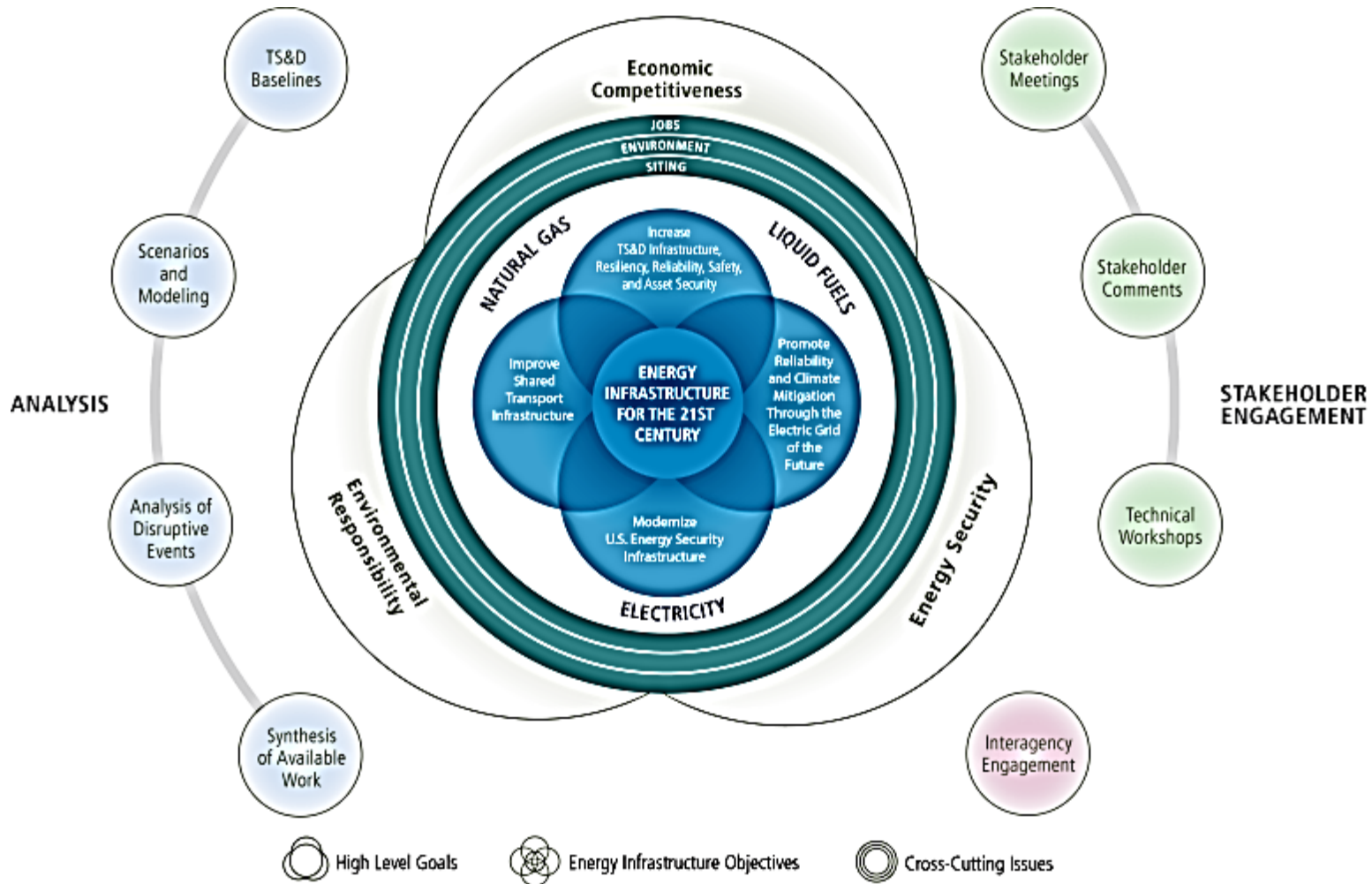
*President Barack Obama  
January 9, 2014*

- **Integrated view** of short-, intermediate-, long-term objectives for Federal energy policy;
- **Outline of legislative** proposals to Congress;
- **Executive actions** (programmatic, regulatory, fiscal, etc.) across multiple agencies;
- **Resource requirements** for RD&D and incentive programs; and
- **Strong analytical base** for decision-making.
- **First year focus** on TS&D infrastructure including: electricity transmission and distribution systems, liquid and gas pipelines, export infrastructure; interdependencies; climate and environment.





# Inputs to the QER





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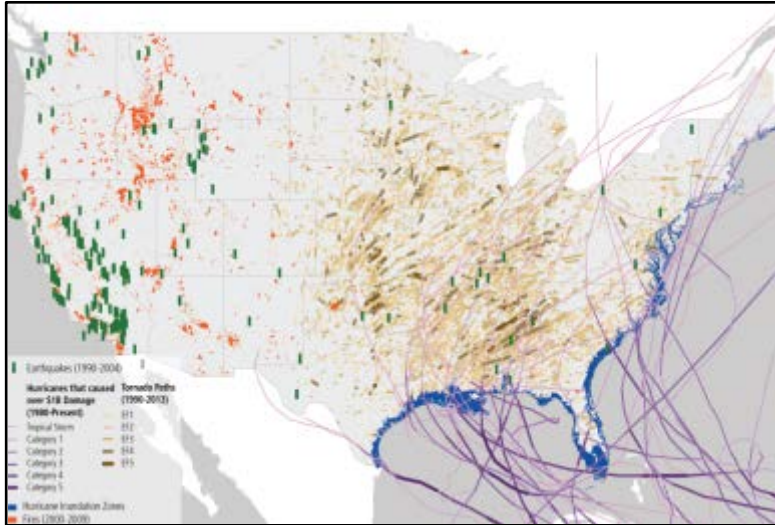
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## Vulnerabilities and Disruptions

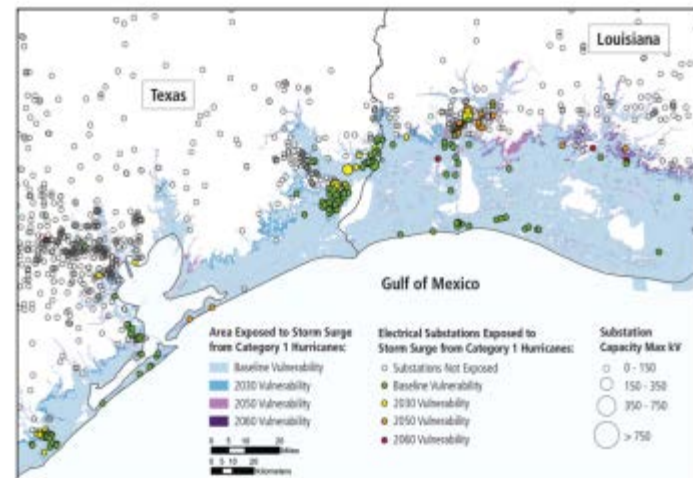
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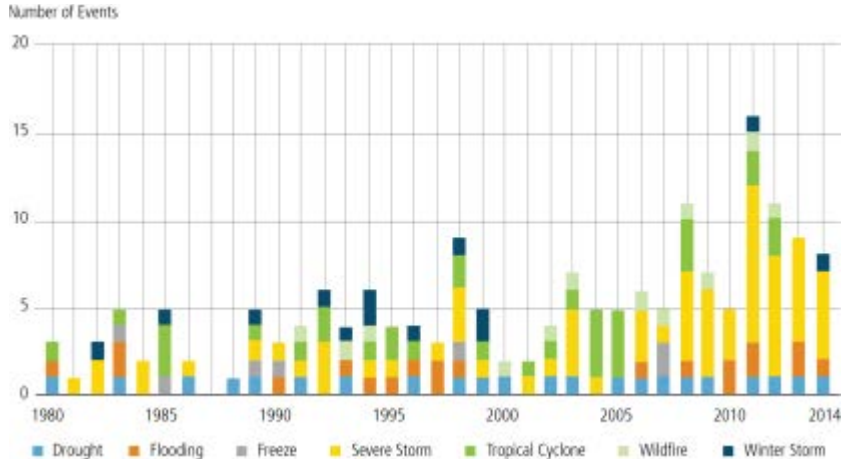
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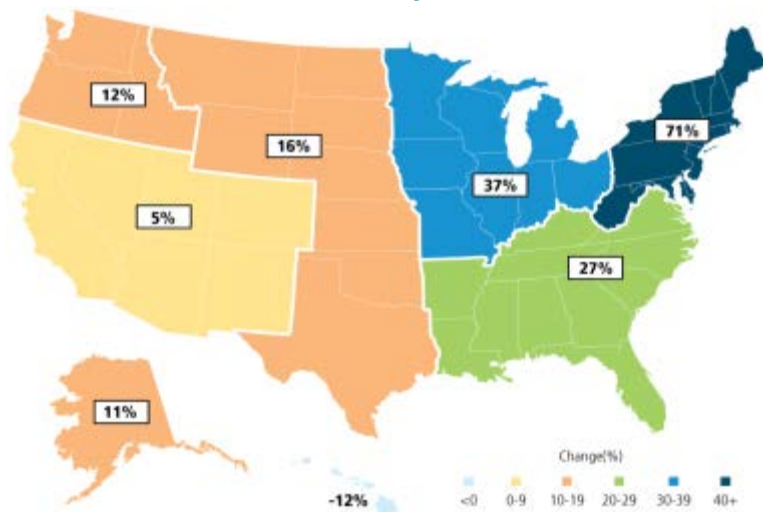


## Trends of Increased Disruptions

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



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

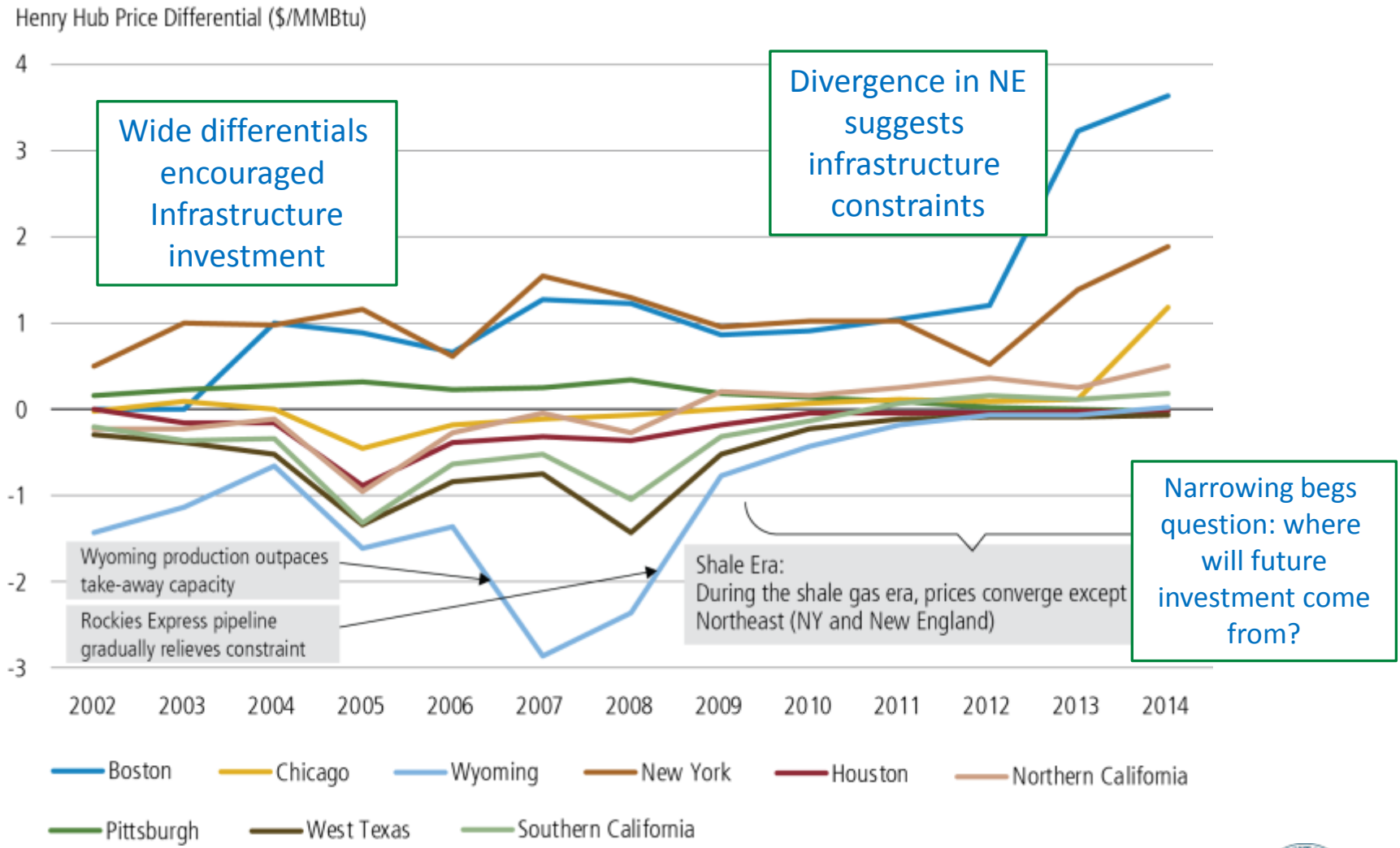


### Selected Findings

- Mitigating energy disruptions is fundamental to infrastructure resilience
- TS&D infrastructure is vulnerable to many natural phenomena, and some extreme weather events have become more frequent; threats and vulnerabilities vary substantially by region
- Cyber incidents and physical attacks are growing concerns
- High-voltage transformers are critical to the grid
- Aging, leak-prone natural gas distribution pipelines and associated infrastructures prompt safety and environmental concerns



# Importance of Gas Transmission Infrastructure



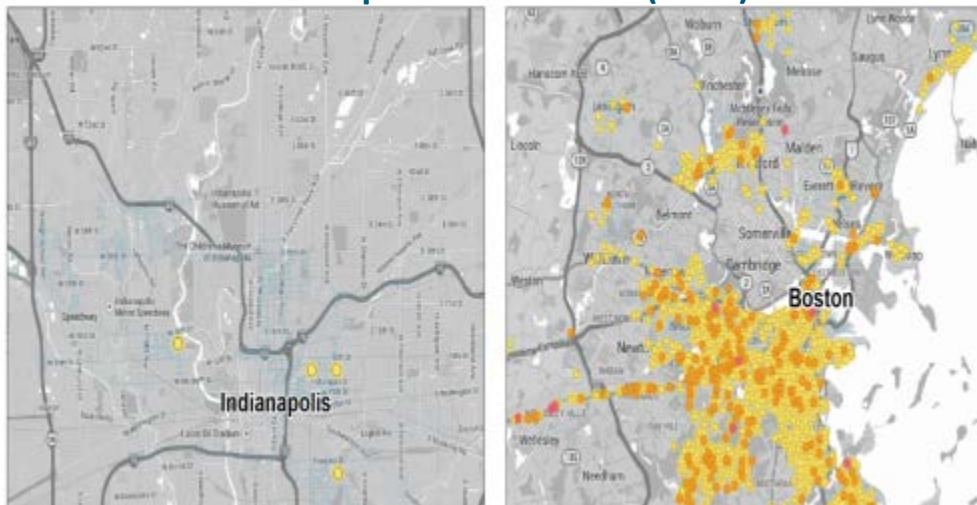
INCREASING RESILIENCE, RELIABILITY, SAFETY, AND ASSET SECURITY





# Leak Prone Pipes in Local Distribution Systems

## Methane Emissions from Natural Gas Distribution Systems in Indianapolis and Boston (2013)



## Public safety risks from distribution pipelines

- Safety incidents are relatively infrequent, but increase as systems age
- The most leak-prone distribution pipeline materials are cast iron and bare steel
- Many companies, states, and localities have taken action to improve safety by accelerating distribution pipeline replacement
- Methane leak mapping in Indianapolis and Boston show effect of newer vs. older pipelines

## Expected Replacement Horizons for Select Utilities for Leak-Prone Mains (Forecasted Timeframe in Years)

Utility Company	Service Territory	State	Forecasted Timeframe (years)
Philadelphia Gas Works	Philadelphia, PA	PA	84
ConEd	New York, NY	NY	35
PECO	Greater Philadelphia, PA	PA	33
PSE&G	Newark, NJ	NJ	30
Pensacola Energy	Pensacola, FL	FL	30
Baltimore Gas Company	Baltimore, MD	MD	30
UGI	Rural Pennsylvania	PA	27
Consumers Energy	Detroit, MI	MI	25
DTE	Detroit, MI	MI	25
National Grid	New York, NY	NY	25
Dominion Hope Gas Co.	Ohio	OH	20
Yankee Gas Services Company	Rural Connecticut	CT	20
Peoples Gas	Chicago, IL	IL	20
National Grid - Niagra Mohawk	Rhode Island	RI	19
Peoples TWP	Southwestern Pennsylvania	PA	19
Peoples Natural Gas Co.	Southwestern Pennsylvania	PA	17
National Grid - Niagra Mohawk	Syracuse, NY	NY	16
Columbia Gas of Pennsylvania	Southwestern Pennsylvania	PA	15
Northern Utilities	Maine	ME	13
CenterPoint	Arkansas	AR	12

### States with Most Cast and Wrought Iron Pipelines

New Jersey

New York

Massachusetts

Pennsylvania

Michigan

Illinois

Connecticut

Maryland

Alabama

Missouri

### States With Most Bare Steel Pipelines

Ohio

Pennsylvania

New York

Texas

Kansas

California

West Virginia

Oklahoma

Massachusetts

New Jersey



# Regional Fuel Resiliency Studies

**Far West.** Increasingly depends on receiving shipments by water from other regions and from ports within region, including Alaska. Not well-connected to other PADDs by pipeline, receive an increasing amount of its oil by rail. Susceptible to earthquakes and wildfires.



**Upper Rocky Mountains.** This region consumes fuels from refineries in the Salt Lake and Denver areas. Main hazards are earthquakes and extreme cold. Pipelines networks are less dense, leading to cities that are far from refining centers often served by long dedicated pipelines.

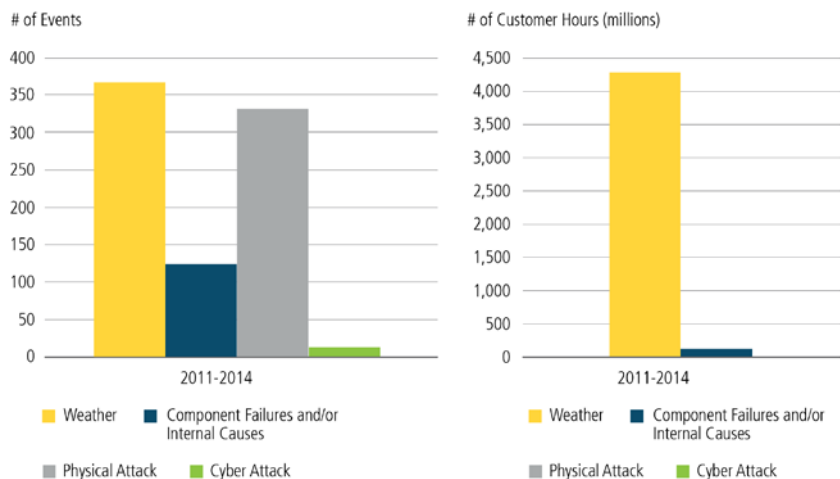


**Southeast.** Florida is heavily dependent on receiving water shipments of refined products. The interior is dependent on pipeline shipment of refined products from the Colonial and Plantation pipelines. Susceptible to weather disruptions of receiving ports, pipeline shipments,



## Recommendations

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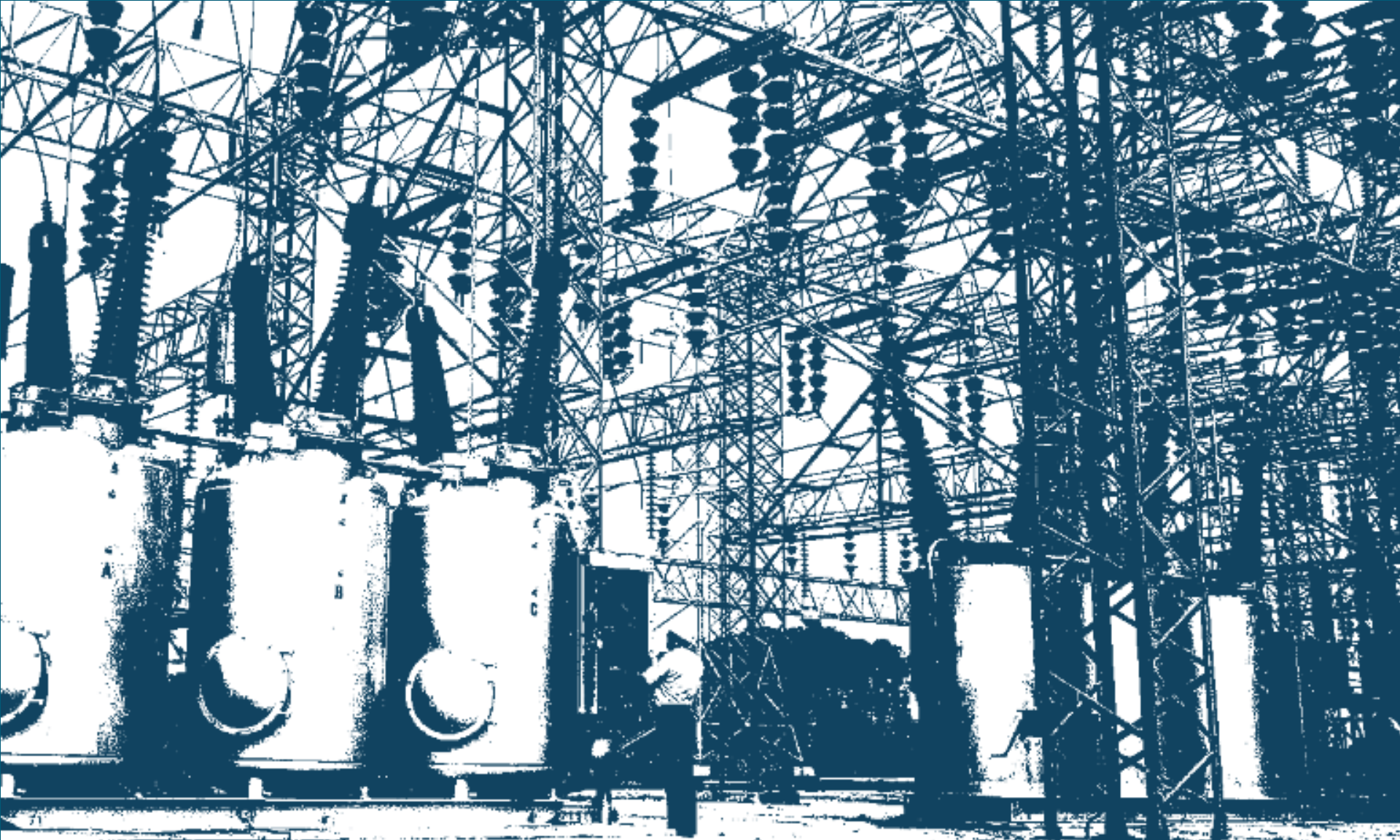
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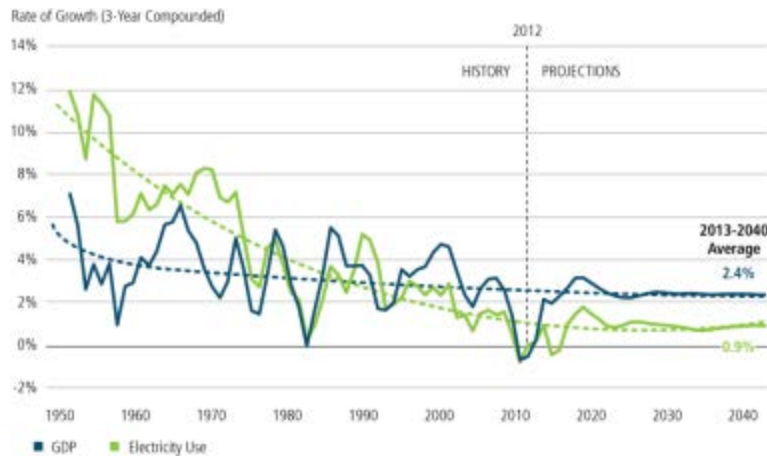
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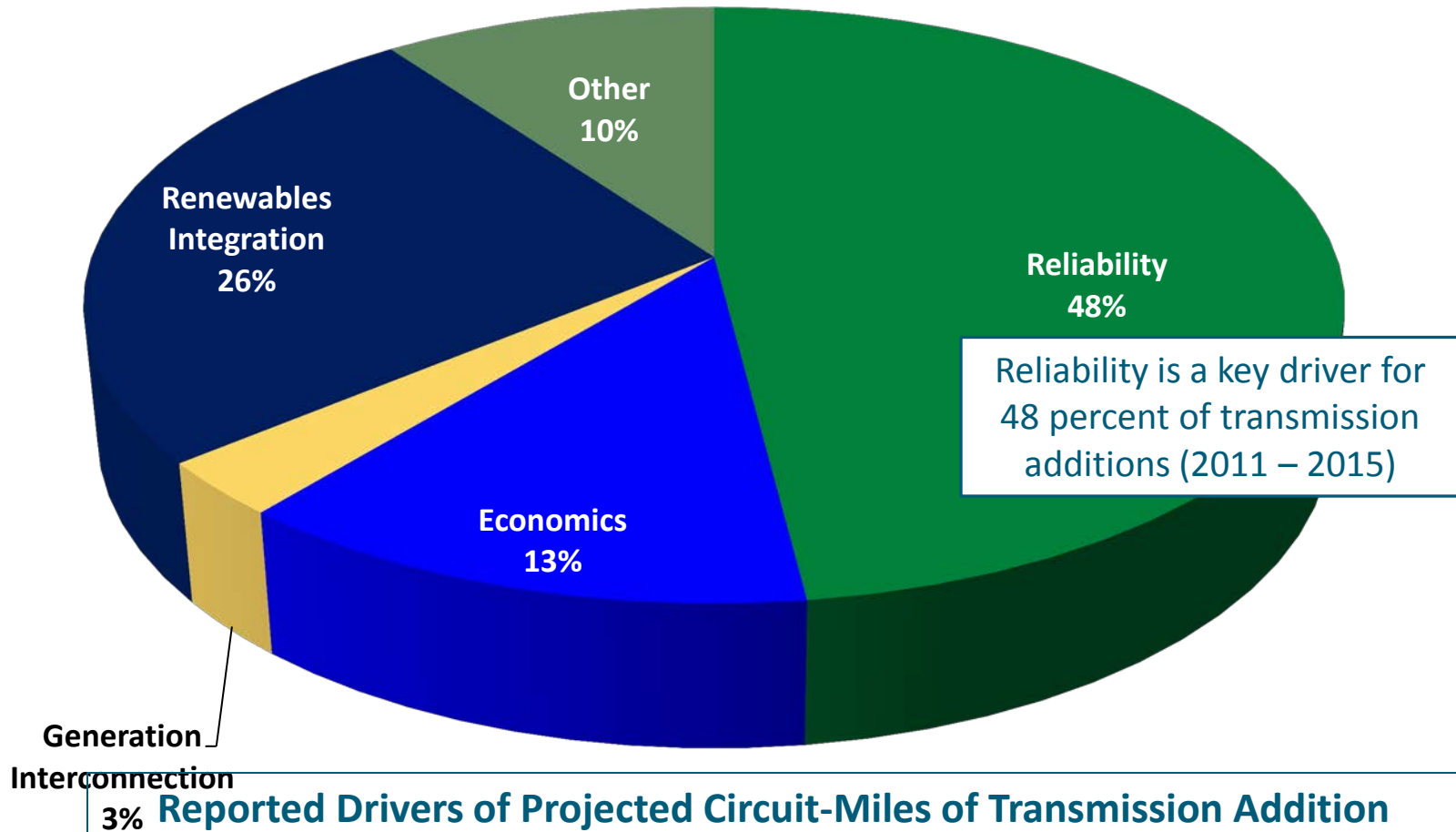
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## Transmission Investment: Today's Drivers



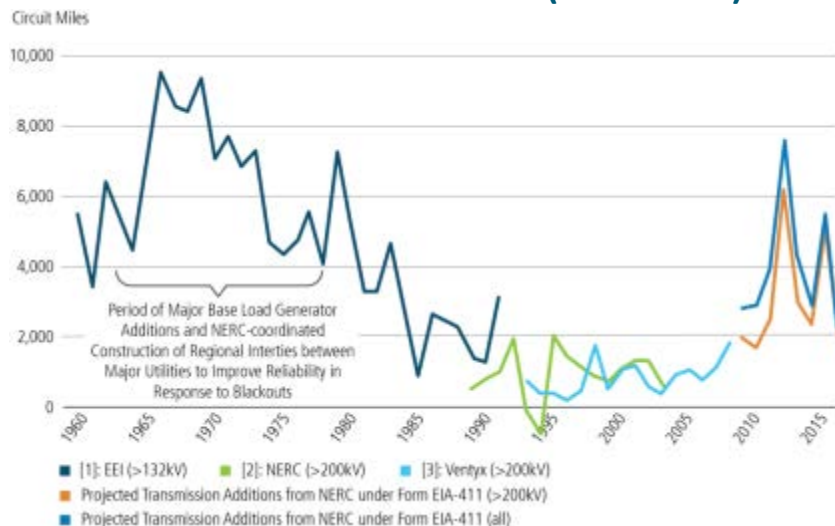
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MODERNIZING U.S. ENERGY SECURITY INFRASTRUCTURES IN A  
CHANGING GLOBAL MARKETPLACE



# Rapidly Changing Supply/Infrastructure Geography

## Crude Oil by Train Loading (red) and Offloading (green) Facilities 2010



- In 2010, the United States and Canada had six rail loading facilities for crude oil and four offloading facilities

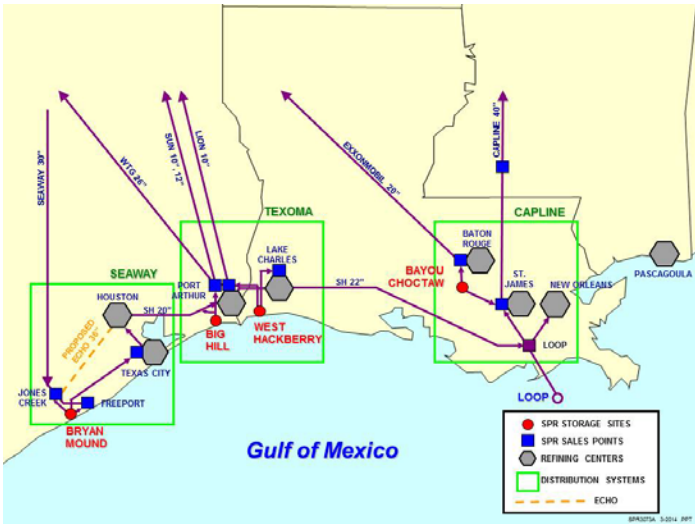
## Crude Oil by Train Loading (red) and Offloading (green) Facilities 2013



- By year-end 2013, crude oil by rail capacity had grown to include 65 loading facilities in Petroleum Administration Defense Districts (PADD) 2, 3, and 4. Rail-to-barge facilities also increased.



## Selected SPR Findings



SPR Infrastructure in the Gulf of Mexico region

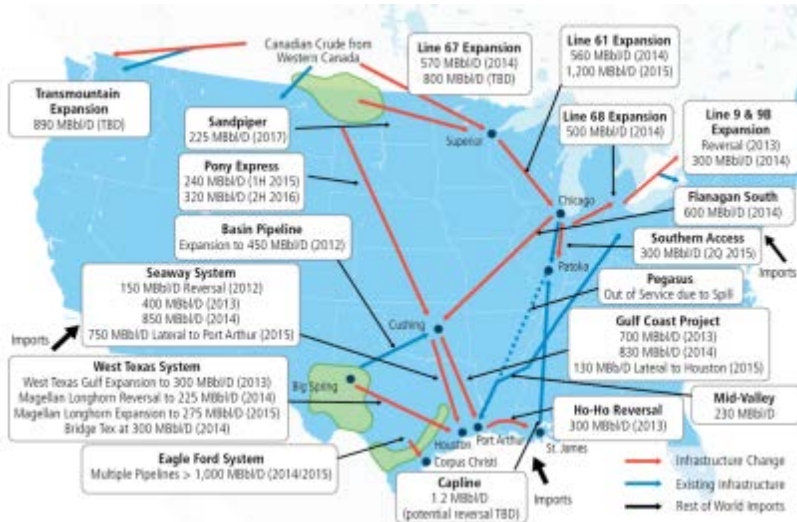


- The SPR was designed to respond to oil embargoes -- to move oil from south to north, and to inland refineries
- Today, the SPR's value is to move oil onto the water and into global oil markets in the event of a disruption, thereby lowering world oil prices and reducing economic harm to the US and its allies
- Congestion in the Gulf of Mexico is significant. Use of the SPR in the Libyan action had limited impact as it displaced some domestic production.
- Design drawdown rate of the SPR: 4.4 million barrels per day
- The SPR is 40 years old



## Findings

### Highlighted Pipeline Reversals and Expansions Accommodating Increased Domestic and Canadian Supply



## Selected Findings

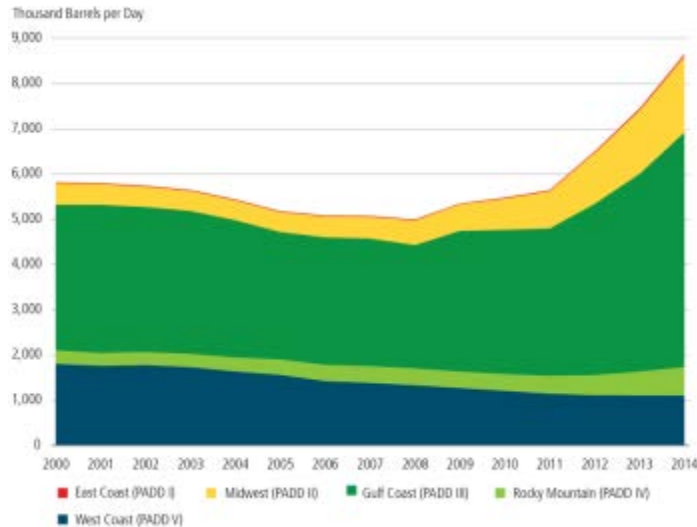
- The United States has achieved unprecedented oil and gas production growth
- The network of oil distribution (“the midstream”) has changed significantly
- The Strategic Petroleum Reserve’s ability to offset future energy supply disruptions has been adversely affected by domestic and global oil market developments coupled with the need for upgrades
- Biofuel production in the United States has increased rapidly over the last decade, enhancing energy security and reducing greenhouse gases from transportation

The Quadrennial Energy Review, April 2015

*“The United States is now the world’s largest producer of petroleum and natural gas. Combined with new clean energy technologies, and improved fuel efficiency, and growth in oil and natural gas production, U.S. energy security is stronger than it has been for over half a century.”*



## U.S. Crude Oil Production by PADD



The Quadrennial Energy Review, April 2015

*“Challenges remain in maximizing the security benefits of our resources in ways that enhance our competitiveness and minimize the environmental impacts of their use.”*

## Selected Recommendations

- Update Strategic Petroleum Reserve (SPR) release authorities to reflect modern oil markets
- Invest \$1.5 - \$2 B to optimize the SPR’s emergency response capability
- Support fuels diversity through research, demonstration, and analysis
- Undertake a study of the relationship between domestic shipping and energy security

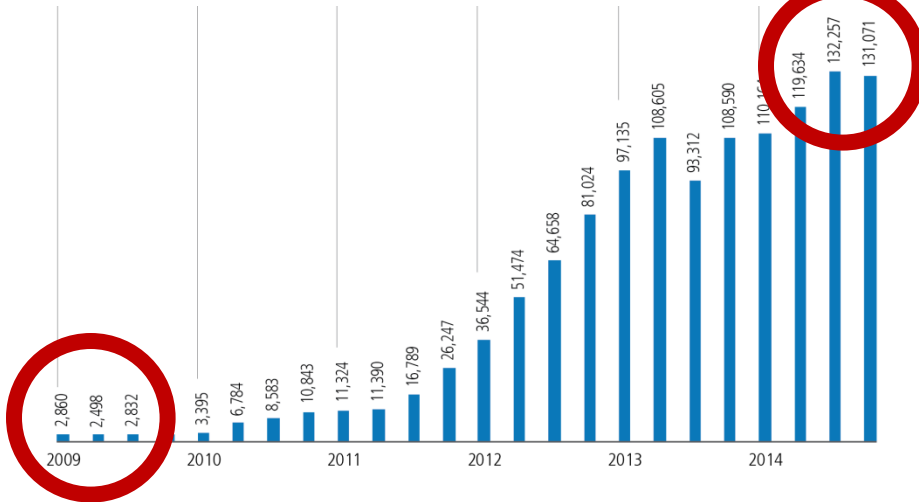




## IMPROVING SHARED ENERGY TRANSPORT INFRASTRUCTURES



### Class I Railcars of U.S. Crude Oil (Quarterly, 2009–2014)



### Rail, Barge, Truck Issues

- Between 2009 and 2014, rail shipments of crude oil increased roughly 4,400 percent
- In one year (2011-12), truck shipments of crude oil increased 53%, rail 423%, and barge 38%
- For every new shale well, the Nation's railroads move approximately 40 rail cars of drilling material
- Ethanol, now displacing 10% of U.S. gasoline demand, moves on rail, barge and truck. 70% of ethanol shipments from production plants to distribution terminals is moved by rail.



### 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,

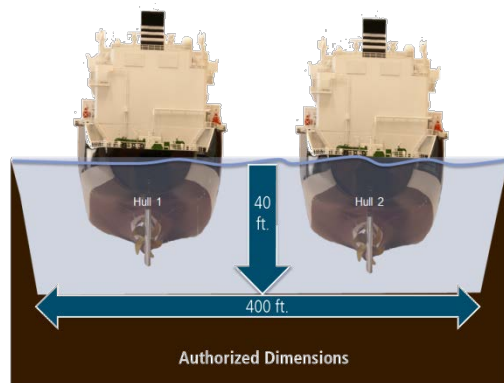
***“the magnitude and duration of recent unexpected shifts in supply and demand for ... rail service... have exceeded previous events in terms of both magnitude and duration, including Hurricane Katrina, which caused major disruptions throughout the entire agricultural transportation network.”***

### Key Rail Findings

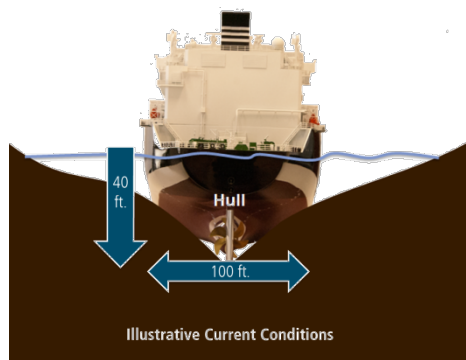
- Oil is an attractive commodity for railroad as it is not seasonal
- On average, roughly 1 million barrels of oil were moved by rail per day in 2014—nearly 12 percent of U.S. domestic crude oil production
- 34 states get coal for power generation from the Powder River Basin in Wyoming, almost all by 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



Lake Charles Ship Channel designed for two tankers to pass



Current channel conditions reduce cargos, idle until high-tide, or, be subject to one-way traffic restrictions

### Selected Waterways Findings

- In 2012, crude oil, refined petroleum products, and coal were 55% of all U.S. waterborne cargo traffic by weight
- Nearly 15 percent of all petroleum products consumed in the U.S. are shipped on inland waterways
- DOT's Beyond Traffic 2045 report concludes that "... several critical trends will have a major impact on the performance of critical marine links in our transportation systems." They include:
  - Increasing imports and exports and containerized freight will lead to greater congestion on America's coastal and inland ports
  - Investment in ports, harbors, and waterways will be essential to meet the demand of increased trade and competition

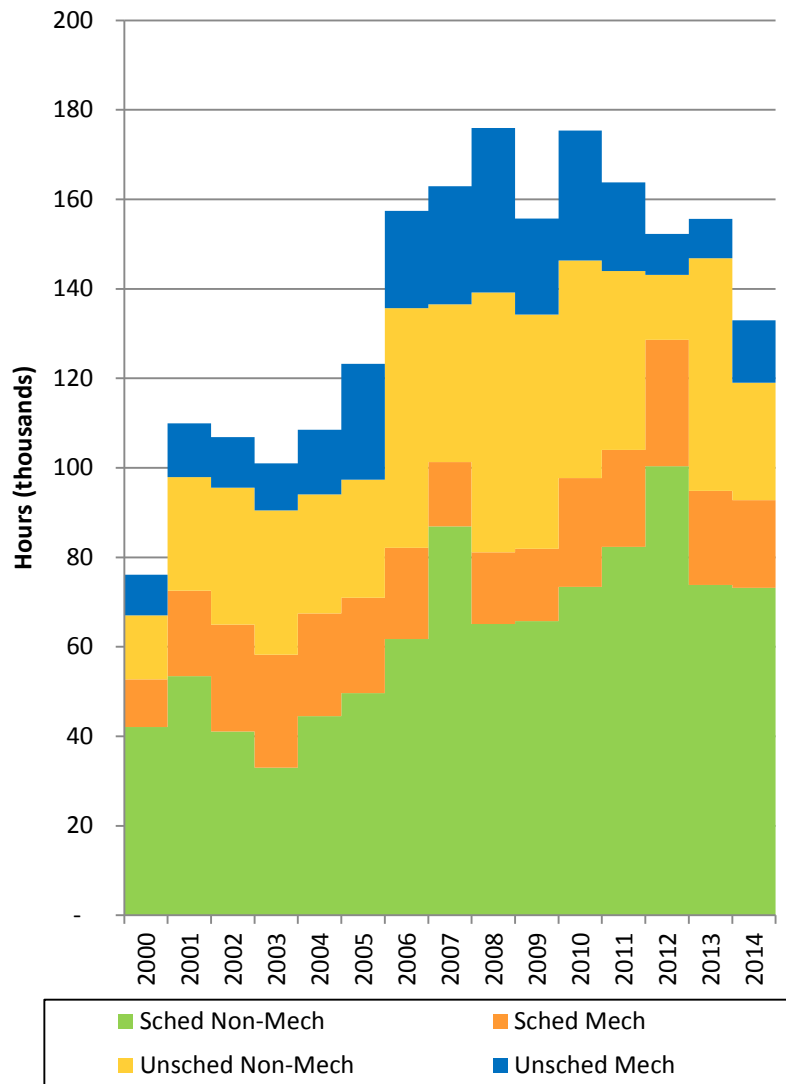
### Top 10 Port Systems by Total Energy Commodity Shipments (2013, millions of short tons)

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%



## Findings

### Hours of Lock Unavailability on U.S. Inland Waterways (2000-2014)



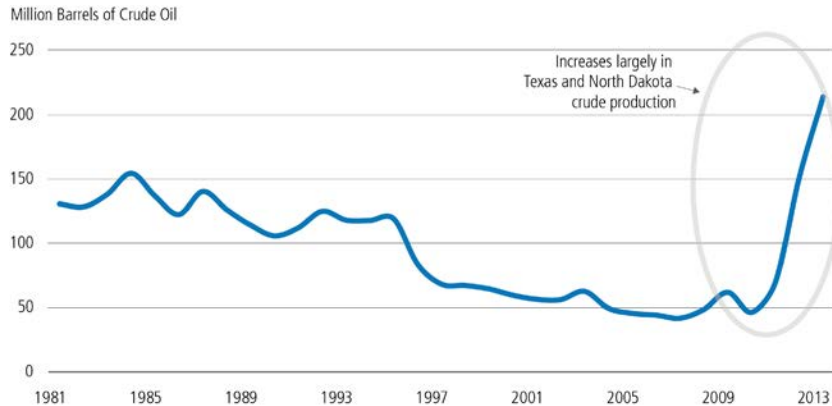
### Selected Findings

- Rapid crude oil production increases have changed the patterns of flow of North American midstream (pipelines, rail, and barge) liquids transport infrastructure
- Limited infrastructure capacities are intensifying competition among commodities, with some costs passed on to consumers
- The ability to maintain adequate coal stockpiles at some electric power plants has been affected by rail congestion
- Funding for the U.S. freight transportation system is complex and involves a combination of Federal, state, local, and private investments
- Multi-modal shared transportation infrastructure is stressed by increased shipments of energy supplies, materials, and components



## Recommendations

### Domestic Crude Refinery Receipts by Barge (1981-2013)



The Quadrennial Energy Review, April 2015

***“Changes in the U.S. energy marketplace are stressing the Nation’s infrastructures... particularly in the case of oil where the rapid increase in U.S. tight oil production is transforming conventional patterns and modes.”***

### Selected Recommendations

- Support a \$2 - \$2.5 B program of competitively awarded grants for shared energy transport systems
- Enhance the understanding of important safety-related challenges of transport of crude oil and ethanol by rail and accelerate responses
- Address critical energy data gaps in the rail transport of energy commodities and supplies
- Support alternative funding mechanisms for waterborne freight infrastructure
- Support public-private partnerships for waterborne transport infrastructure

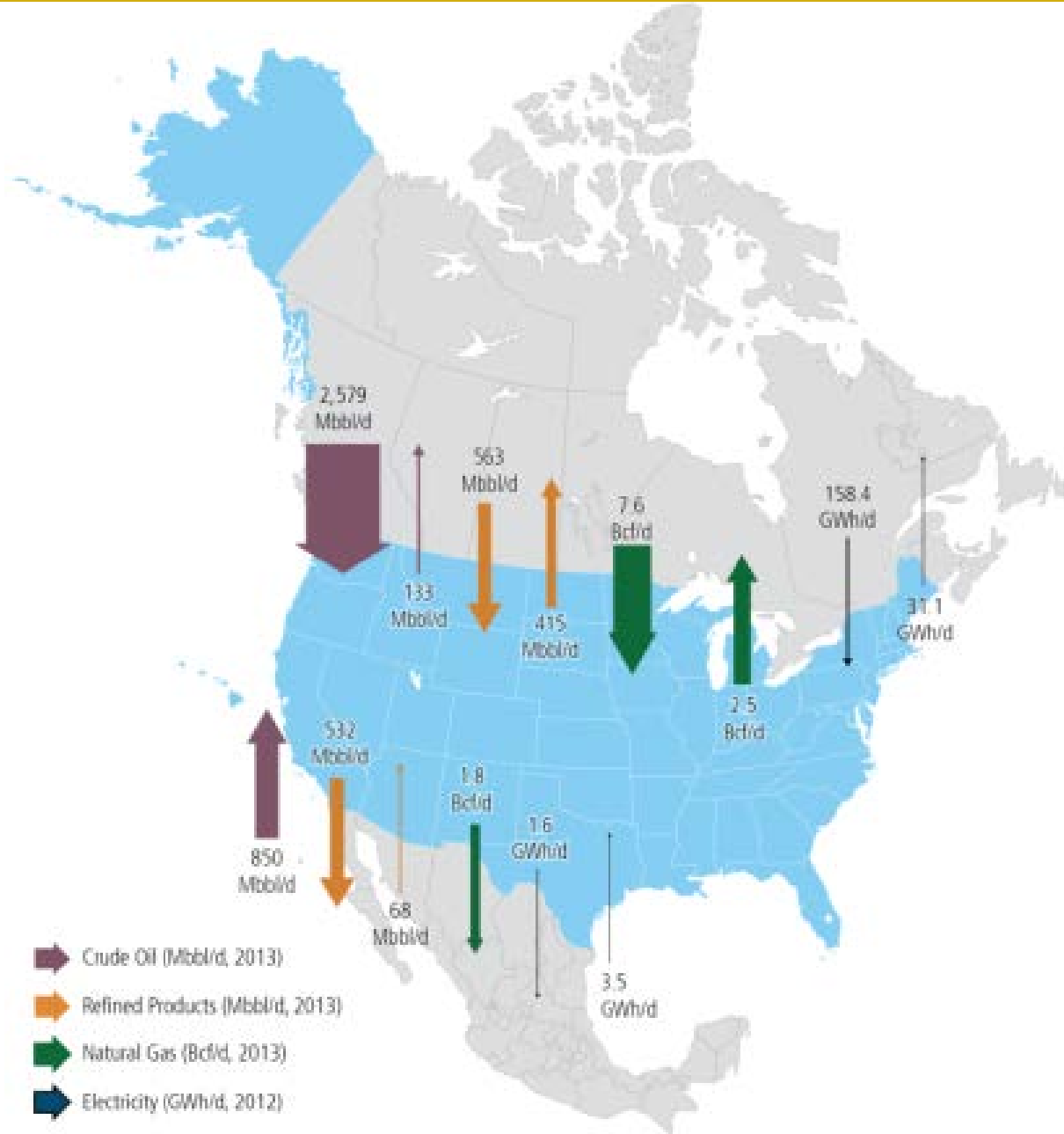




# INTEGRATING NORTH AMERICAN ENERGY MARKETS



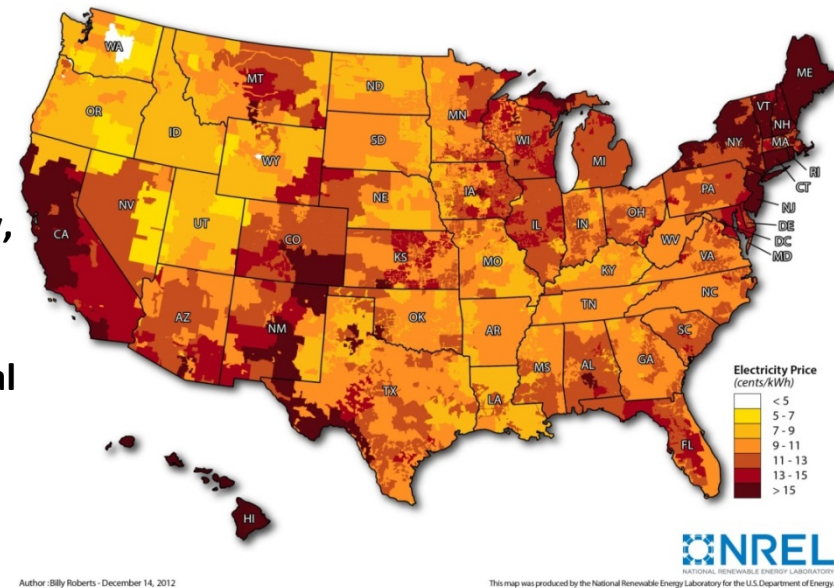
# North American Energy Flows

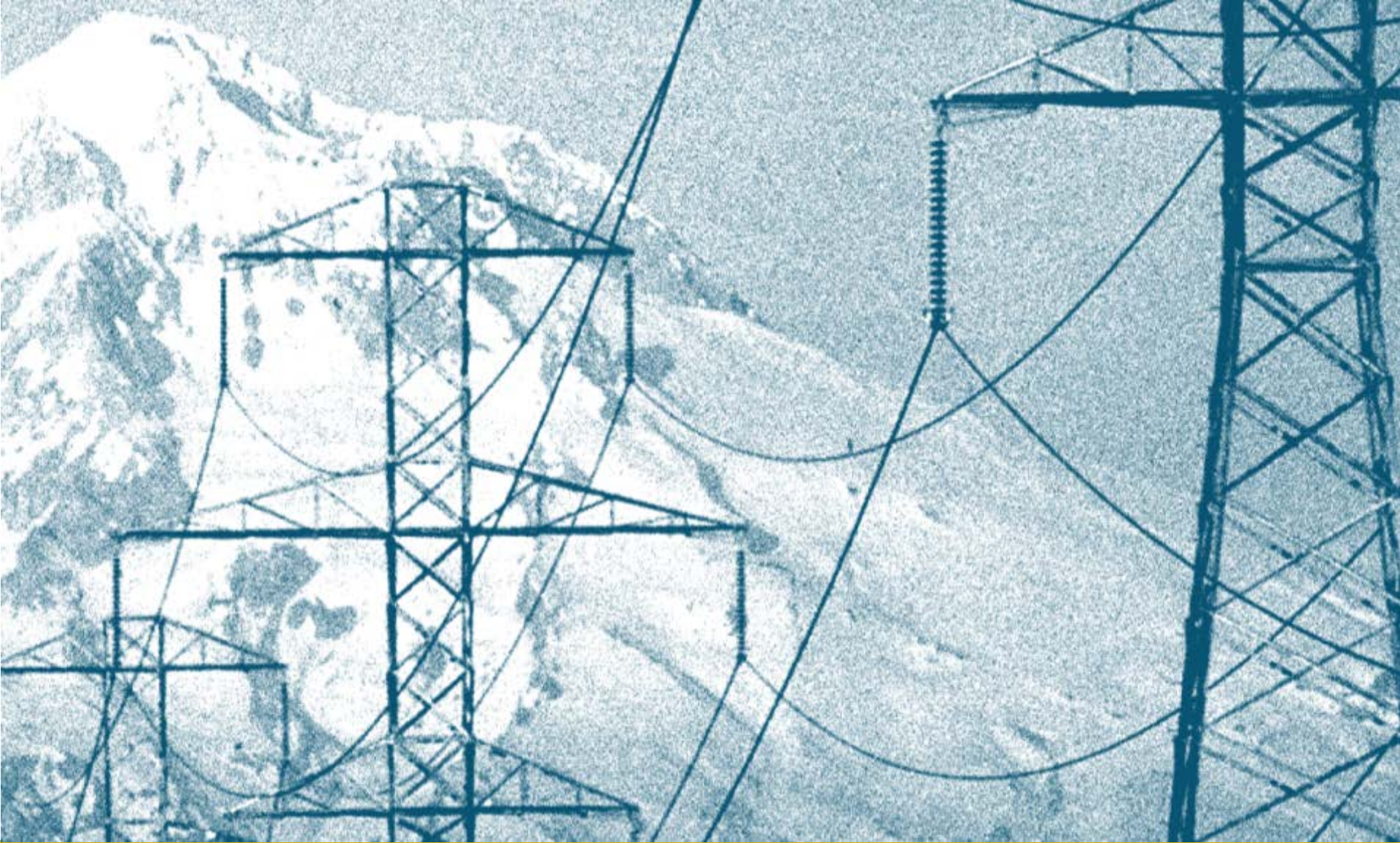


### Selected Recommendations

- Continue advances that have been made in the North American energy dialogue
- Increase the integration of energy data among the United States, Canada, and Mexico
- Undertake comparative and joint energy system modeling, planning, and forecasting
- Establish programs for academic institutions and not-for-profits to develop legal, regulatory, and policy roadmaps for harmonizing regulations across borders
- Coordinate training and encourage professional interactions
- Partner with Canada and the Arctic Council on Arctic energy safety, reliability, and environmental protection
- Partner with Canada and the Arctic Council on energy delivery to remote areas
- Promote Caribbean energy TS&D infrastructure

### Regional Variation in Electricity Prices





## ADDRESSING ENVIRONMENTAL ASPECTS OF TS&D INFRASTRUCTURE



### Selected Findings

- TS&D infrastructure can serve as an enabler for – or barrier to – better environmental outcomes for the overall energy system
- Energy transport, refining, and processing infrastructure contribute to emissions of criteria air pollutants that pose risks to public health and the environment

### Current CO<sub>2</sub> - Enhanced Oil Recovery (EOR) Operations and Infrastructure



### Selected Recommendations

- Improve quantifications of emissions and expand R&D for natural gas TS&D infrastructure
- Support funding to reduce diesel emissions
- Enact financial incentives for the construction of CO<sub>2</sub> pipeline networks





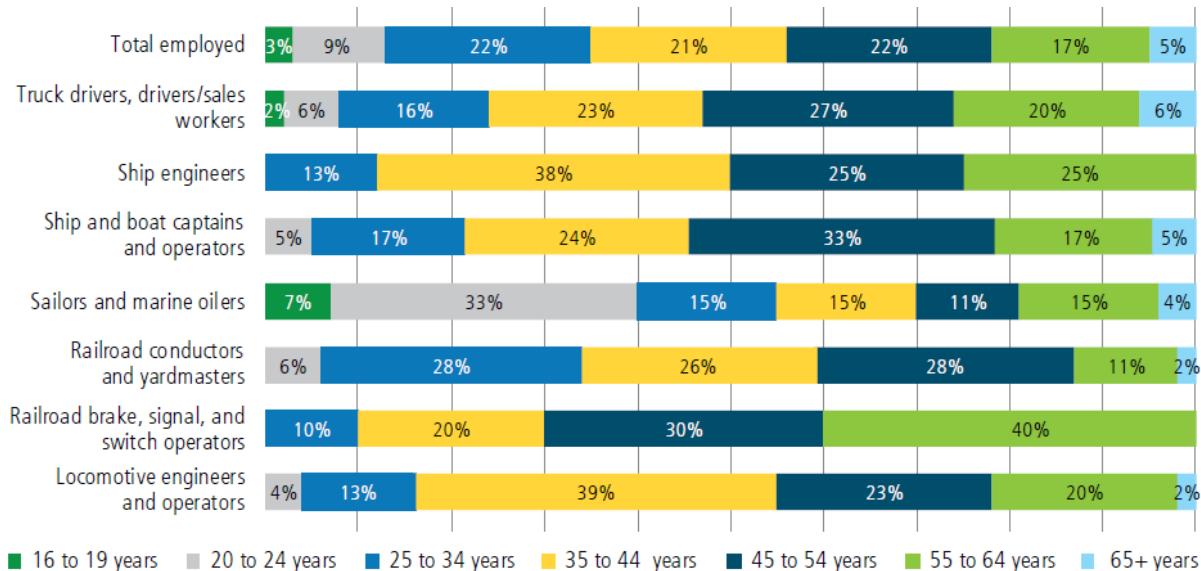


## ENHANCING EMPLOYMENT AND WORKFORCE TRAINING



## Findings and Recommendations

### Age Distribution of Select Transportation Workers (2014)



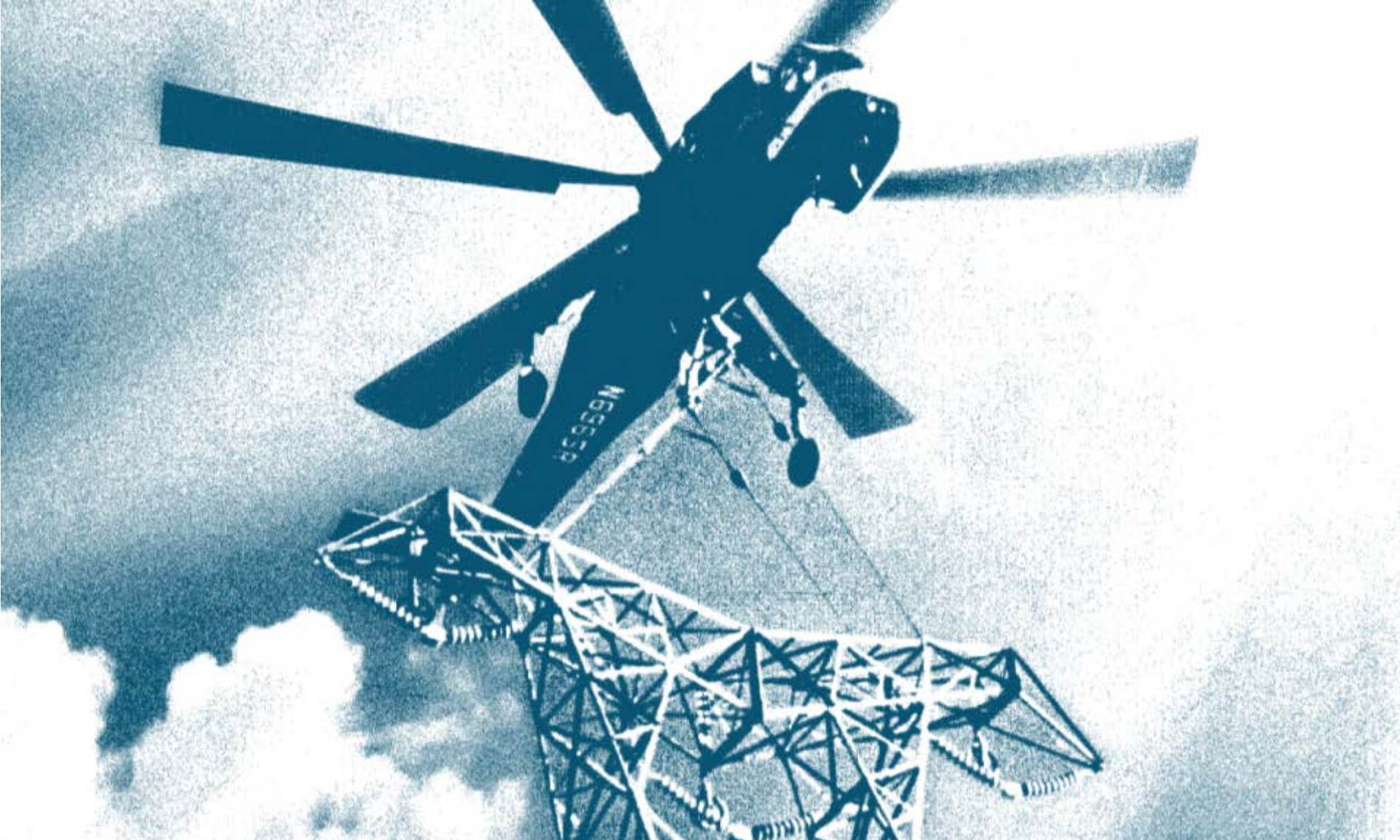
### Selected Findings

- By 2030, projections indicate that the energy sector overall, including the TS&D segment, will employ an additional 1.5 million workers, mainly in the construction, installation and maintenance, and transportation areas. 200,000 more workers with computer and mathematics skills will be required.
- Defining priorities in the area of jobs and workforce training and establishing effective programs requires good data

### Selected Recommendations

- Facilitate national credentials for energy occupations. DOE should support and facilitate an industry-led process of defining needed skills in a number of emerging occupations.
- Establish an interagency working group to reform existing energy jobs data collection systems





## SITING AND PERMITTING OF TS&D INFRASTRUCTURE



### Selected Findings

- Close collaboration with tribal, state, and local governments is critical to siting, permitting, and review of infrastructure projects
- Robust public engagement is essential for the credibility of the siting, permitting, and review process

### Selected Recommendations

- Enact statutory authorities to improve coordination across agencies
- Allocate resources to key Federal agencies involved in the siting, permitting, and review of infrastructure projects
- Adopt Administration proposals to authorize recovery of costs for review of project applications

