NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Evaluating Severe Natural Gas Disruptions and Interdependency Impacts to Bulk Power System Reliability

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September 29, 2021

RELIABILITY | ACCOUNTABILITY




Discussion Outline

- Overview of the risks associated with changing resource mix and NERC's assessment role
- Natural gas risks and special assessments identifying specific areas of concern
- Recent electric reliability disruptions related to natural gas risks
- How the electric industry is responding and future challenges

About NERC: Mission

To ensure the reliability of the North American bulk power system

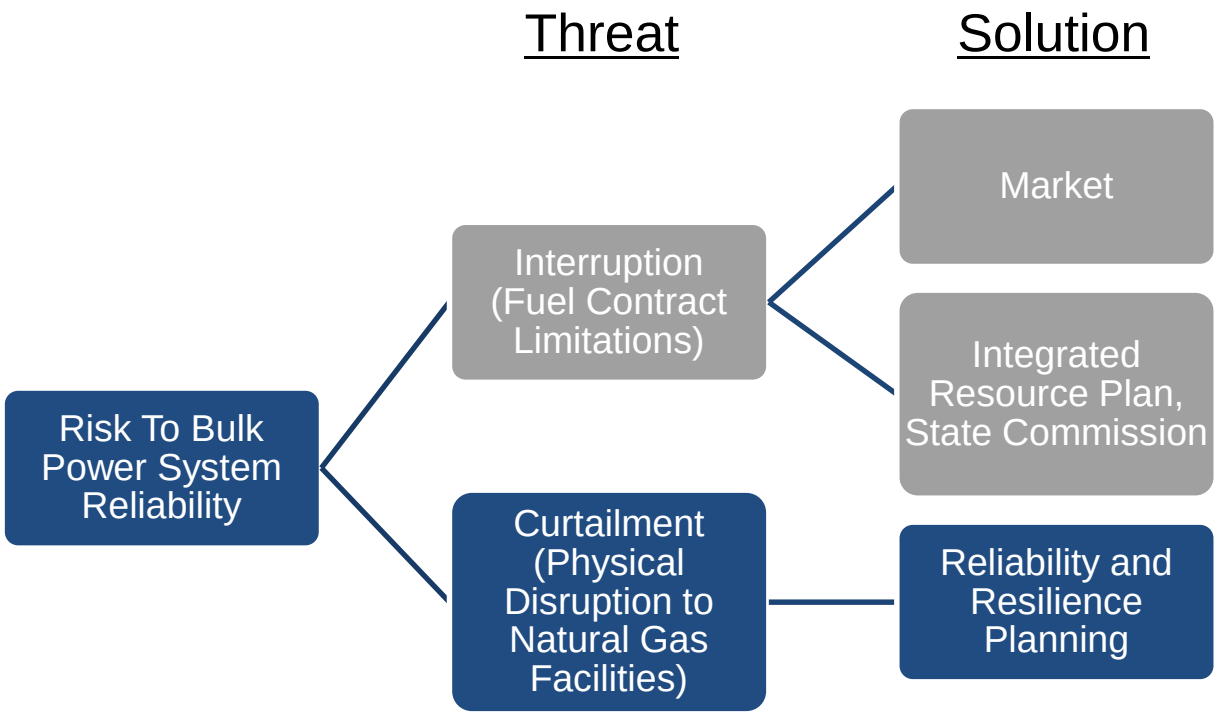
- Develop and enforce reliability standards
- Assess current and future reliability
- Analyze system events and recommend improved practices
- Encourage active participation by all stakeholders
- Accountable as ERO to regulators in the United States (FERC) and Canada (NEB and provincial governments)

Key Messages

- Conventional generation retirements create BPS reliability concerns when **Essential Reliability Services** and **fuel assurance** mechanisms are not replaced
- Declining reserve margins projected to tighten **operational reliability**, particularly under extreme conditions
- Fuel diversity is a means to fuel assurance, but solutions need to consider **regional differences**
- Finding solutions to the limited pipeline capacity problem should encompass **wholesale electric market** action as well as **natural gas regulatory frameworks**

Gas – Electric Interdependency

- Increased dependence on natural gas for generating capacity can amplify the bulk power system's vulnerability to disruptions in fuel supply, transportation, and delivery.



ERO

- Identify, assess, and report on risks to BPS
- Support decision makers and provide technical expertise and data

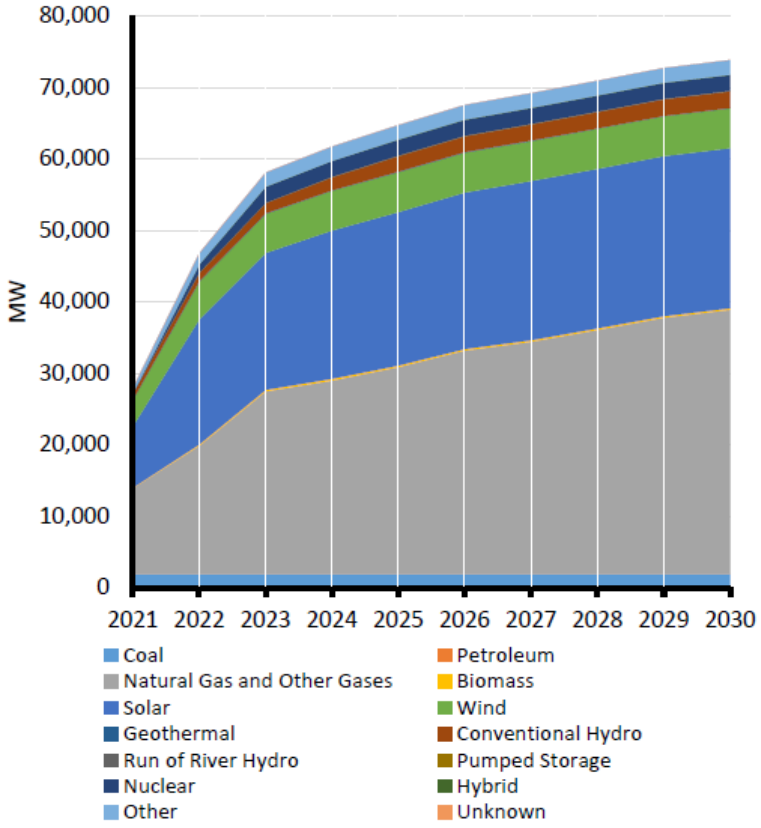
- Establish performance requirements (Reliability Standards)
- Provide technical guidance (Reliability Guidelines)

Findings From Previous NERC Assessments

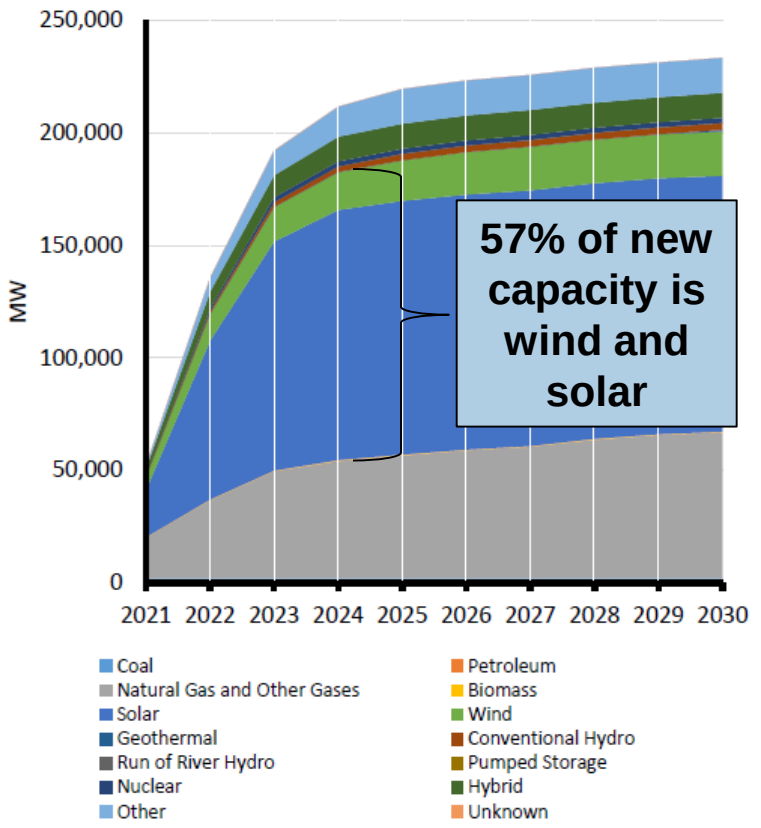
- Natural gas expected to increase
  - Replace retired generation
  - Offset variable resources
  - Meet increasing electricity demand
- Fuel not easily stored on-site
- Widely used outside the power sector
- Disruptions are rare
- Interdependencies have larger effect with increased reliance

Finding:
Variable Resources Growth Surpassing All Other Future Generation

- Variable generation is surpassing natural gas-fired generation for future capacity additions to the grid



On-Peak Capacity Additions (Anticipated) Through 2030

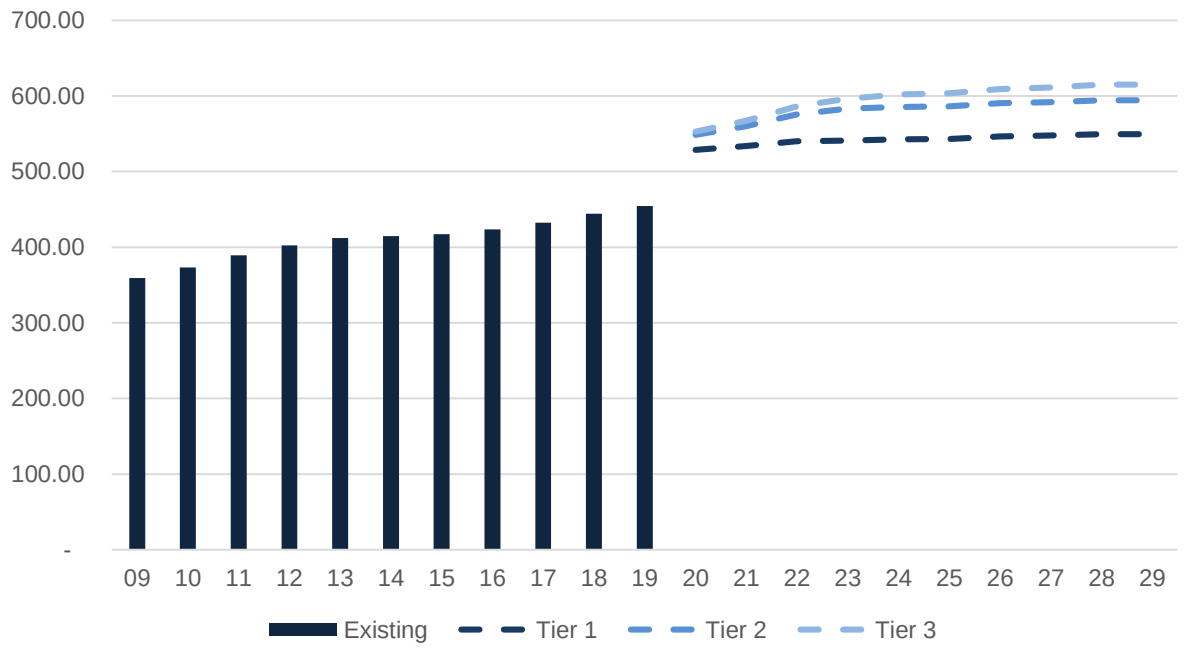


On-Peak Capacity Additions (Anticipated and Prospective) Through 2030

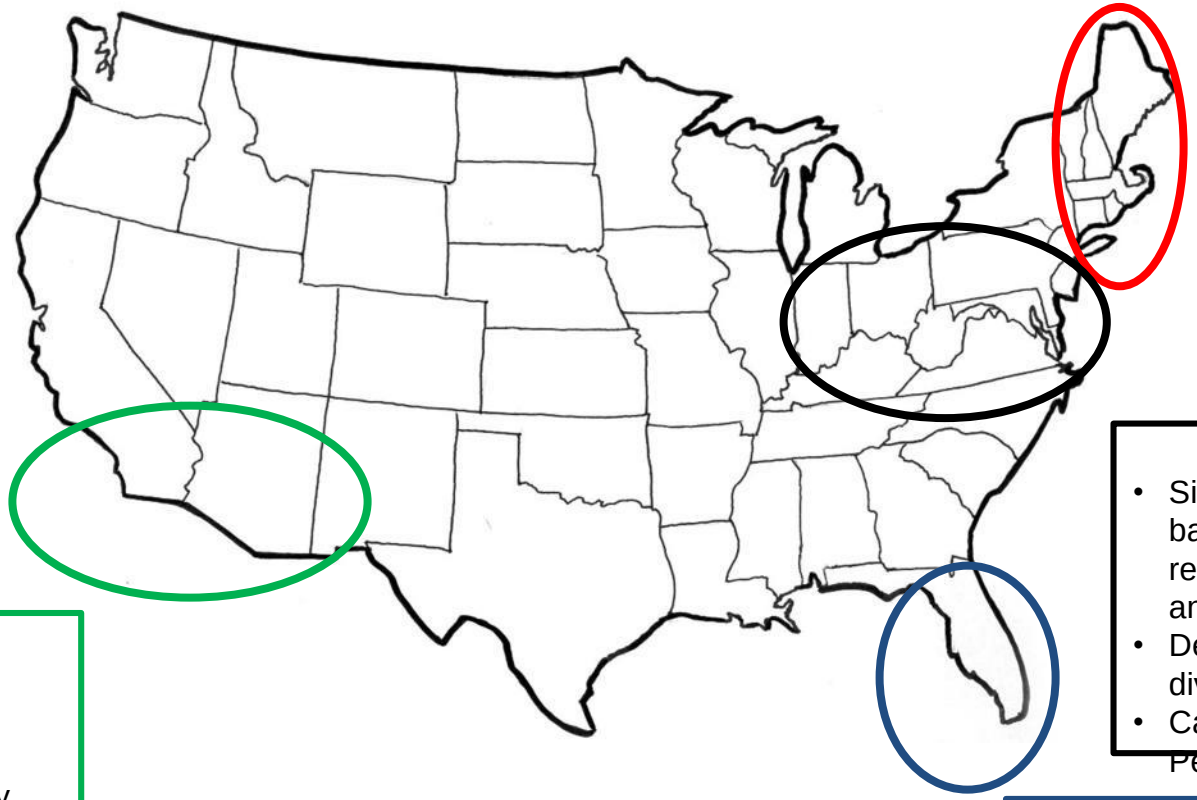
Changing Resource Mix: Increasing Gas-Fired Generation

- On-peak natural gas-fired capacity has increased to 455 GW, up from 359 GW in 2009.
- 100 GW of Tier 1 gas-fired capacity is planned during the next decade.

Assessment Area	2024 (%)
FRCC	78.1%
WECC-CAMX	68.2%
Texas RE-ERCOT	63.3%
NPCC-New England	52.3%
WECC-SRSG	51.8%
WECC-AB	51.8%



Regional Fuel Assurance Conditions



New England
- Infrastructure constrained
- Limited firm service
- "Anti-gas" sentiments
- Pay-for-Performance

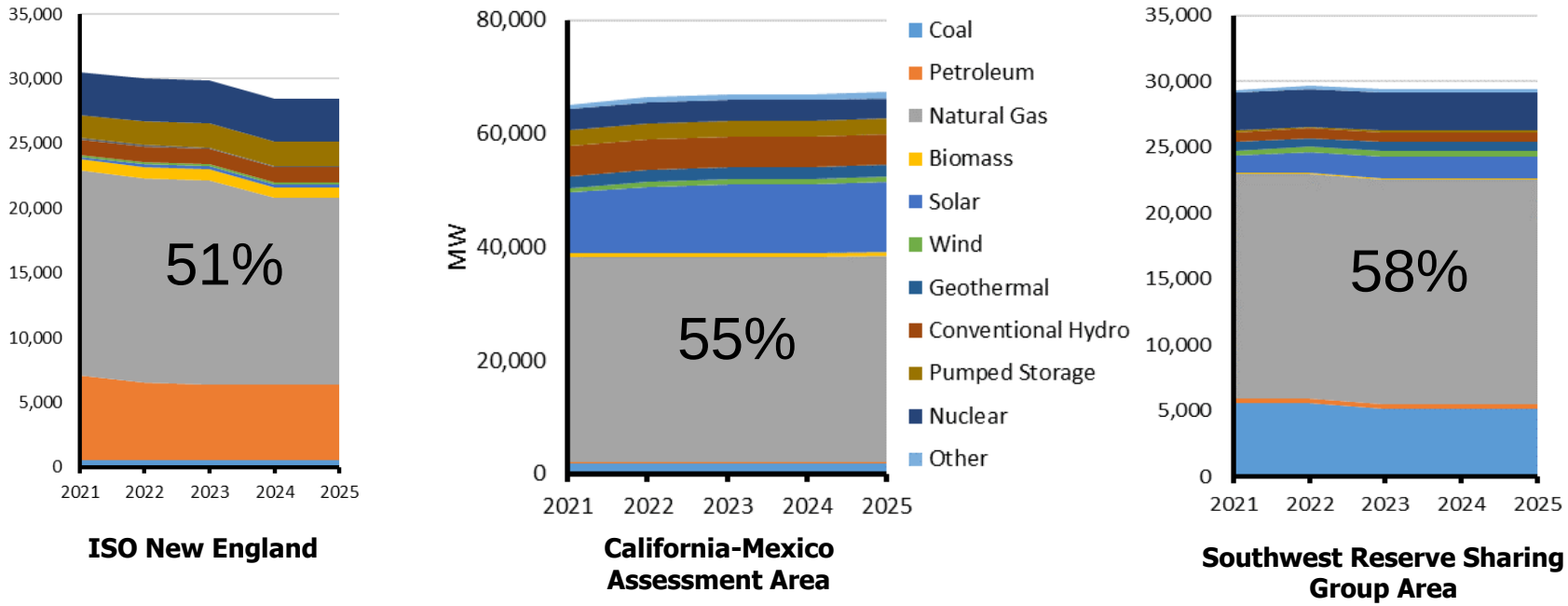
PJM
- Significant baseload retirements anticipated
- Declining fuel diversity
- Capacity Performance

CA/DSW
- Aliso Canyon/storage constraints
- System flexibility
- Pipeline constraints
- "Anti-gas" sentiments (CA)
- Limited firm service
- LDC Curtailment queue

Florida
- Firm service in place
- Dual fuel acceptable
- 78%+ gas on peak
- Lack of fuel diversity

Fuel Supply Risk

- In areas with high reliance on natural gas-fired electricity generation *and* limited supply infrastructure there is increased reliability risk



On-Peak Capacity of Existing and Anticipated Resources in Areas with Natural Gas Fuel Supply Infrastructure Constraints

Differences in the Gas Generation Availability

- Dual-fuel maintained on-site
- Firm fuel agreements
- Multiple pipeline connections

- Dual-fuel capable
- Part of firm fuel portfolio
- Multiple pipeline connections

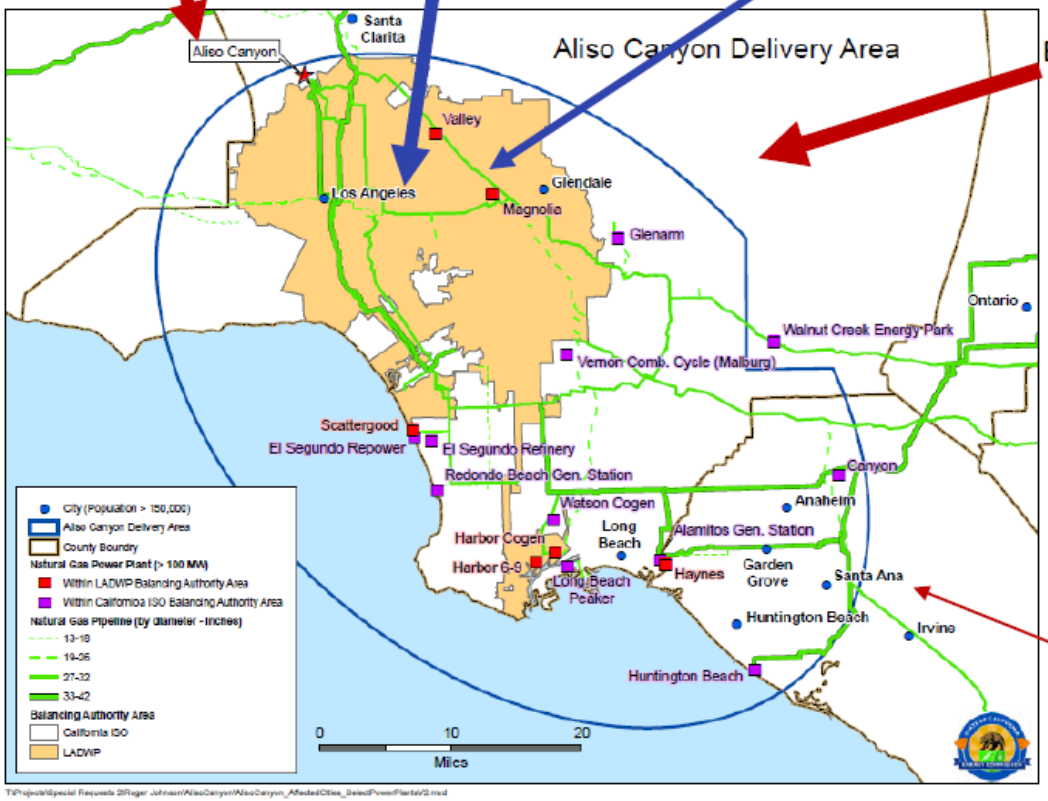
- Dual-fuel capable, no inventory
- Interruptible fuel, spot
- Single pipeline connection

- Not dual-fuel capable
- Interruptible fuel, spot
- Single pipeline connection

Higher individual reliability

Lower individual reliability

Aliso Canyon Out of Service and Resulting Electric Reliability Concerns



Potential Impacted Generation

LA Basin:

- 9,800 MW natural gas generation
- ~95% of total local capacity

Rest of Southern California:

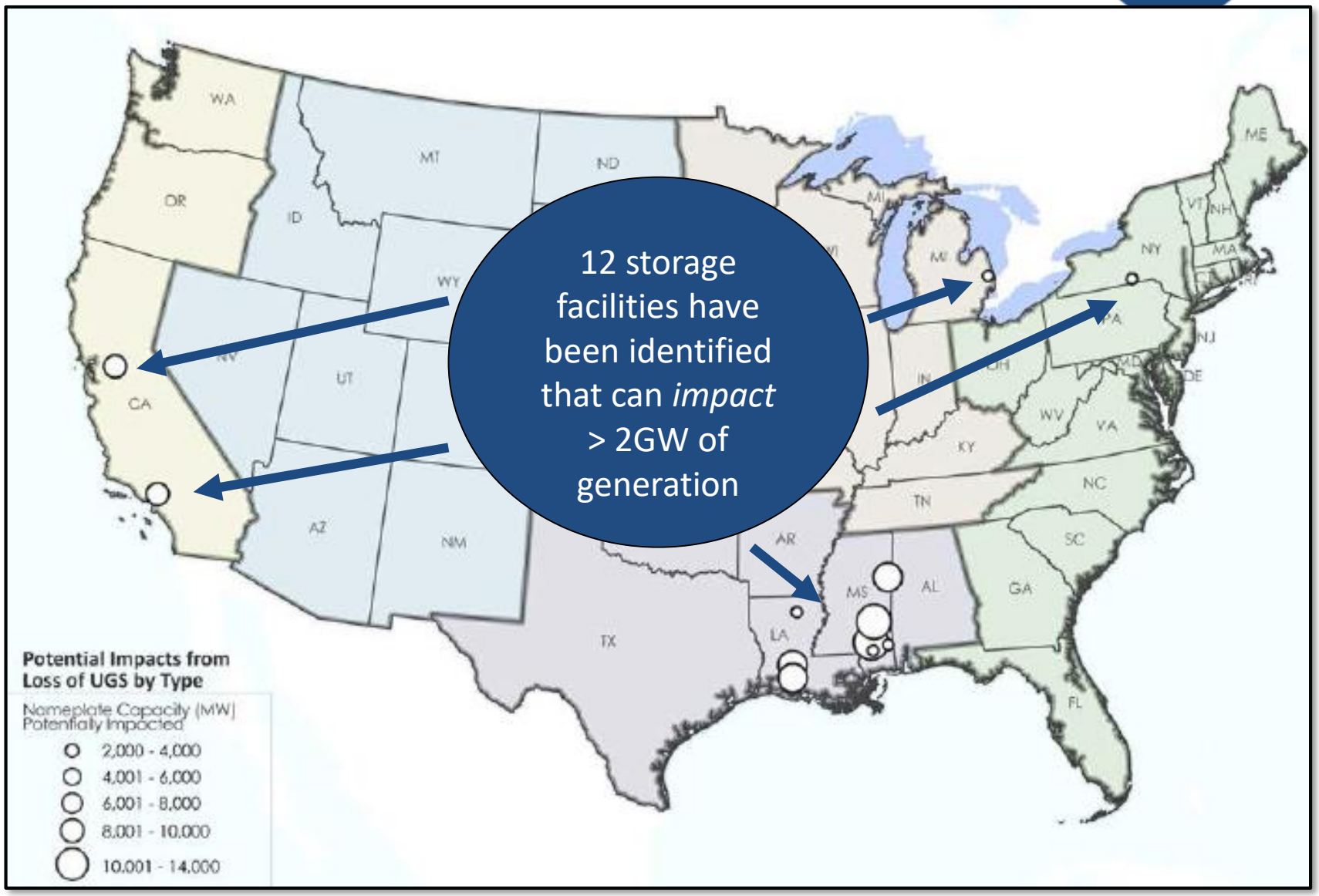
- >15,000 MW natural gas generation

Maximum Import Capacity

- 5,500 MW DC capacity
- 14,900 MW AC capacity
- 20,400 MW total*

* Typically limited to 17,000 - 18,000 MW

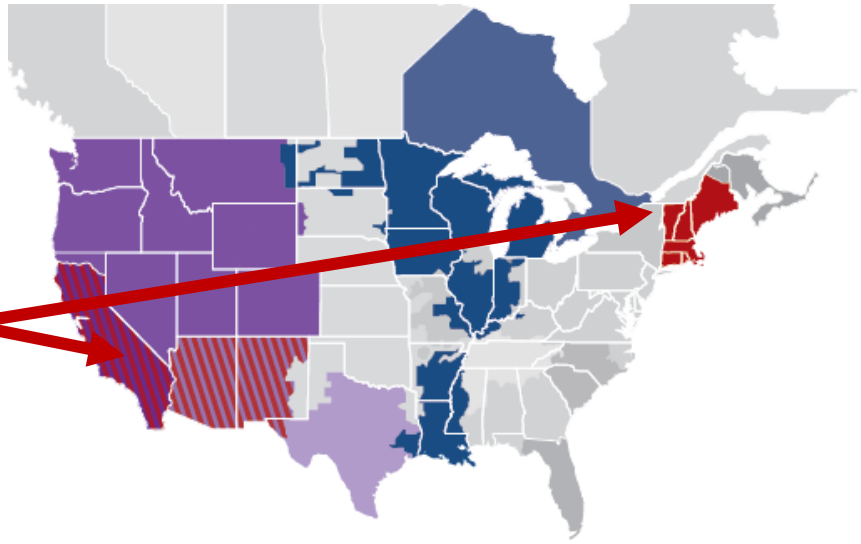
Storage Facilities



Fuel Assurance

Some areas are at risk of reliability impacts due to potential fuel supply issues

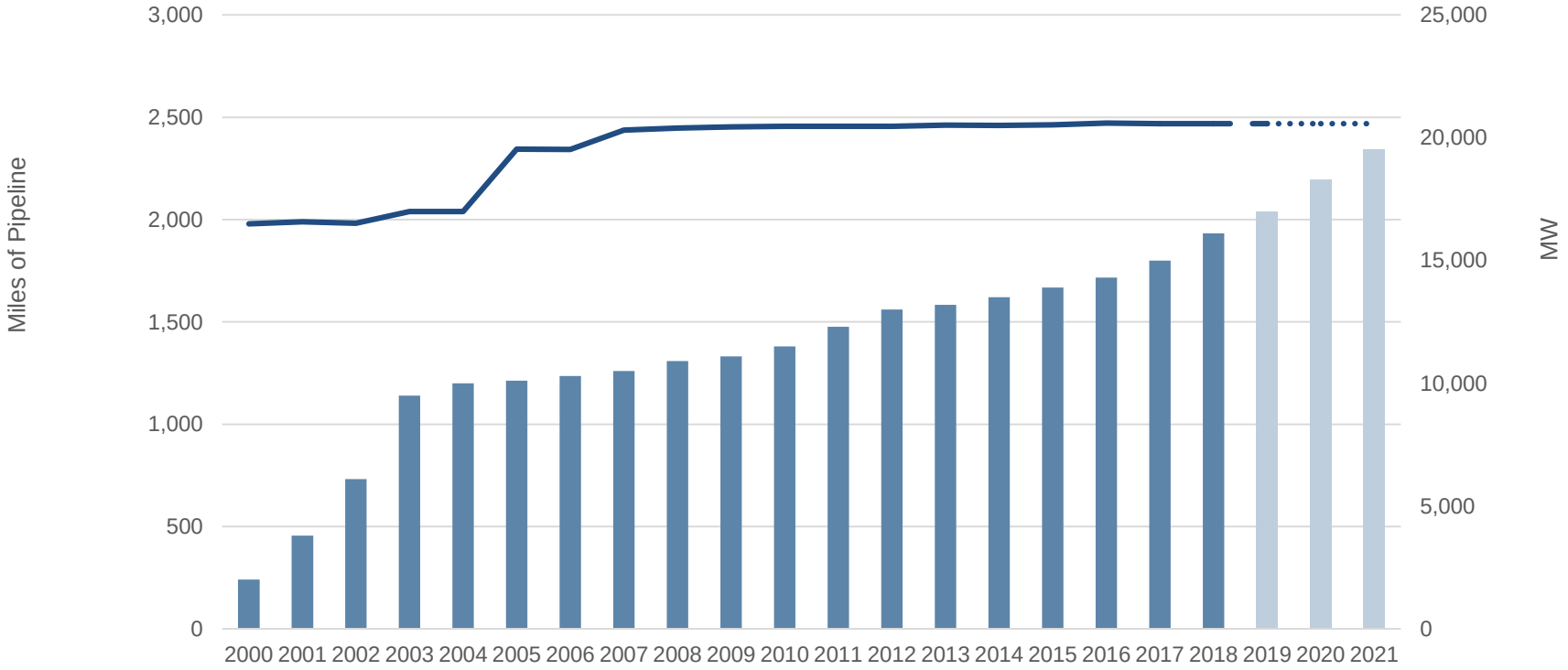
- **New England:** Extreme winter conditions can disrupt fuel
- **California and U.S. Southwest:** Fuel at risk from extreme events due to limited storage and supply infrastructure



- Fuel supply and transportation limitations can affect the ability of generation resources to deliver needed electricity

Gas Infrastructure vs. Gas Generation Build Out

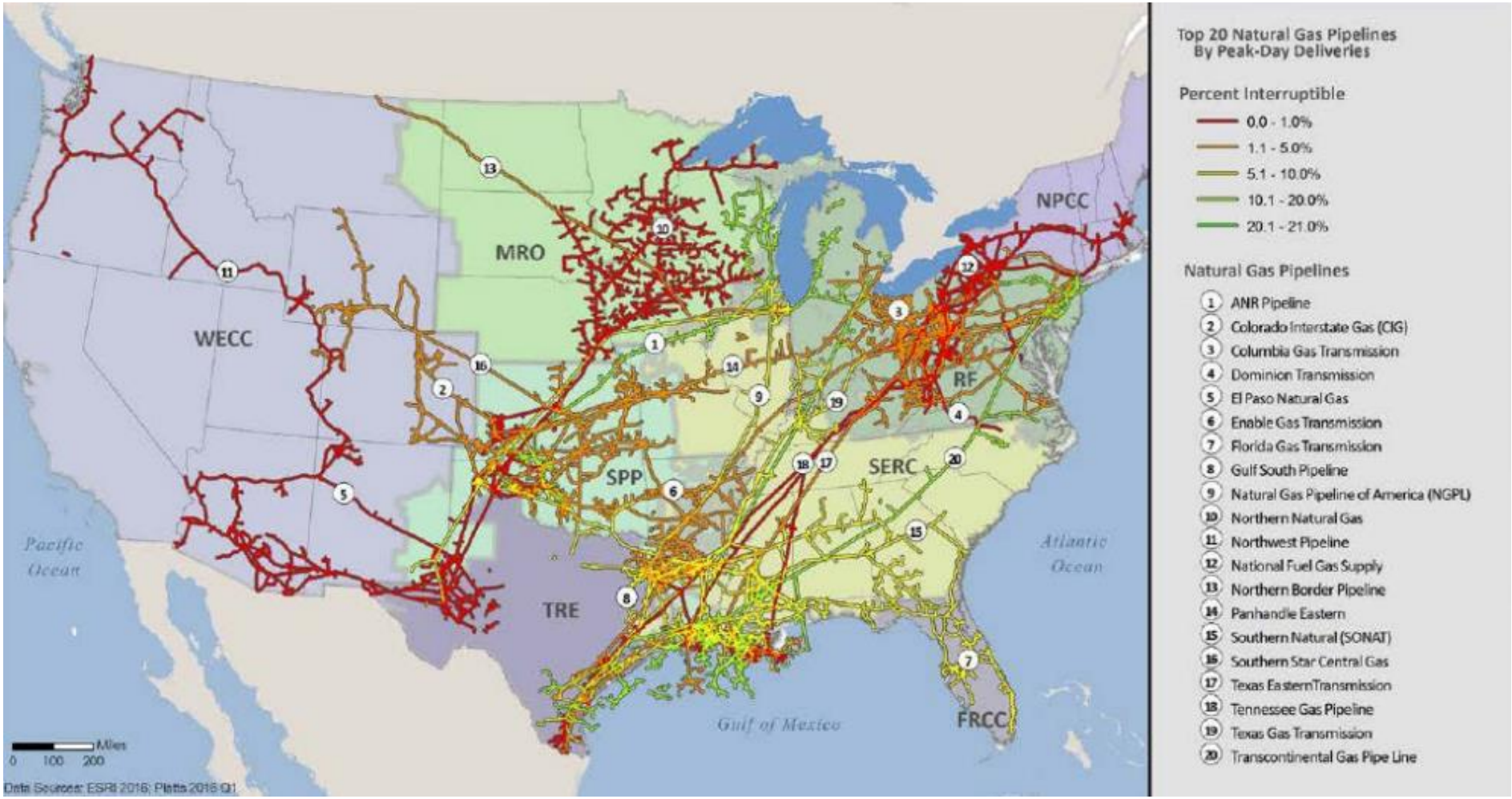
Gas-Fired Generation Outpaces Natural Gas Pipeline Expansion



Source: Velocity Suite, FERC Form 2 Page 514
State Breakout of Miles of Transmission Lines

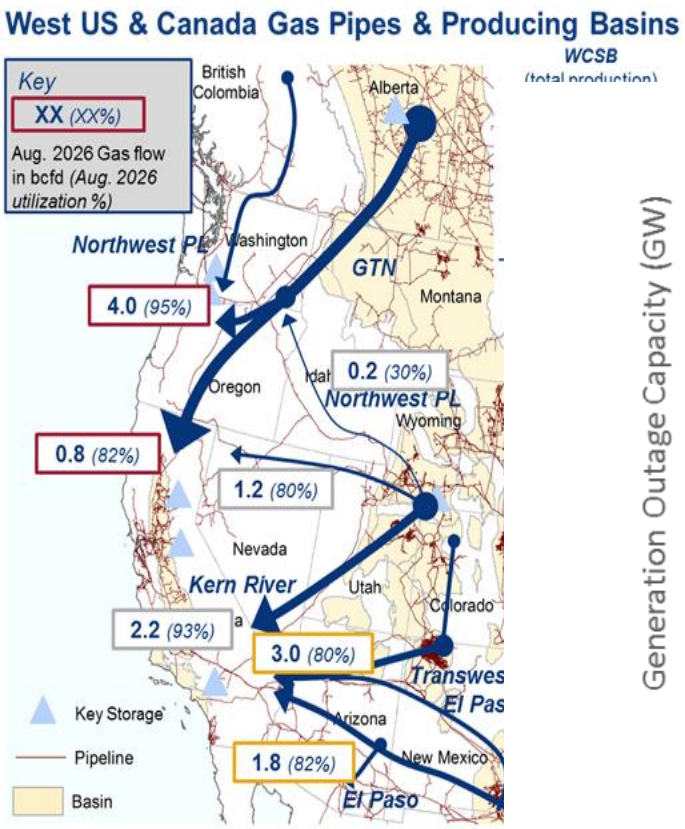
Top-20 Gas Pipelines by Peak-Day Delivery Arrangement

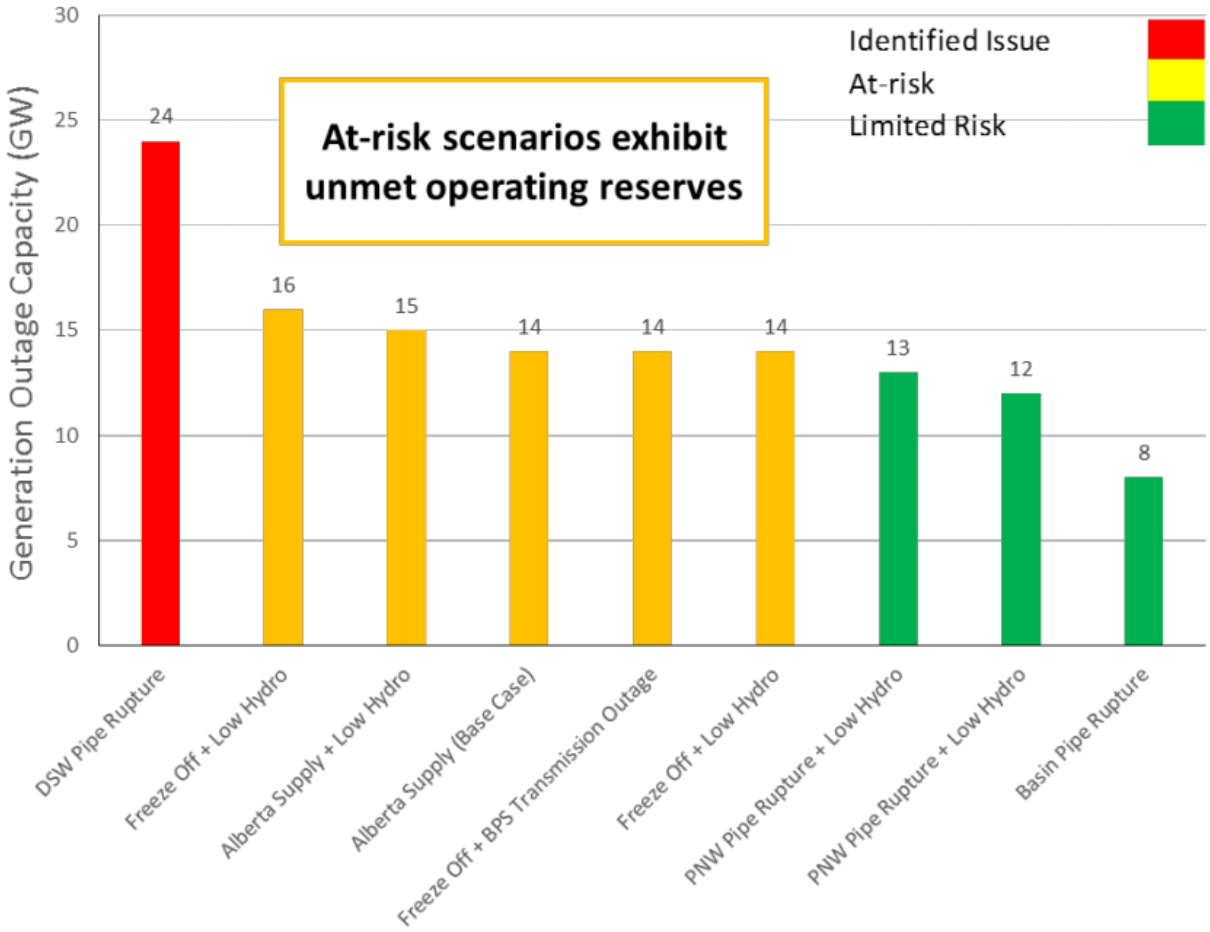
Red pipelines mean there were no interruptible flows on-peak



Source: ANL

Outage Risk Evaluations Helps Prioritize Mitigation Planning – Western Interconnection

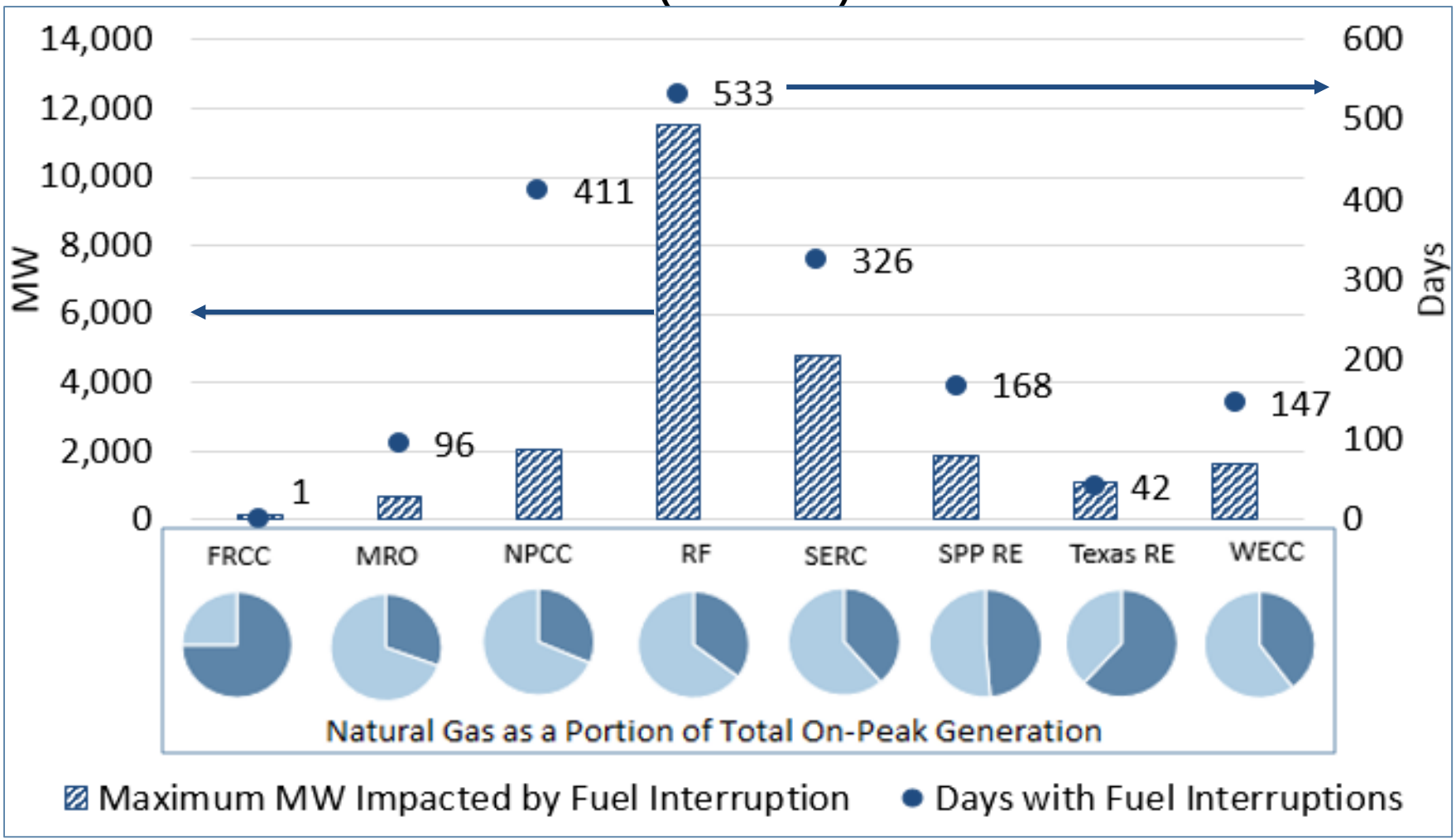




See the Western Interconnection Gas-Electric Interface Study:
https://www.wecc.org/Reliability/Western%20Interconnection%20Gas-Electric%20Interface%20Study%20Public%20Report.pdf

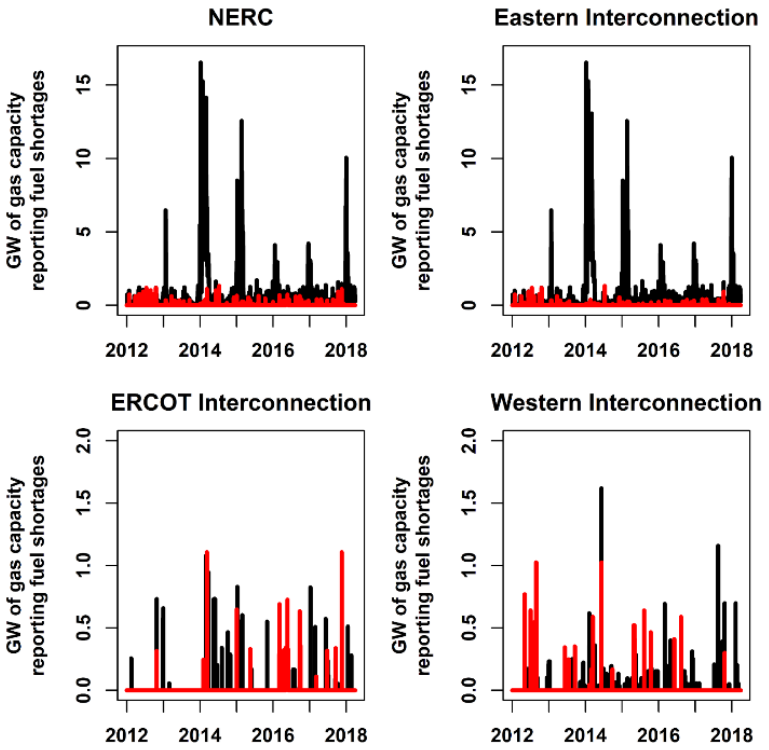
Long-Term Reliability Assessment Key Finding

Reported GADS Outages of Natural Gas Generation Due to "Lack of Fuel" (2012-2015)



Firm vs Non-Firm

Gas plants were affected by fuel shortages regardless of their pipeline contract statuses



- During some hours, firm contract plants made up all fuel shortages (firm is not a cure-all)
- In some regions, the peaks in the gas fuel shortage time series were sometimes mostly made up of capacity on firm pipeline contracts

Fuel shortages at gas plants with firm pipeline contracts

Fuel shortages at all gas plants (plot is overlaid by firm plot)

Source: G. Freeman

Pipeline Single Points of Disruption (Major "Trunk" Lines)

New England

Interstate Directly Connected*

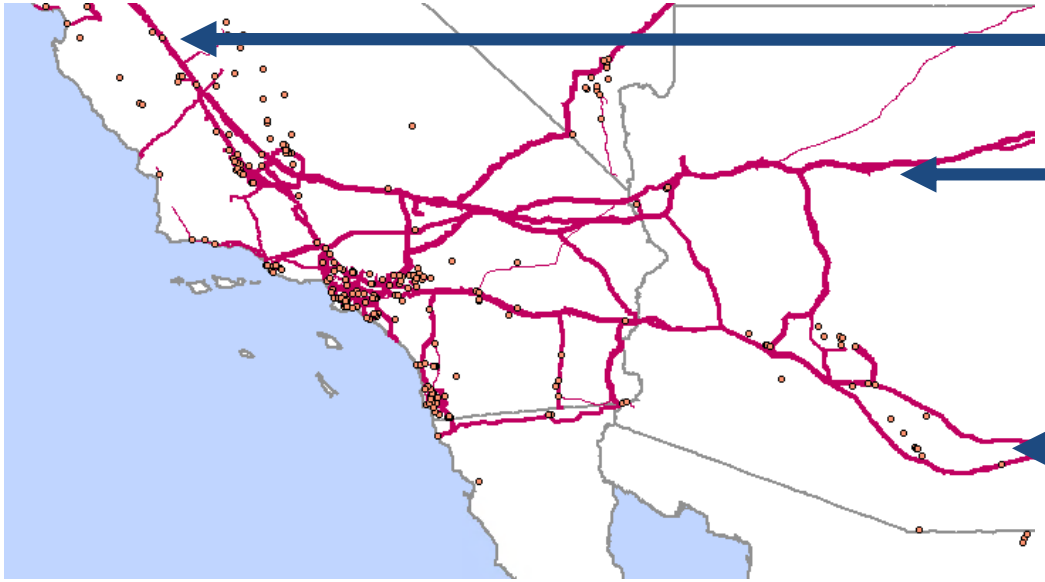
- Tennessee (3,221 MW)
- Algonquin (6,593 MW)
- Maritimes (2,356 MW)

LDC Directly Connected

2,330 MW

Source: EIPC, New England ISO

Pipeline Single Points of Disruption (Major "Trunk" Lines)



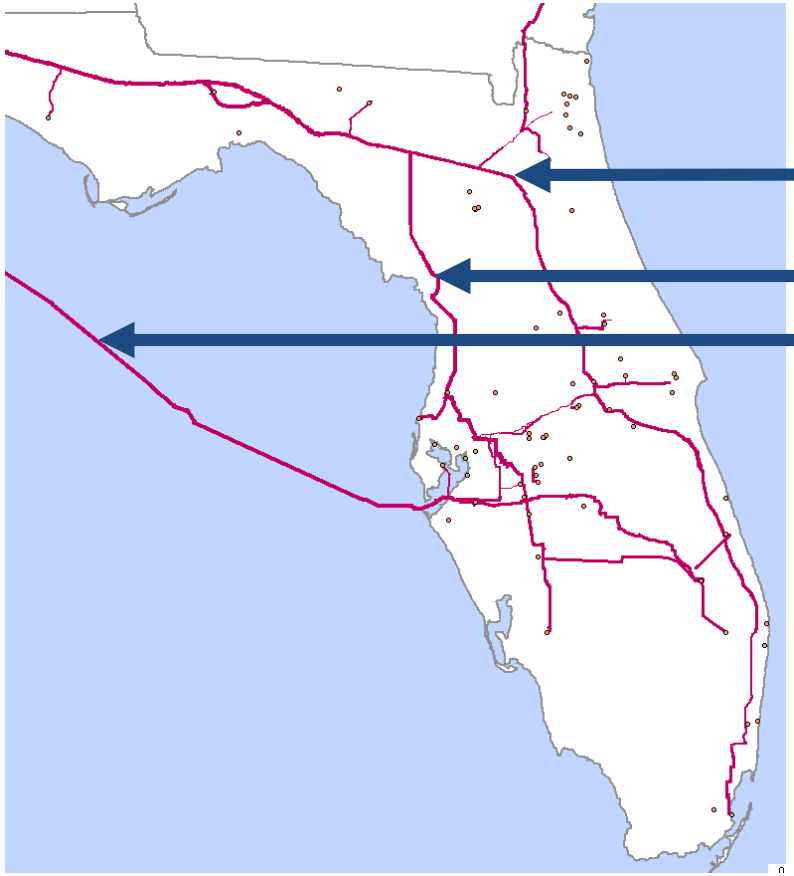
South CA-AZ

Interstate Directly Connected

- SoCal Gas
- PG&E
- El Paso

*most electric generation is directly connected to non-interstate LDC systems

Pipeline Single Points of Disruption (Major "Trunk" Lines)



Florida

Interstate Directly Connected

- Gulfstream
- Florida
- Sabal Trail

Solutions and Objectives for Ensuring Electric Reliability

- Maintain Fuel Security
  - Maintain fuel and resource diversity
  - Maintain firm fuel supply and transportation
  - Maintain dual-fuel capability
  - Maintain on-site fuel back-up inventory
- Resiliency Planning for Large Disruptions
  - Evaluate largest/multiple facility outages regardless of likelihood
  - State and Electric (e.g, ISO/RTO, local utility) partnerships
  - Incentives and rules in market areas
  - Security and risk assessment
- Enhance Situational Awareness
  - System operator intelligence on fuel inventories, contracts, shipments
  - Coordination with pipeline operators

WEATHER | WINTER STORM
FREEZING FIASCO
The Washington Post
Democracy Dies in Darkness
WEDNESDAY, FEBRUARY 17, 2021
Millions in grip of Arctic freeze
OVER A DOZEN DEAD; EXTENSIVE OUTAGES
Much of hard-hit South to see more snow, cold
Bitter cold, ice, snow paralyze half of USA
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Blackouts controversy hea
Abbott, lawmakers vent anger at grid operator after snowstorm
The Dallas Morning News
Dallas, Texas, Monday, February 15, 2021
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Texas Power Grid
Nxxx,2021-02-17,A,001,Bs-4C,E1
The New York Times
NEW YORK, WEDNESDAY, FEBRUARY 17, 2021
Bitter Cold, Stretching From Canada to the Rio Grande
Low temperatures below 0°F
Between 0° and 32°F
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WINTER STORM SLAMS TEXAS
FAILURES OF POWER

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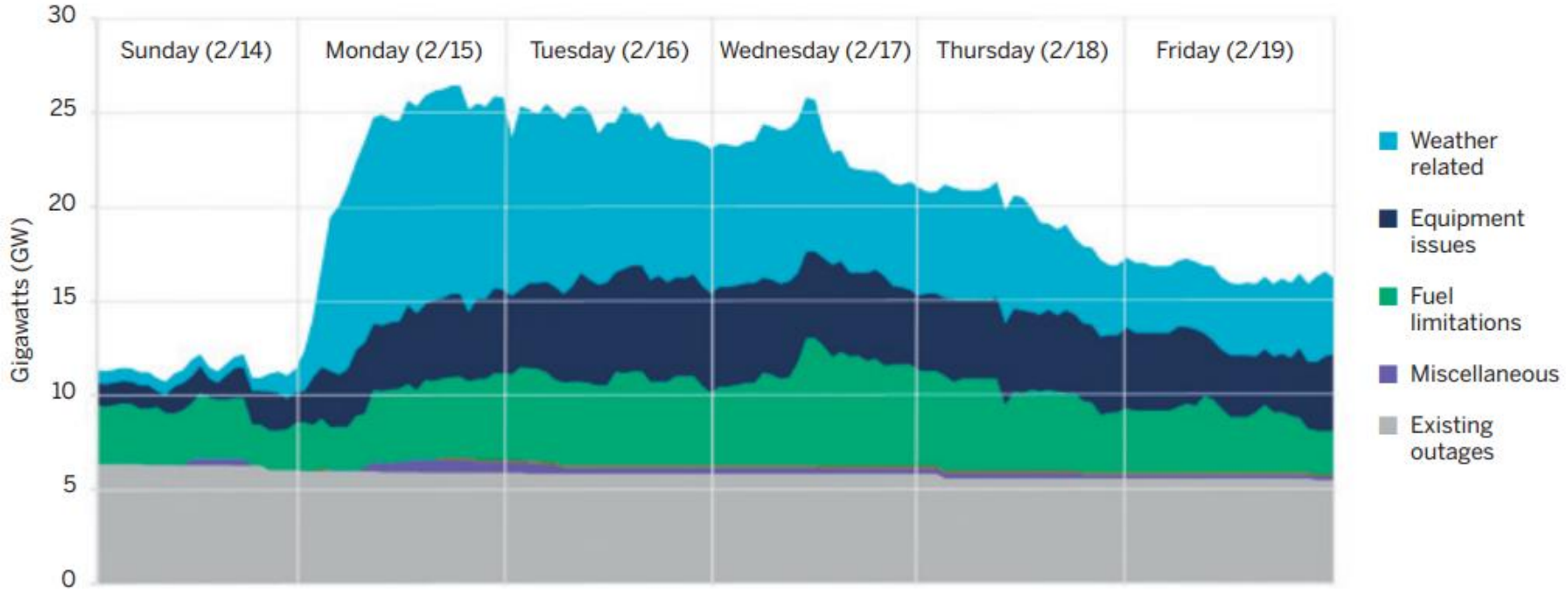
More Widespread than Texas

- Texas - ERCOT
  - Total load shed 20,000 MW at peak
  - Load shed request duration: 70.5 hours
  - Customer outage across Texas: 3.7M
  - Lowest Frequency: 59.3 Hz
  - Installed capacity out of service: 52,277 MW
    - Natural Gas generation offline: 26,000 MW
    - Wind generation offline due to icing: 14,000 MW
- Midwest to Louisiana - MISO
  - Load shed: 1,430 MW
  - Installed capacity out of service: 59,000 MW
- Dakotas to Southern Plains - SPP
  - Load shed: 3,443 MW
  - Installed capacity out of service: 25,000 MW

**Additional load shedding in Northern parts of Mexico due to natural gas shortage*

Texas: Generation Out of Service by Fuel Type

Correlated Outages for Natural Gas Generators by Cause During the ERCOT February 2021 Event

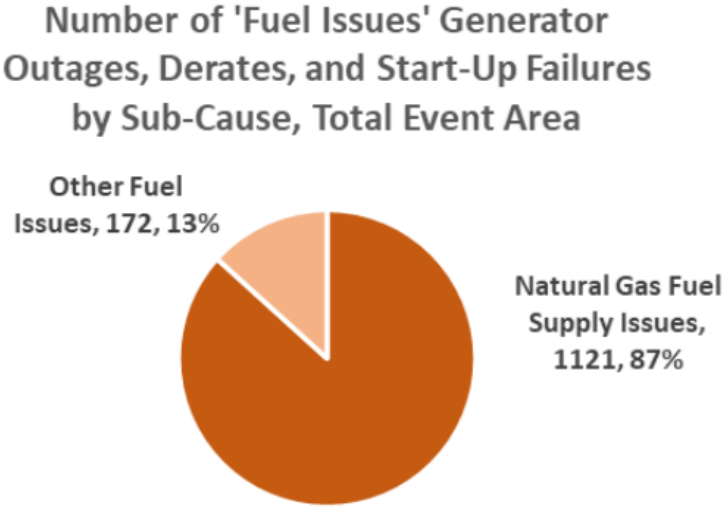


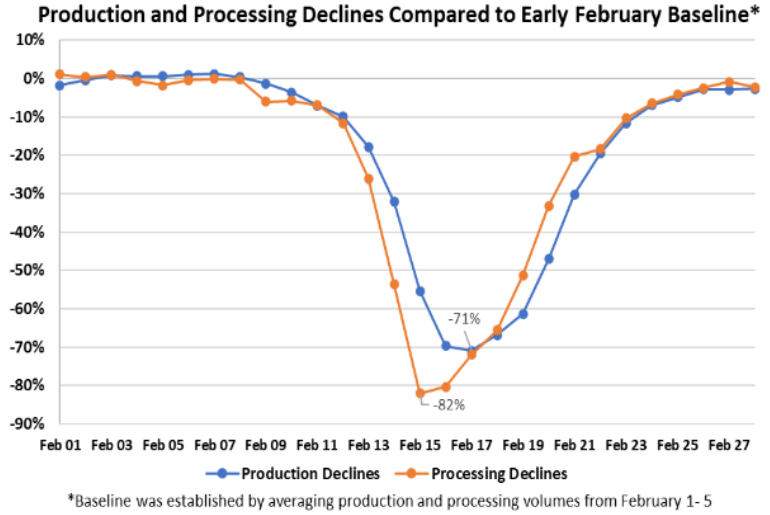
Note: Extreme cold temperatures began on Monday morning.

Source: Electric Reliability Council of Texas (2020c).

Interdependency in Action

- Out of all outages and derates caused by Fuel Issues, 87% were natural gas fuel supply issues.
- Most natural gas production not identified as critical load
- As a result, firm load shed contributed to the decline in production of natural gas.





Initial Lessons Learned and Findings

- Generation winterization challenges (primarily wind and natural gas), as well as natural gas infrastructure
- Demand forecasting and growth assumptions
- Load shedding impacted natural gas compressor and well-head operations, impacting natural gas generation
- Review of load shedding schemes
- Identifying energy limitations in the context of extreme weather and fuel availability
- Market refinements

Recommendations Regulators and Policy Makers

- Regulators and Policy Makers
  - Dual-fuel capability, emergency plans, air permits
  - Cyber and physical security
  - Fuel assurance, natural gas infrastructure built into long-term resource plans, policies
- Industry
  - Scenario analysis of extreme events
  - Dual-fuel testing and preparation can be improved
  - Reliability signals in markets reflecting the risk of gas supply disruptions
- NERC
  - Review Reliability Standards
  - Develop planning guidance

Key Risk Functional Areas

Four high level risk profiles:

Grid Transformation

A. Bulk Power System Planning

B. Resource Adequacy and Performance

C. Increased Complexity in Protection and Control Systems

D. Situational Awareness Challenges

E. Human Performance and Skilled Workforce

F. Changing Resource Mix

Extreme Natural Events

A. Extreme Natural Events, Widespread Impact

- GMD

B. Other Extreme Natural Events

Security Risks

A. Physical

B. Cyber

C. Electromagnetic Pulse

Critical Infrastructure Interdependencies

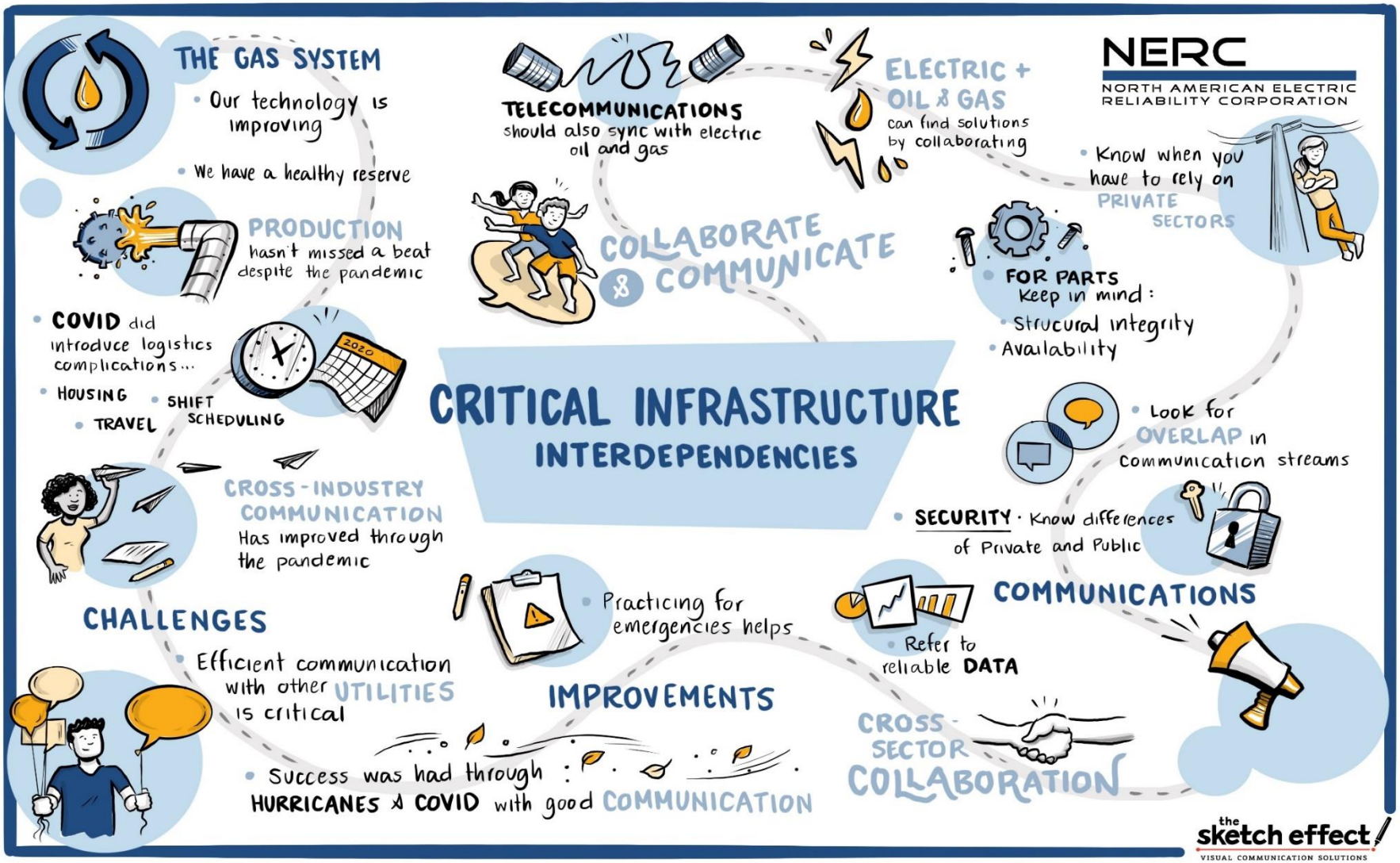
A. Communications

B. Water/Wastewater

C. Oil

D. Natural Gas

Critical Infrastructure Interdependencies

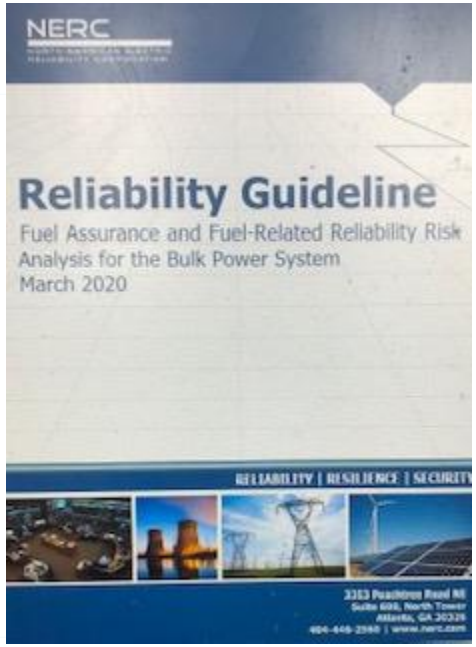


Electric Gas Working Group (EGWG)

- Develop Guidelines and white papers
- Provide assistance to NERC Event Analysis where fuel disruptions are involved
- Recommendations for the development of tools/guides to enhance operational awareness of fuel related information
- Provide support in the development of metrics related to fuel assurance risk for the SOR
- Support the development of data collection requirements for fuel related issues for the LTRA

Fuel Assurance Reliability Guideline

- Definition of Fuel Assurance
- Fuel Supply Primer
- Analysis Considerations
- Risk Analysis Framework



https://www.nerc.com/comm/RSTC/EGWG/RG-Fuel_Assurance_Fuel-Related_Reliability_Risk_Analysis_BPS.pdf

Questions and Answers