NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

A Changing Risk Environment Requires Extraordinary Action

A Bulk Power System Reliability Perspective

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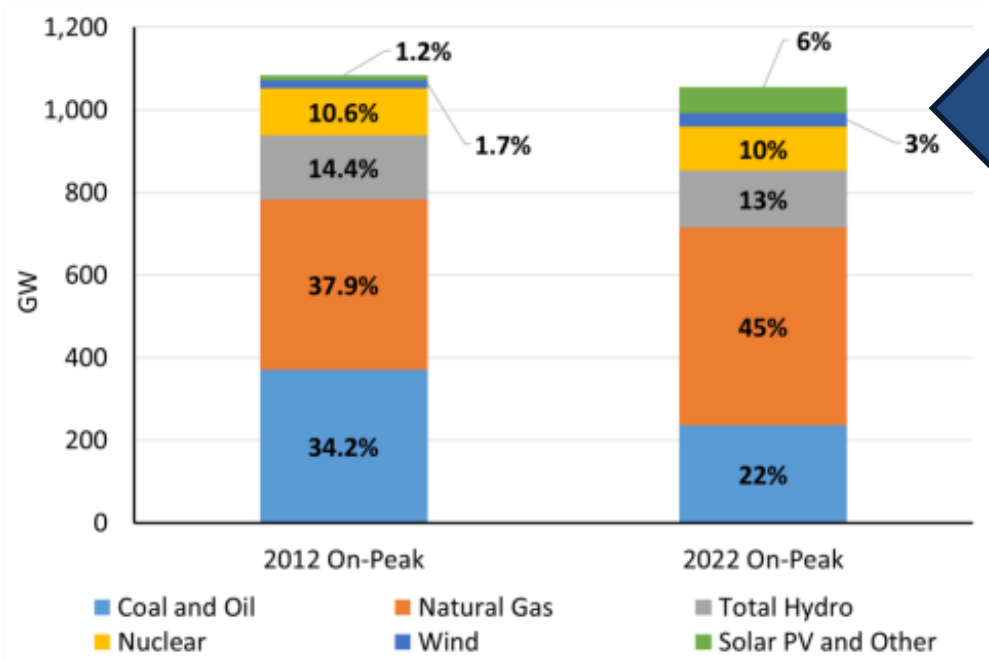
The Kleinman Center for Energy Policy: Wholesale Power Markets, Reliability, and the Energy Transition

November 8, 2023

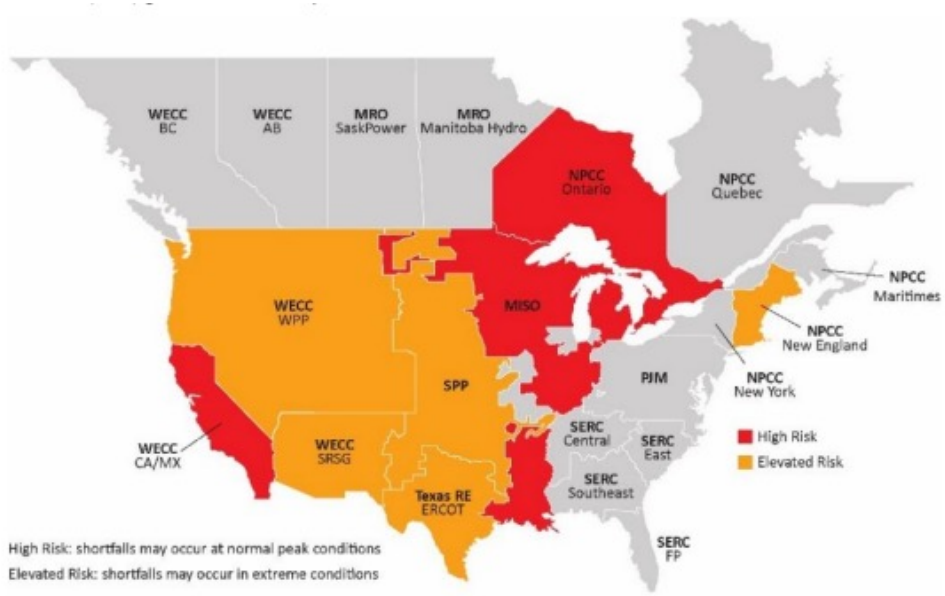
Across an Interconnected System: Less Resources Means More Reliance on Neighbors

2012 and 2022 Peak Capacity Resource Mix NERC-Wide

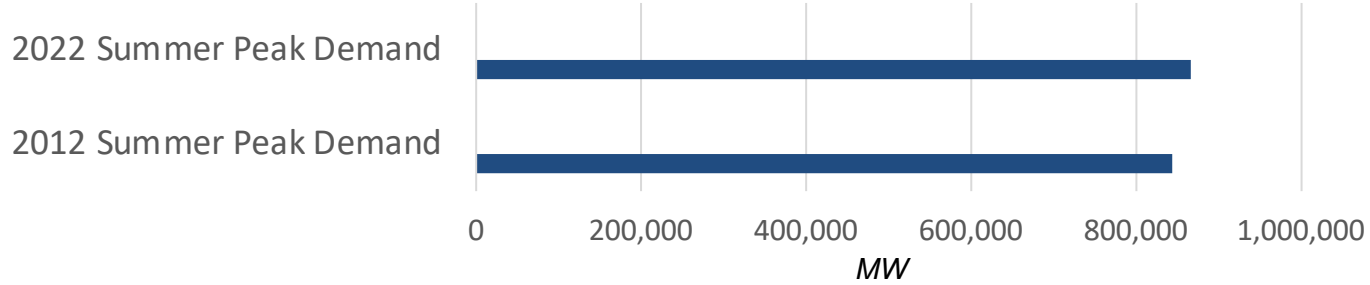


4% Decrease

2025 Risk Areas



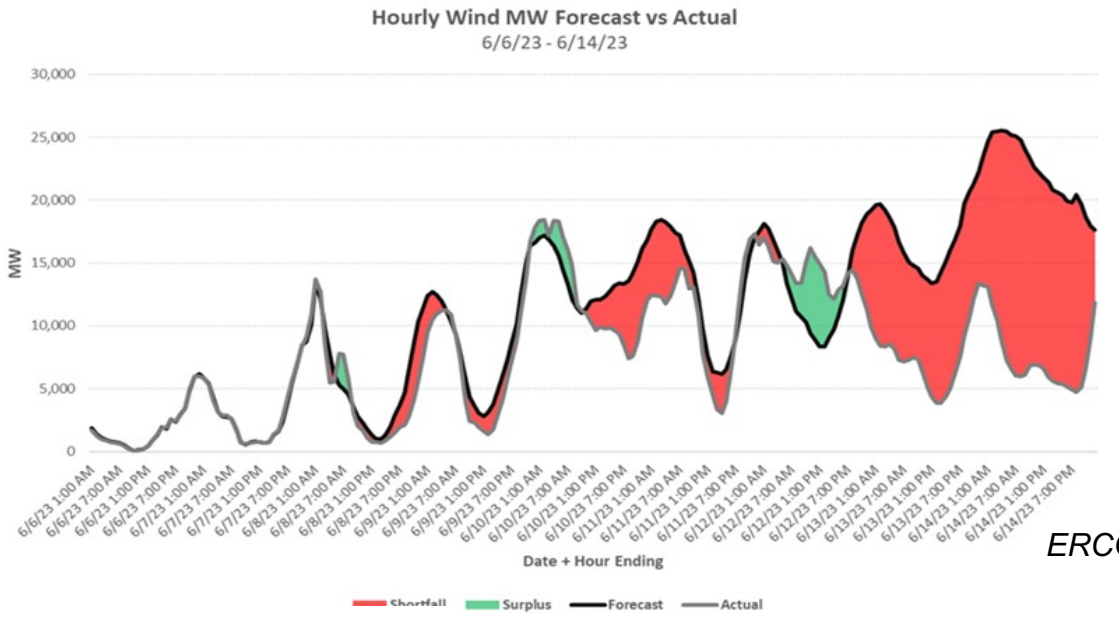
NERC-Wide Summer Peak Demand Changes 2012 and 2022



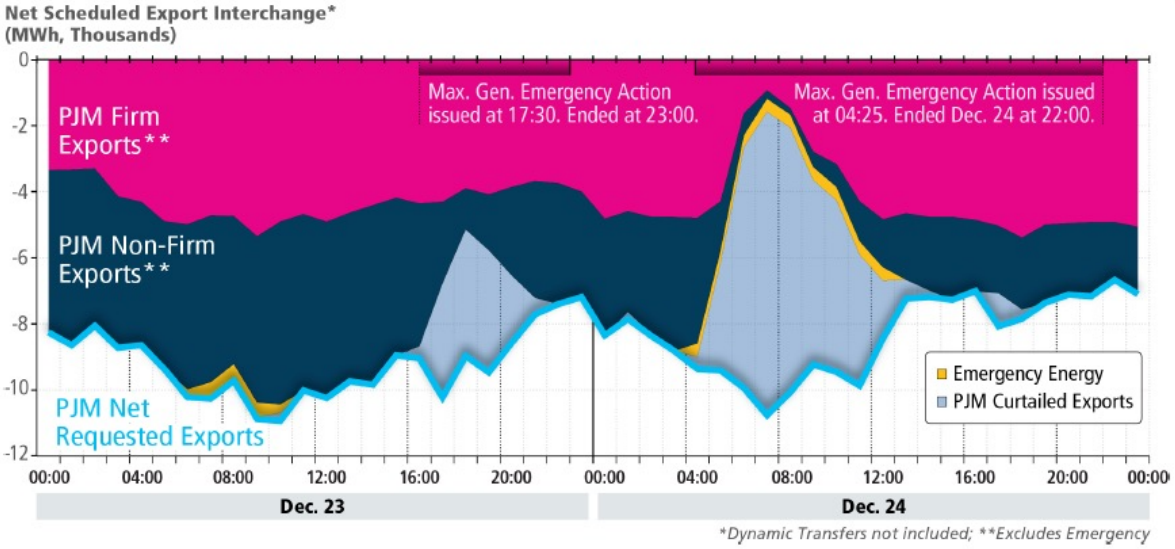
3% Increase

Recent Examples Highlight Need for Wide-Area Energy Assessments

ERCOT, SPP, MISO: *A "wind drought" caused 60 GW of installed wind capacity to generate 300 MW*

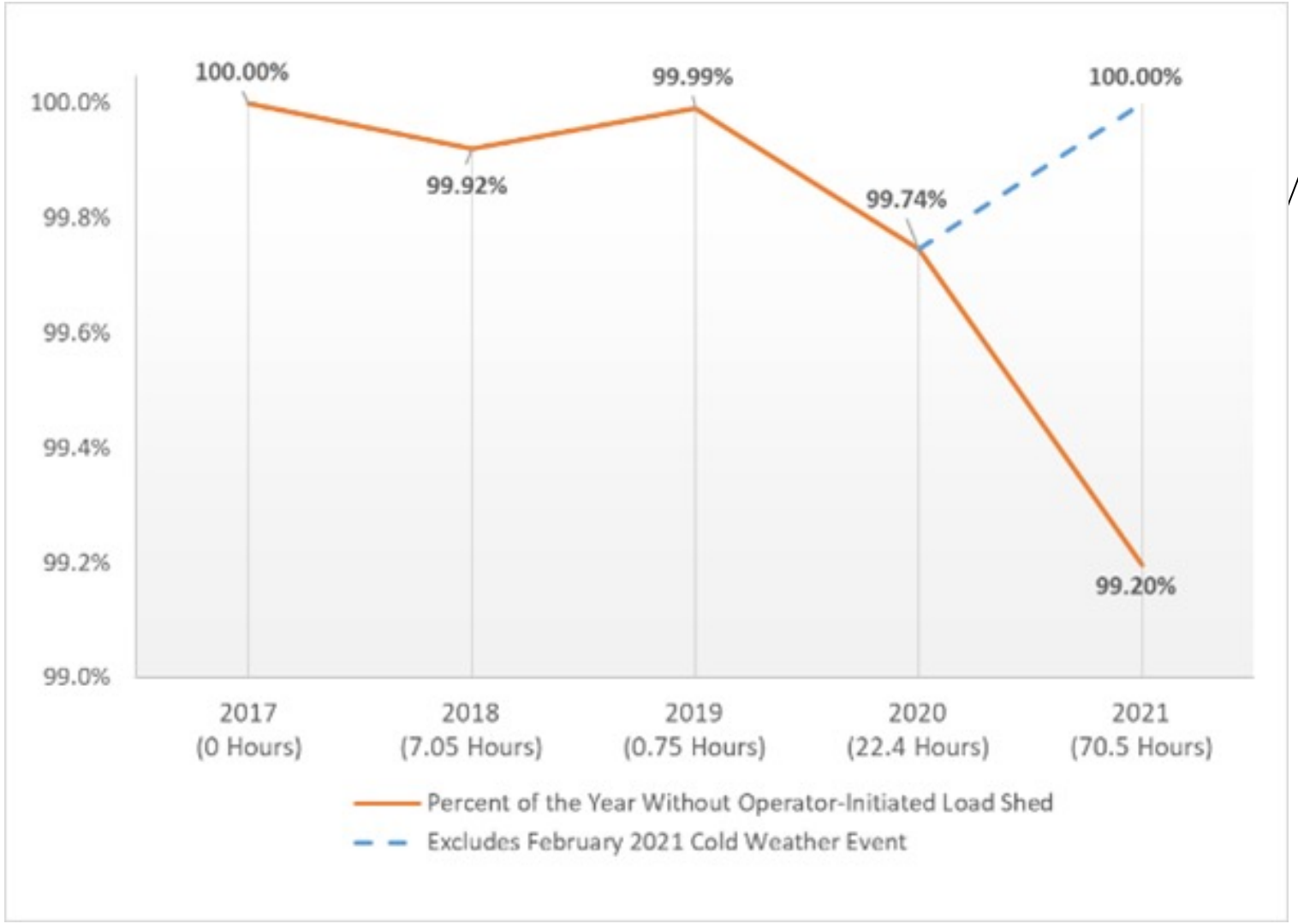


ERCOT



PJM: *Transmission system during extreme cold weather limited the ability to export to support southern neighbors*

Hours Without Operator-Initiated Firm Load Shed (%/year)



2021

- *10 EEA-3 Alerts*
- *1,015 GWh unserved energy*
- *Occurred February*

Winter Storm Elliot Wide-Area Inquiry Nearing Completion: Preliminary Results

Similarities to Past Extreme Cold Weather Events

	2011 Event	2014 Event	2018 Event	2021 Event	2022 Event
Significant levels of incremental unplanned electric generating unit losses with top causes found to be mechanical/electrical, freezing, and fuel issues.	✓	✓	✓	✓	✓
Significant natural gas production decreases occurred, with some areas of the country more severely affected.	✓			✓	✓
Short-range forecasts of peak electricity demands were less than actual demands for some BAs in event area	✓		✓	✓	✓

Hyper Complex Risk Environment

Rapidly Changing Resource Mix

- Retirements of traditional generation
- Natural gas interdependencies
- Inverter-Based Resource (IBR) integration
- DER performance and visibility

Extreme Weather Complexities

- Extreme not infrequent
- Broader deeper longer

Energy & Environmental Policy

- Electrification
- Emissions
- Transmission

Rapidly Evolving Threat Landscape

- S/W vulnerabilities
- Supply chain
- Ransomware
- Physical attacks

Hyper Complex Risk Environment Results in Increased BPS Reliability Risk

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Fuel assurance/uncertainties

- Natural gas
- Renewables

Loss of key "essential reliability services" with retirements

- Inertia/frequency response
- Reactive Power/voltage support
- Dispatchability

Appropriate level of investment in infrastructure for hardening & resilience

- Extreme weather
- Coordinated Physical attack
- Insufficient transfers

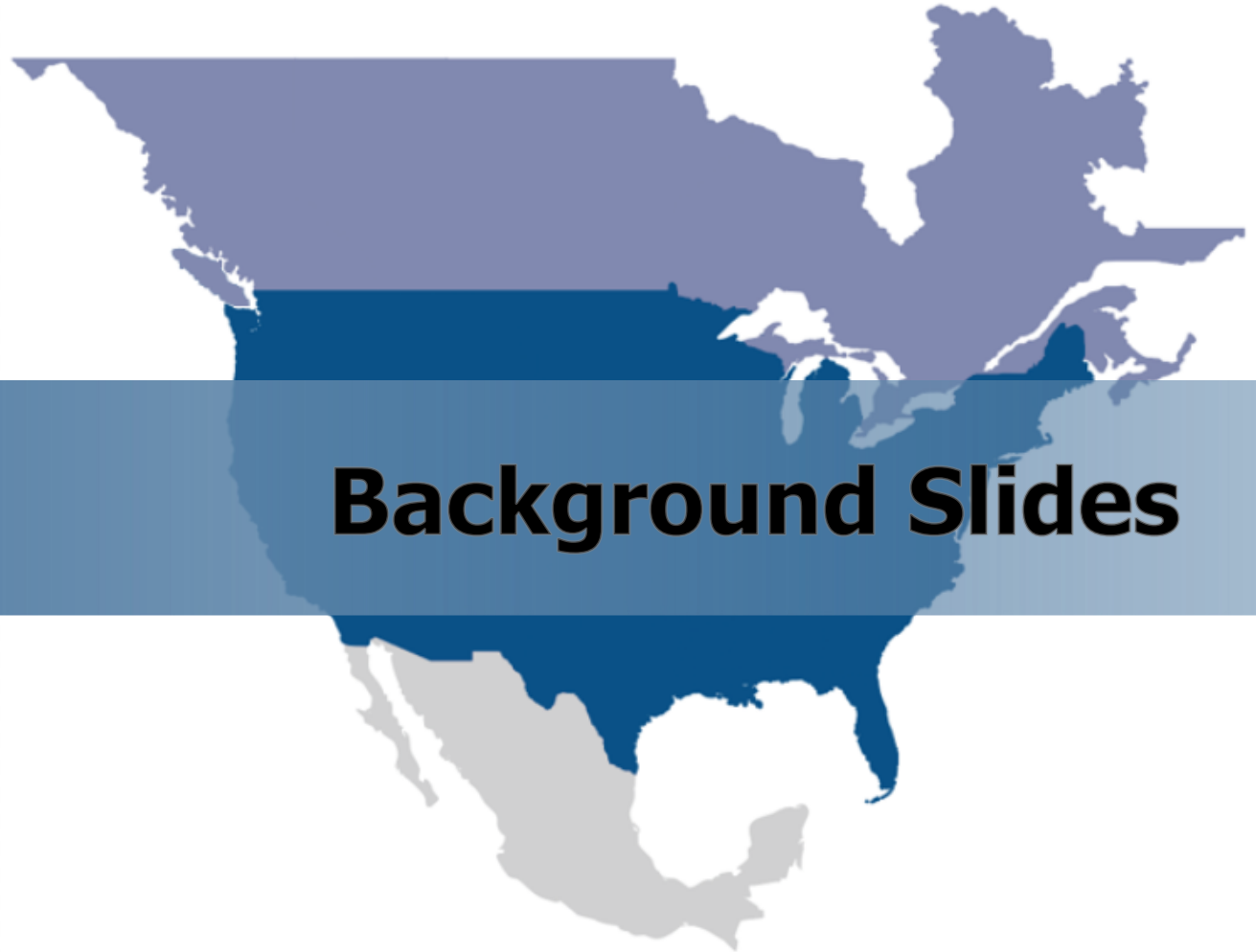
Expanding cyber attack surface

- Industry Control Systems (ICSs)
- IBRs/DERs/EV Charging

Sophistication of recent cyber attacks

- SolarWinds (one to many)
- Pipedream, Industroyer malware

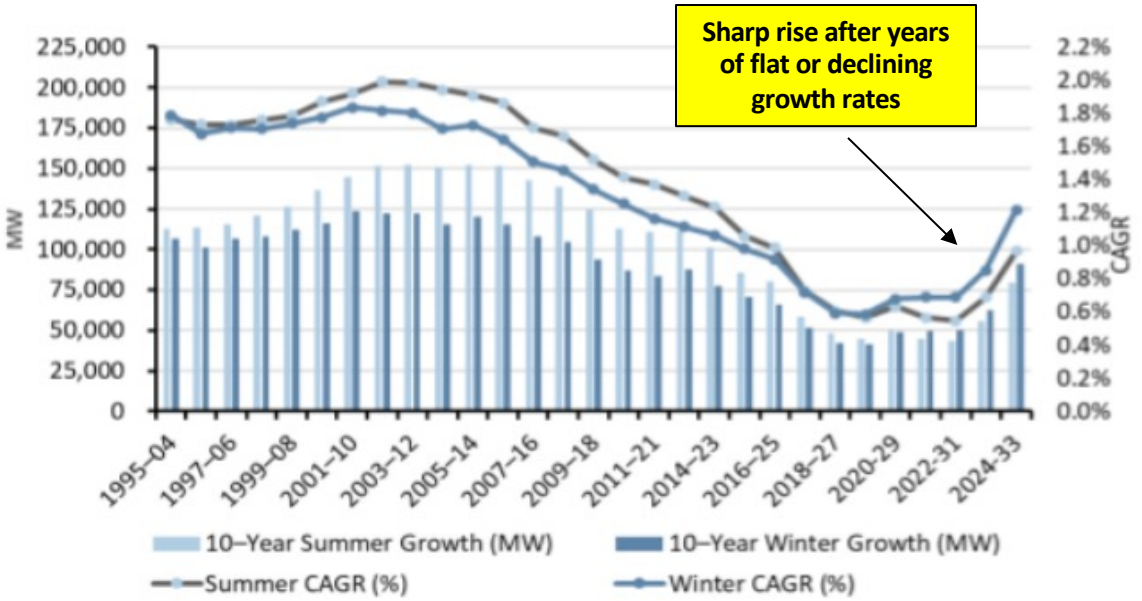
Q&A -- Discussion



Background Slides

Peak Demand and Energy: Electrification Growth Across North America

- 10-year Peak Demand and Energy growth showed largest increases in years
  - Further increases from electrification and EV adoption are anticipated
- Peak demand growth is accelerating – Growth rate doubled in last two years
- **Growth in some areas is affecting adequacy of reserves and seasonal energy risks**

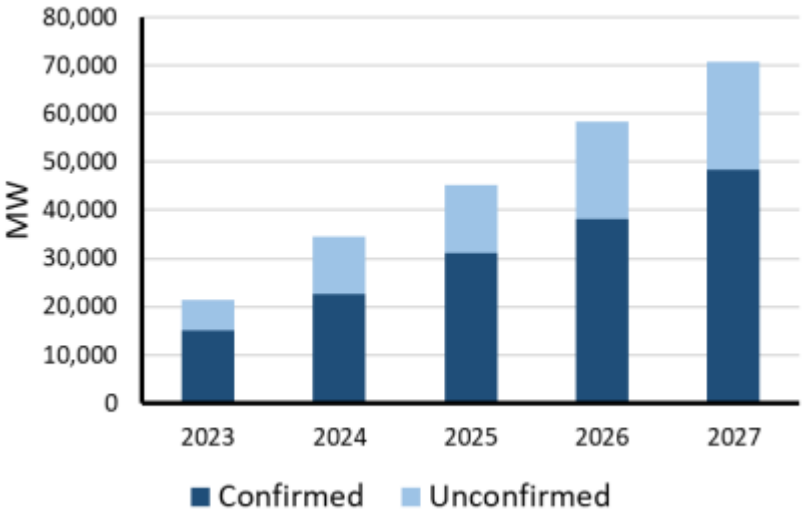


2022 LTRA 10-year Summer and Winter Peak Demand Growth

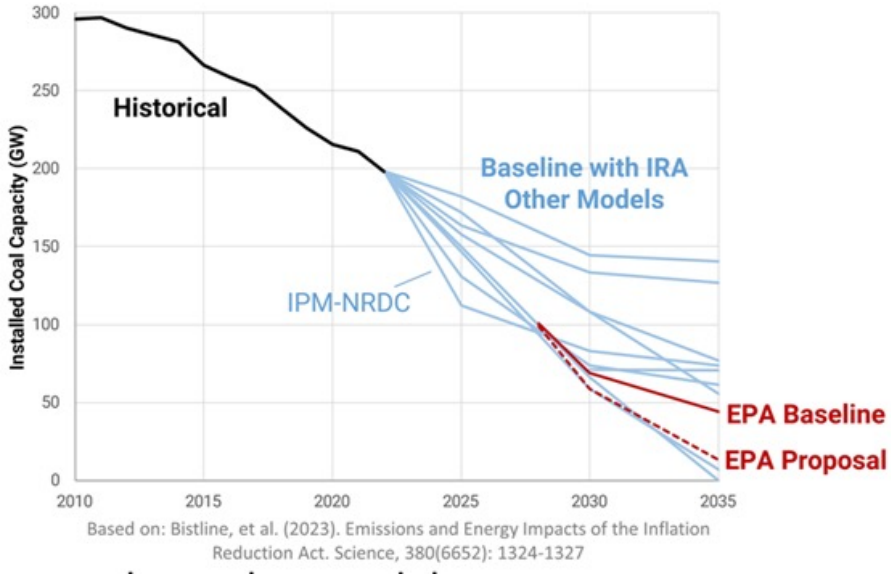
Largest 10-year Winter Peak Demand Growth		Largest 10-year Summer Peak Demand Growth	
Assessment Area	Demand Change	Assessment Area	Demand Change
NPCC-New York	2.36%	WECC-SRSG	1.69%
WECC-SRSG	2.06%	NPCC-Ontario	1.27%
NPCC-New England	1.95%	WECC-CAMX	1.19%
NPCC-Ontario	1.32%	MRO-SaskPower	1.05%
Texas RE-ERCOT	1.30%	NPCC-Maritimes	1.03%

Managing the Pace of Generator Retirements

- Known generator retirements totaling over 110 GW
- New and proposed U.S. EPA regulations are expected to further accelerate retirements
- **2023 Long-Term Reliability Assessment will consider updated retirement information and scenarios for assessing future resource adequacy and reliability risks**



2022 NERC LTRA



2023 EPRI

Capacity and Energy Risk Assessment

Ontario

- Reserve Margins below target in 2025
- Planned retirements and nuclear work

MISO

- Reserve Margins below target in 2023
- 5,700 MW of thermal generation retirements since 2022

California-Mexico

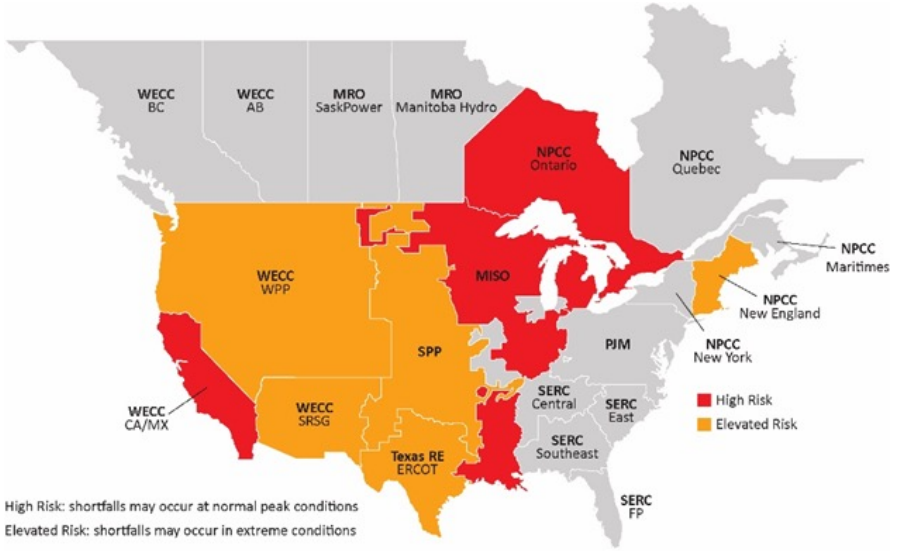
- Load loss hours anticipated due to variable resource mix and demand
- Improving trend in metrics with recent capacity additions

U.S. West

- Unserved energy projections are increasing in summer months

New England

- Fuel risk in extended cold weather



ERCOT

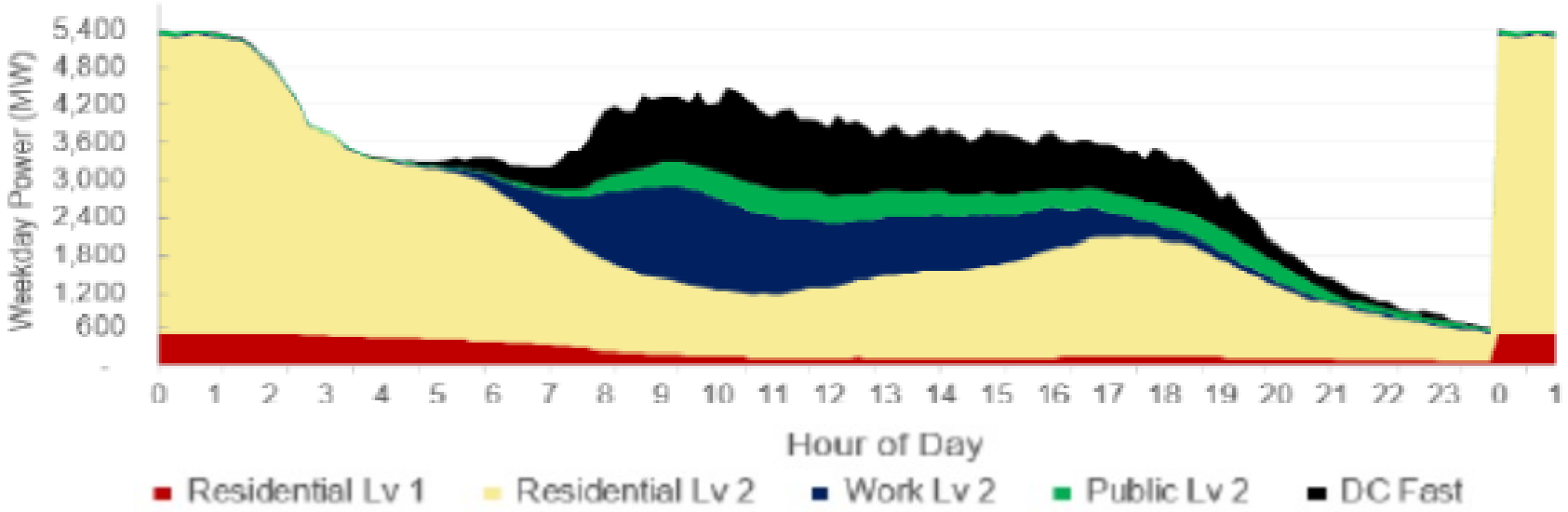
- Energy risk shifts to winter due to potential impacts of extreme weather

SPP

- Energy shortfalls likely during low-wind and high demand periods

EV Charging Assessment - CAISO

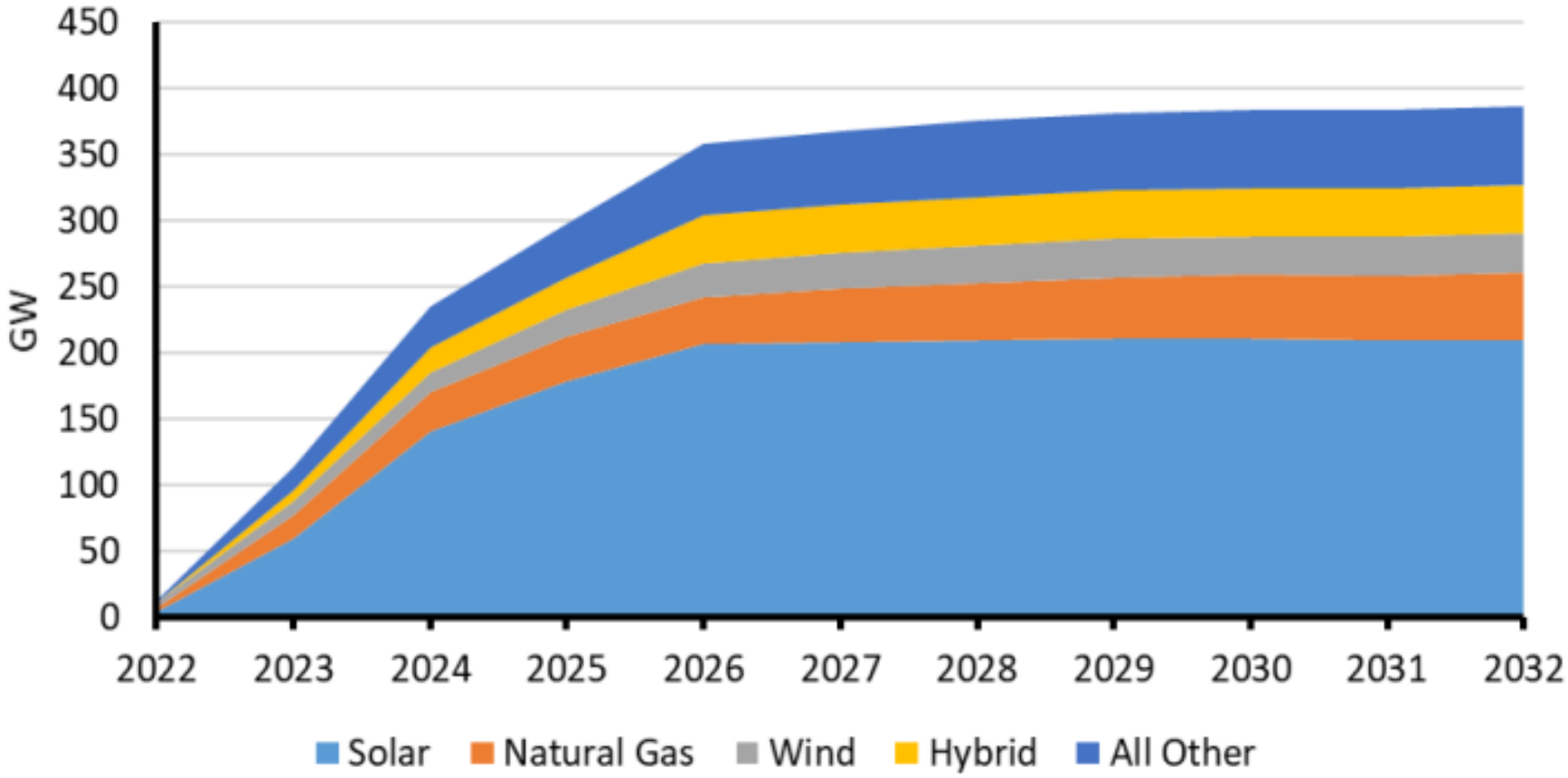
- **Executive Order N-79-20:** By 2035, 100 percent EV sales
- Charging millions of EVs will introduce significant new electric load
- By one estimate, up to 5,500 MW
- Early alignment and coordination needed



Projected 2030 Statewide PEV Charging Load for Intraregional Travel of 8 Million Light-Duty EVs

AB 2127 Report: https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127

On-Peak Resource Mix Changes through 2032



A Changing Context for the BPS

Must Wins:

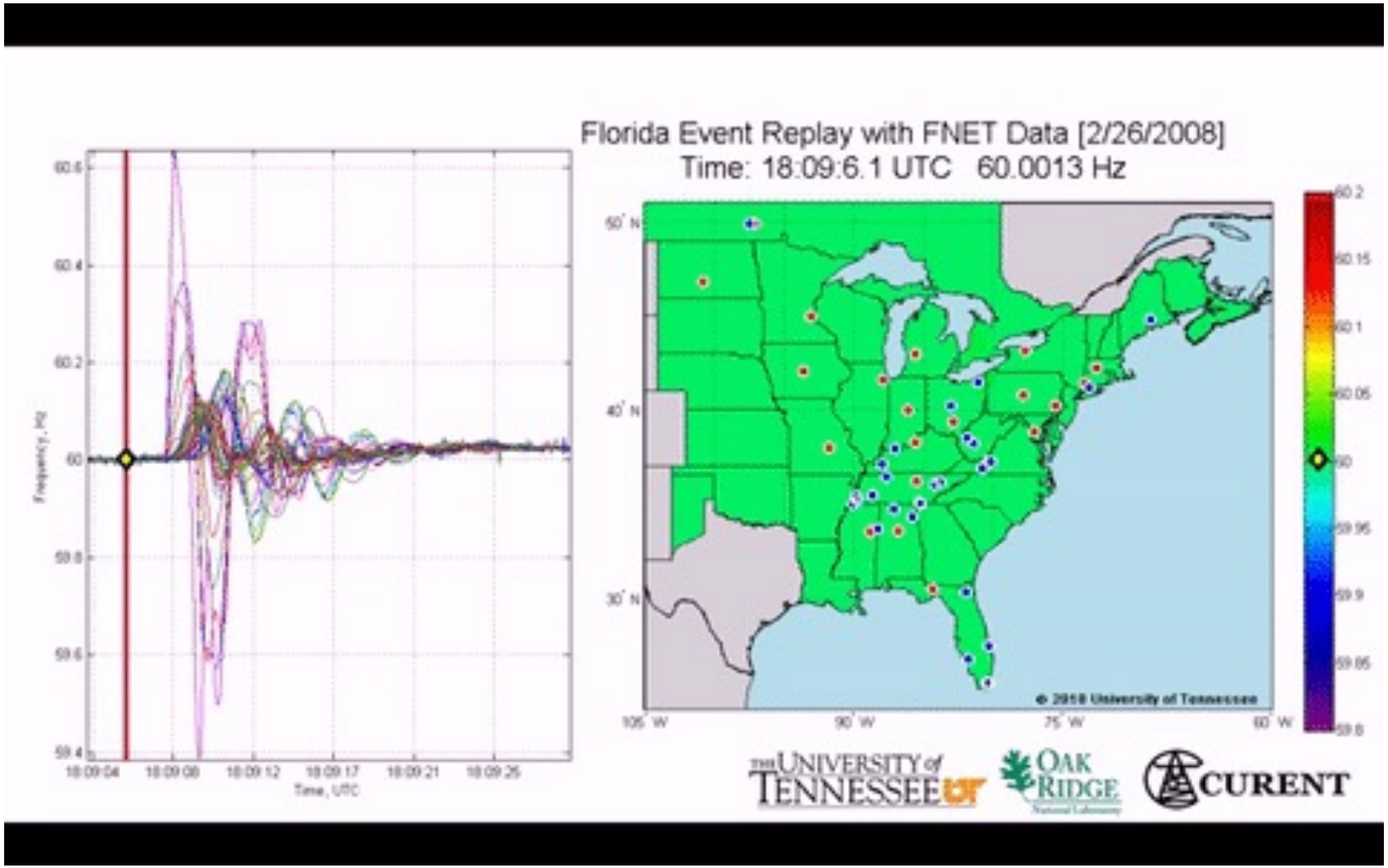
1. **Manage the pace of transformation** through market mechanisms and inter-agency coordination on policies that impact generation
2. Develop sufficient **transmission**, to integrate renewables and distribute them, make the system more resilient
3. Maintain a robust fleet of **balancing resources**, with an ability to provide **Essential Reliability Services**
4. Ensure a robust **energy supply chain** for the balancing resources, with sufficient access to fuel and stored energy to withstand long-duration, wide-spread extreme weather events
5. **STATES:** Refine resource adequacy requirements that preserves energy assurance

Different Generators Provide Different Services to the Grid

	Frequency Response		Voltage Control	Ramp Capability			Fuel Assurance			Flexibility					Other			
	Primary Frequency Response	Synchronous Inertia	Voltage Control	Ability to Dispatch for Regulation	Contingency Reserve	Load Following	On-site Fuel Inventory	Can Use Alternate Fuel	Fuel Availability through Geographic Location or Transportation	Ability to Cycle Start Up/Shutdown Multiple Times per Day	Fast Startup <30 minutes	Minimum Run Time After Start Up	Availability during Peak Times	Availability during Non-peak Times	Black Start Capability	No Environmental Restrictions may pertain to cooling water, emissions, wind speeds	Complies with public policy clean energy mandates	Generator Equivalent Availability Factor
Hydro	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🟢	🟢	🟢	🟢	🟡	🟡	🟡	🟡	🟢	🟢
Natural Gas – CT	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟡	🟡	🟡	🟢	🟡	🟢	🟢	🟢	🟡	🔴	🔴
Oil – Steam	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟡	🔴	🟡	🟢	🟢	🟢	🔴	🔴	🟡
Coal – Steam	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟡	🔴	🔴	🔴	🟢	🟢	🔴	🟡	🔴	🟡
Oil/Diesel – CT	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🔴	🔴	🔴
Nuclear	🟡	🟢	🟢	🔴	🔴	🟡	🟢	🔴	🟢	🔴	🔴	🔴	🟢	🟢	🔴	🟡	🟢	🟢
Demand Response	🔴	🔴	🔴	🔴	🟡	🔴	🔴	🔴	🟡	🟡	🟡	🟢	🟢	🟢	🔴	🟢	🟢	🟢
Solar	🟡	🔴	🟡	🟡	🟡	🟡	🔴	🔴	🟢	🟢	🟢	🟢	🟡	🟡	🔴	🟢	🟢	🟢
Battery	🟡	🔴	🟡	🟢	🟢	🔴	🔴	🔴	🟢	🟢	🟢	🟢	🟡	🟡	🟡	🟢	🟢	🟢
Solar + Battery	🟡	🔴	🟡	🟢	🟢	🟡	🔴	🟡	🟢	🟢	🟢	🟢	🟡	🟡	🟡	🟢	🟢	🟢
Wind On-Shore	🟡	🔴	🟡	🟡	🔴	🟡	🔴	🔴	🟢	🟢	🟢	🟢	🟡	🟡	🔴	🟢	🟢	🟢
Wind Off-Shore	🟡	🔴	🟡	🟡	🔴	🟡	🔴	🔴	🟢	🟢	🟢	🟢	🟡	🟡	🔴	🟢	🟢	🟢

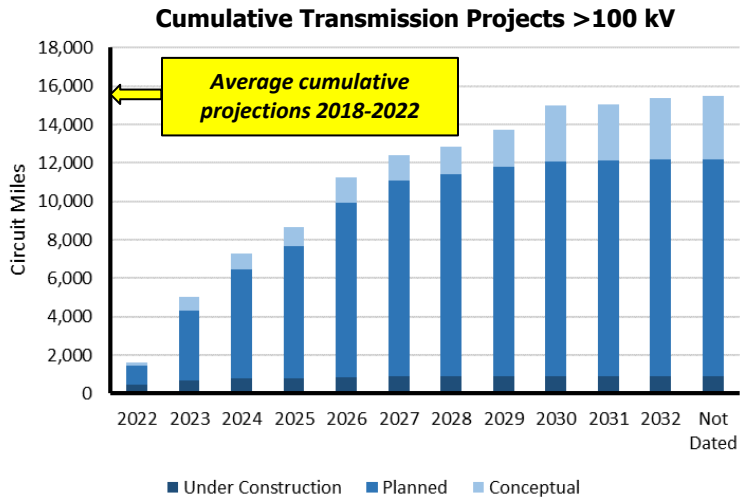
🟢 Exhibits Attribute
🟡 Partially Exhibits Attribute
🔴 Does Not Exhibits Attribute

Frequency Excursion – Interconnection-wide Phenomena

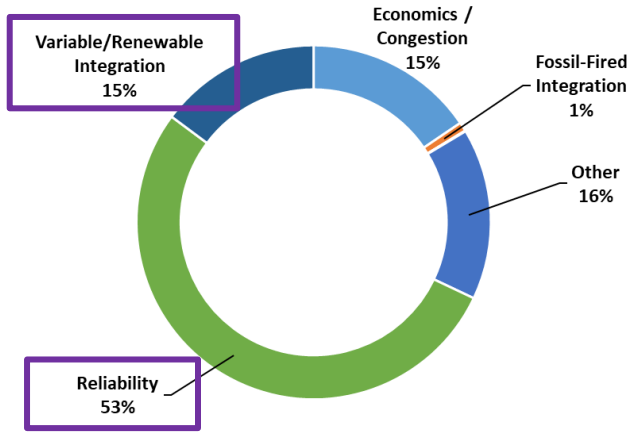


Trend in Transmission Projects: Steady

- Little change in transmission miles projections in past five years
- Most projects are initiated to support grid reliability
- Miles of transmission being planned or constructed for renewable integration increased from 1,589 mi to 2,376 mi since 2021 LTRA



Transmission Miles in Planning or Construction through 2032			
Area	**Miles**	**Area**	**Miles**
WECC WPP	3,439	SERC SE	629
NPCC New York	1,635	WECC SRSG	581
PJM	983	NPCC Ontario	570
WECC CAMX	902	NPCC New England	506
WECC BC	775	All other areas	<500 mi each



Transmission Project Primary Driver