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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Reliability Impacts of Inverter Based Technology

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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

Increased BPS Reliability Risks

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Rapidly Evolving Threat Landscape

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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

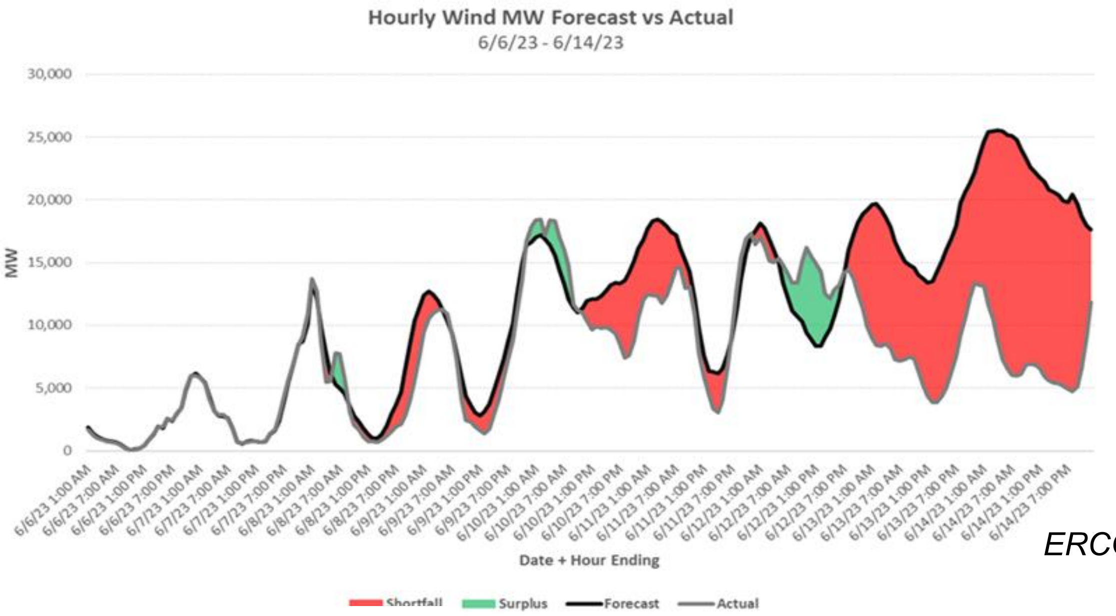
- Industry Control Systems (ICSs)
- IBRs/DERs/EV Charging

Sophistication of recent cyber attacks

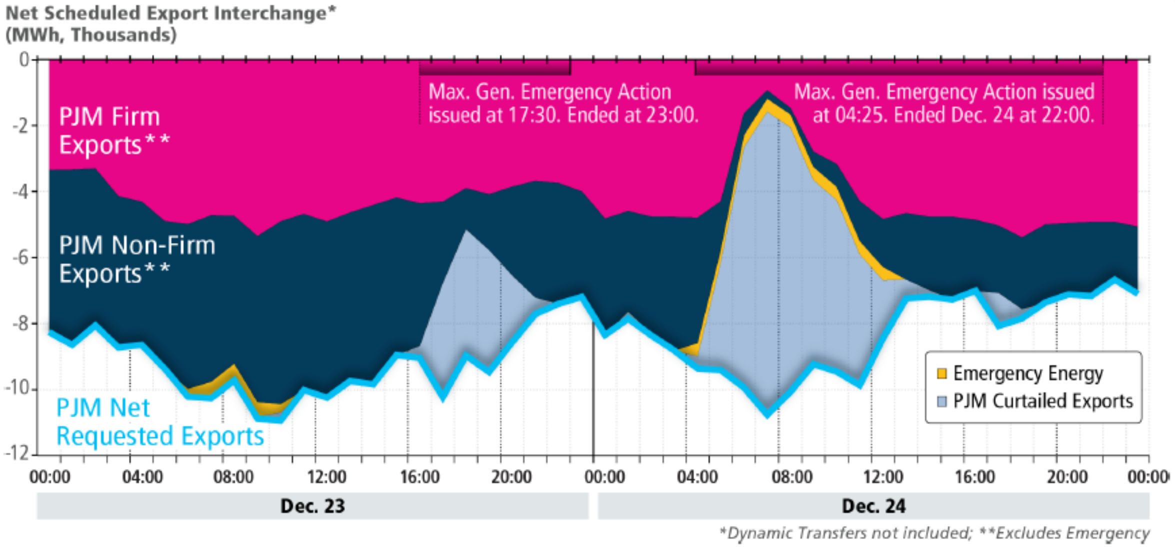
- SolarWinds (one to many)
- Pipedream, Industroyer malware

Recent Examples of Reliability Impacts

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*

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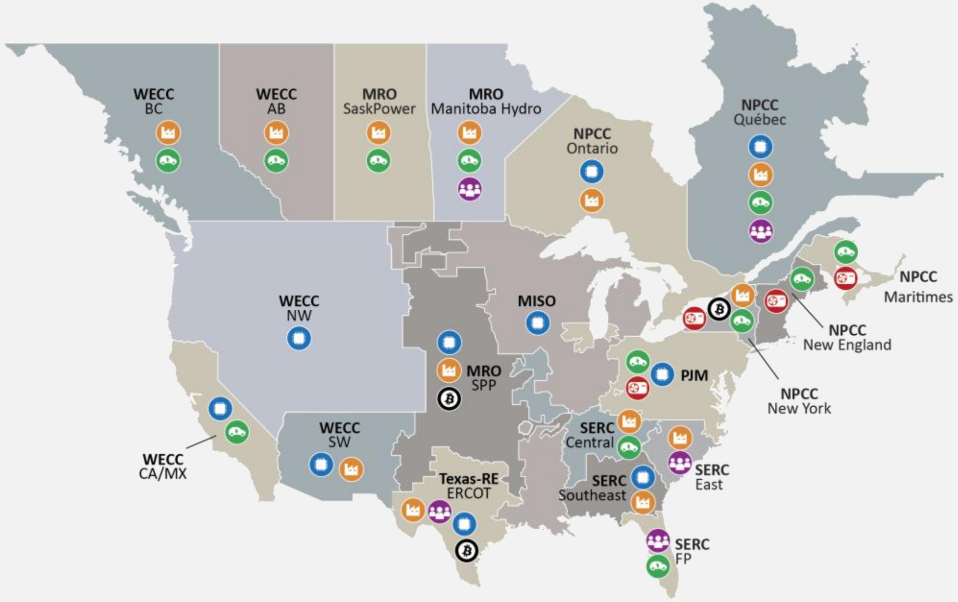
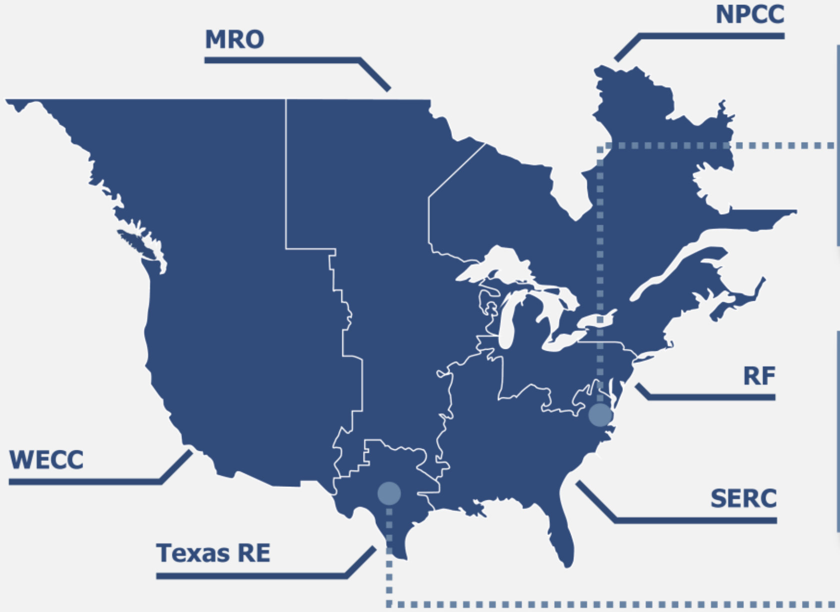
Large Load Events

Rapid Growth



- DATA CENTERS
- LARGE INDUSTRIAL LOADS
- TRANSPORTATION ELECTRIFICATION
- CRYPTO
- HEAT PUMPS
- DEMOGRAPHIC CHANGES

System Events



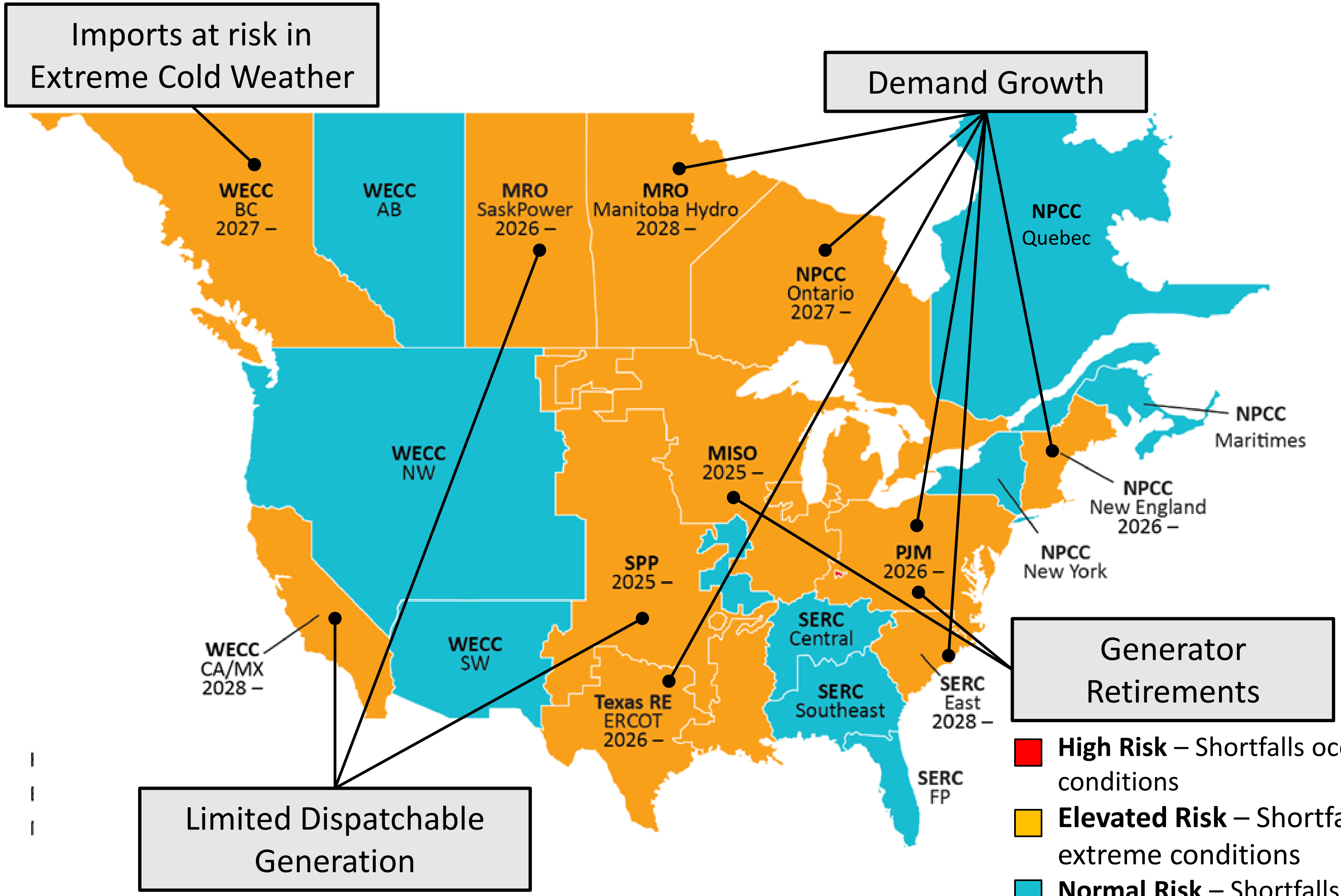
EI Data Center Load Loss Events

- 1500 MW Load Loss (July 2024)
- 1800 MW Load Loss (February 2025)

ERCOT Crypto Mining Load Loss Events

- 25 Loss Events (November 2023–January 2025)
- 100–400 MW Load Loss

2024 LTRA Finding | Increasing Energy Risks Over The Next 5 Years



Risk Map | with Primary Driver and Initial Shortfall Year

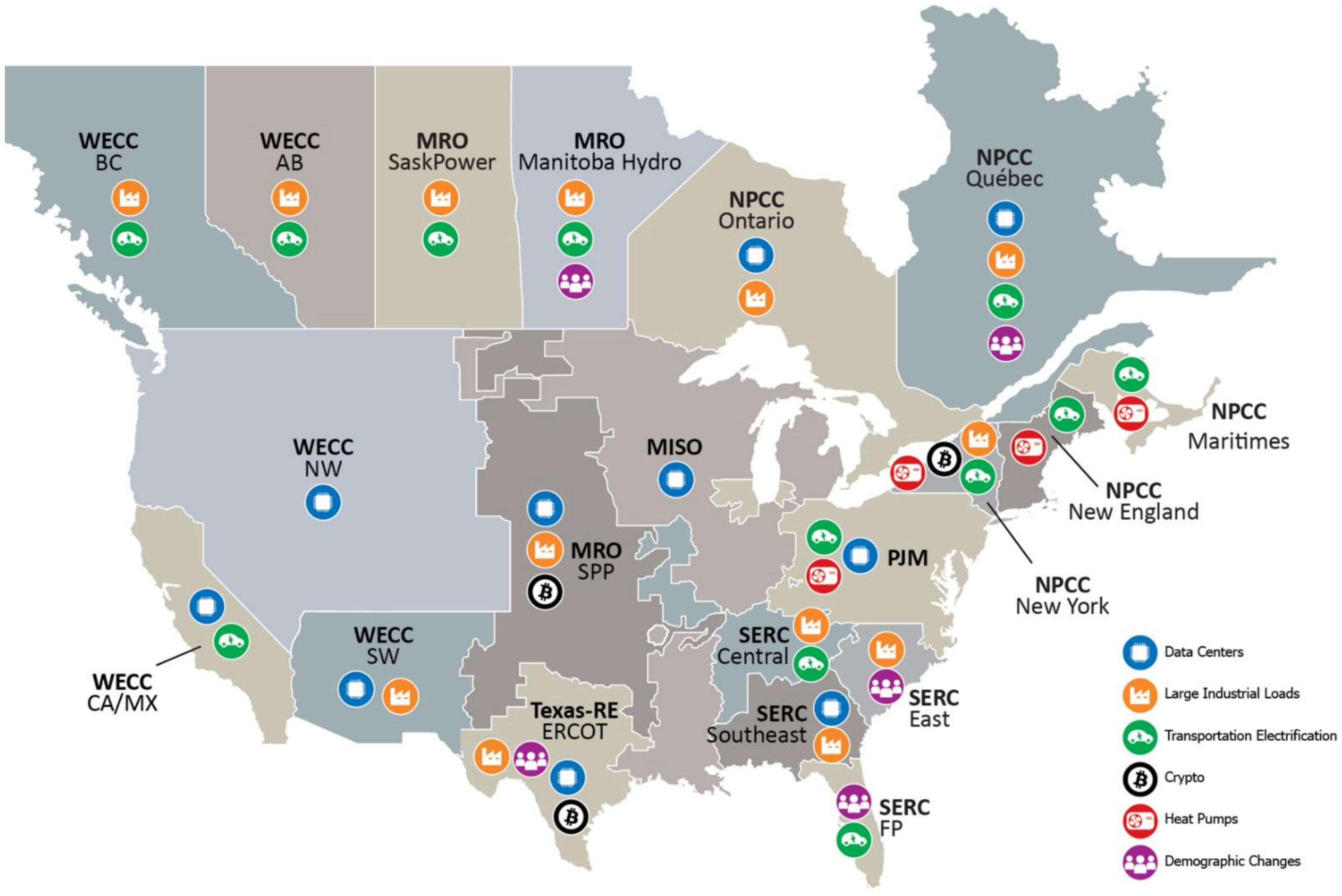
- **High Risk** – Shortfalls occurring in normal peak conditions
- **Elevated Risk** – Shortfalls occurring in extreme conditions
- **Normal Risk** – Shortfalls not expected under studied conditions

Assessment Inputs:

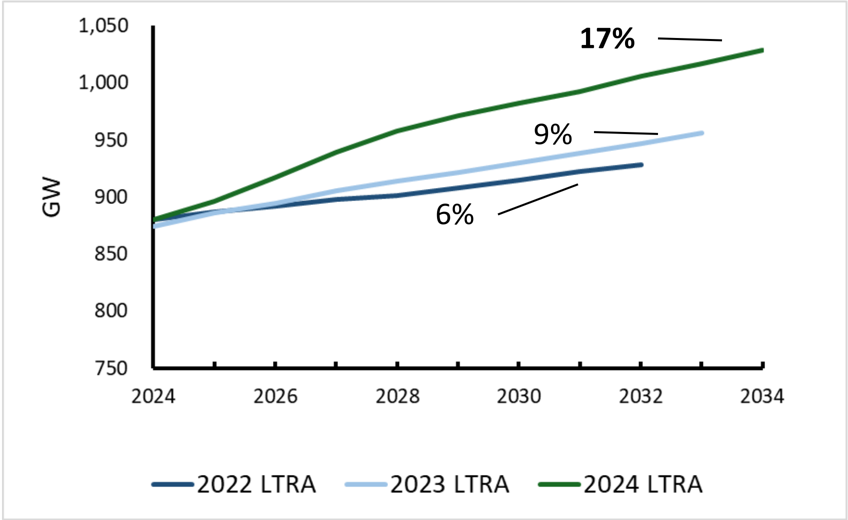
- Probabilistic Assessment (Studied Years 2026 and 2028)
- Planning Reserve Margins (2025 through 2029)

Risk determination based on established resource adequacy criteria (1-day-in-10 years) and NERC-National Academy of Engineering Workshop Report criteria for load-loss and unserved energy

2024 LTRA Trend | **Demand Growth Is Accelerating**



Demand Growth Drivers
Reported by planners in each assessment area



10-year BPS Summer Peak Demand Growth
With 10-year Growth From Previous LTRA

Winter BPS demand growth is outpacing Summer

- 149 GW (18%) increase over current peak in the next 10 years
- Driven by electrification and increasing solar PV that reduces summer demand during daytime

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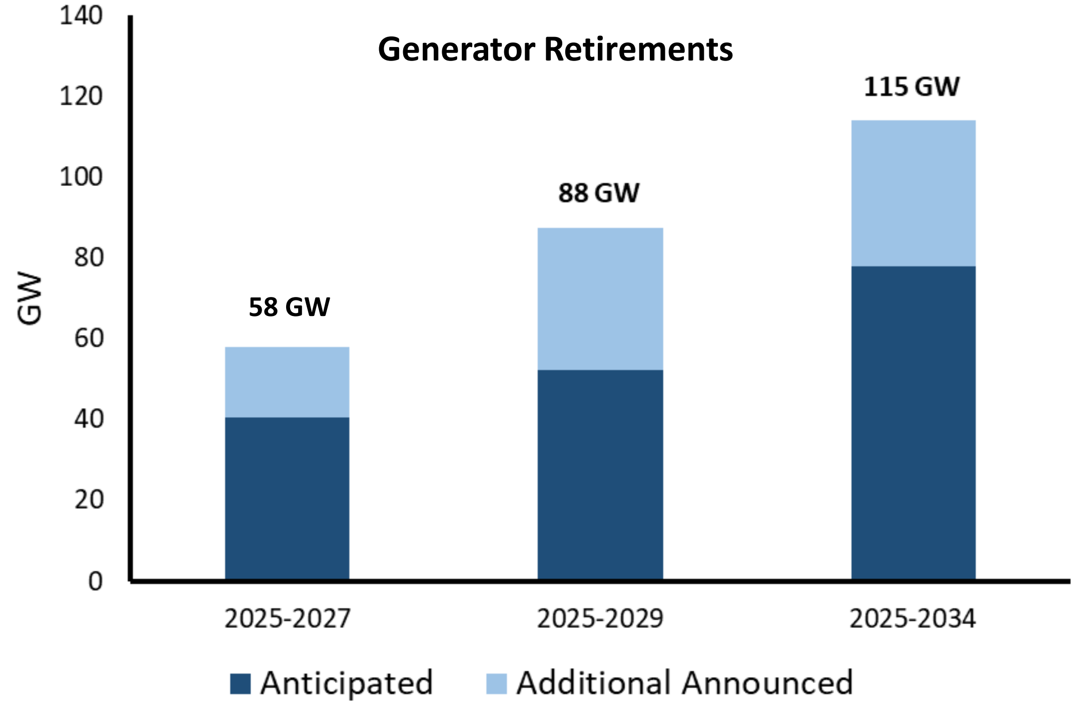
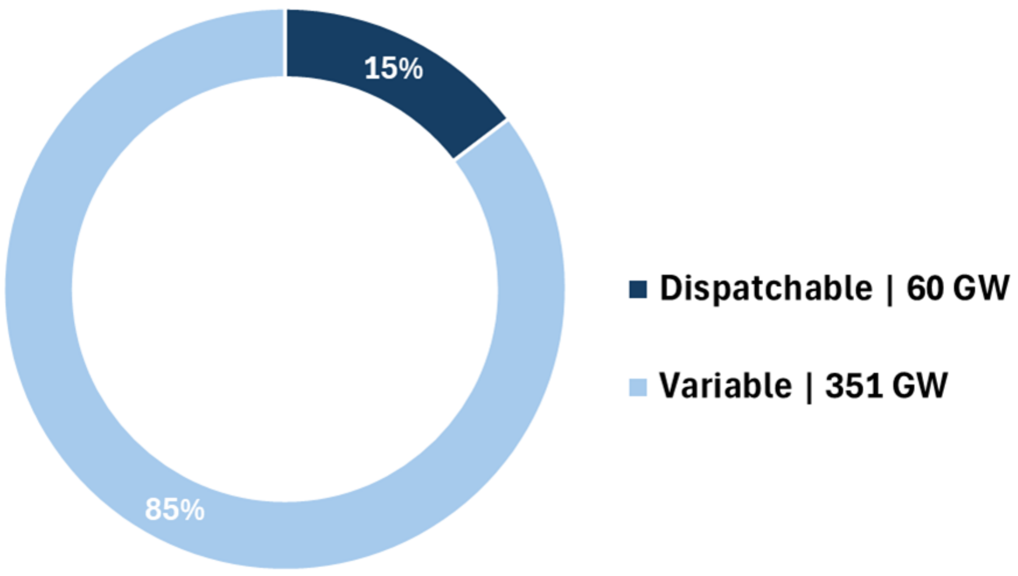
2024 LTRA Finding | Generator Retirements and Fewer Dispatchable Resources Threaten Future Adequacy

Accelerating Retirements: Resource needs to meet escalating demand growth are threatened by the current pace of generator retirements.



Declining Dispatchable Resources: Replacement resources projected over the next decade are more weather dependent and lack key reliability attributes.

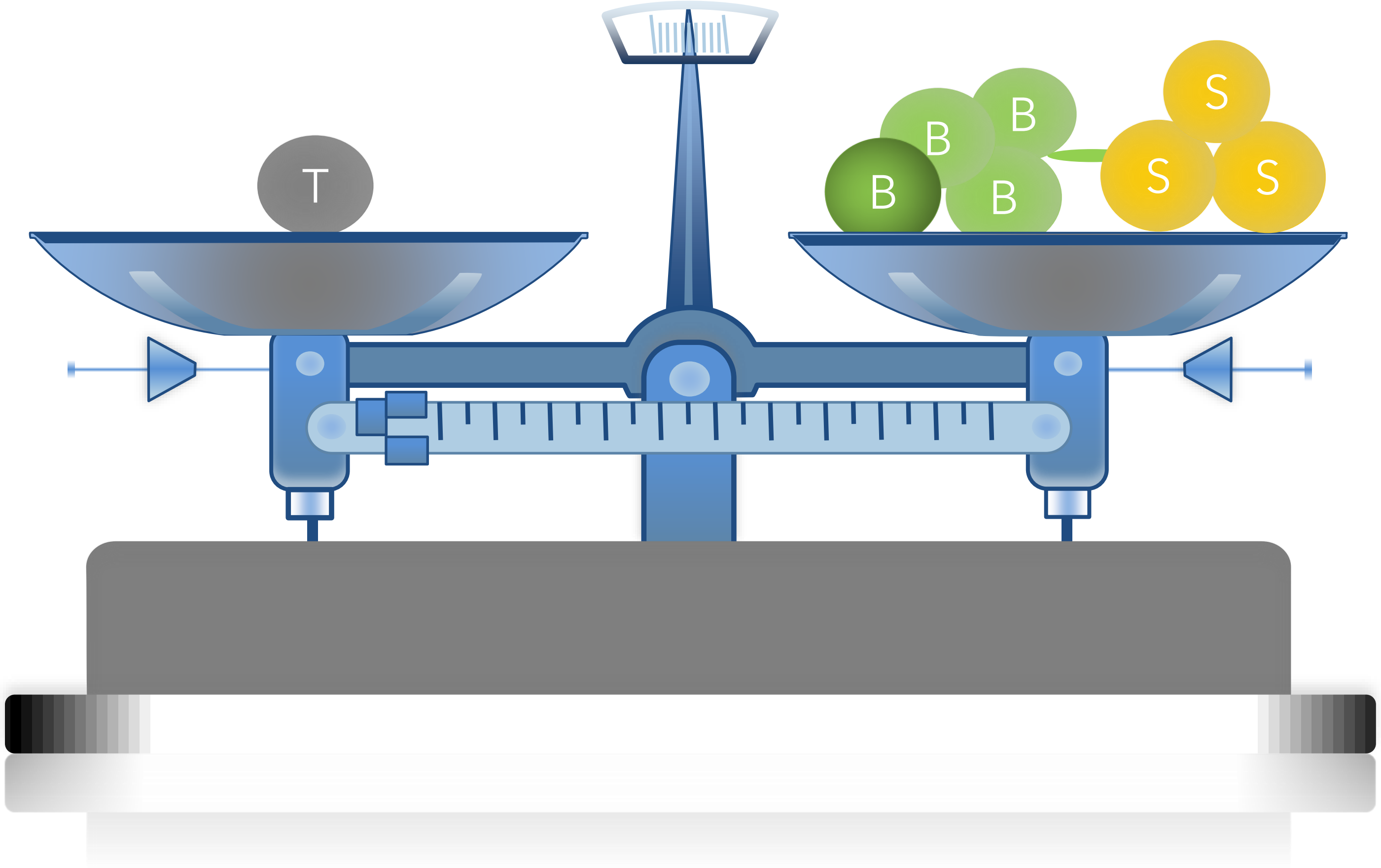


Current Interconnection Queue Resources

Base load compared to hybrid

Retire 100 MW Base Load Generation

- *100 MW Traditional Base Load generates 2400 MWh*



300 MW Solar + 400 MW Batteries

- *Assume 8 hours of sunlight*
- *Assume no losses in conversion*

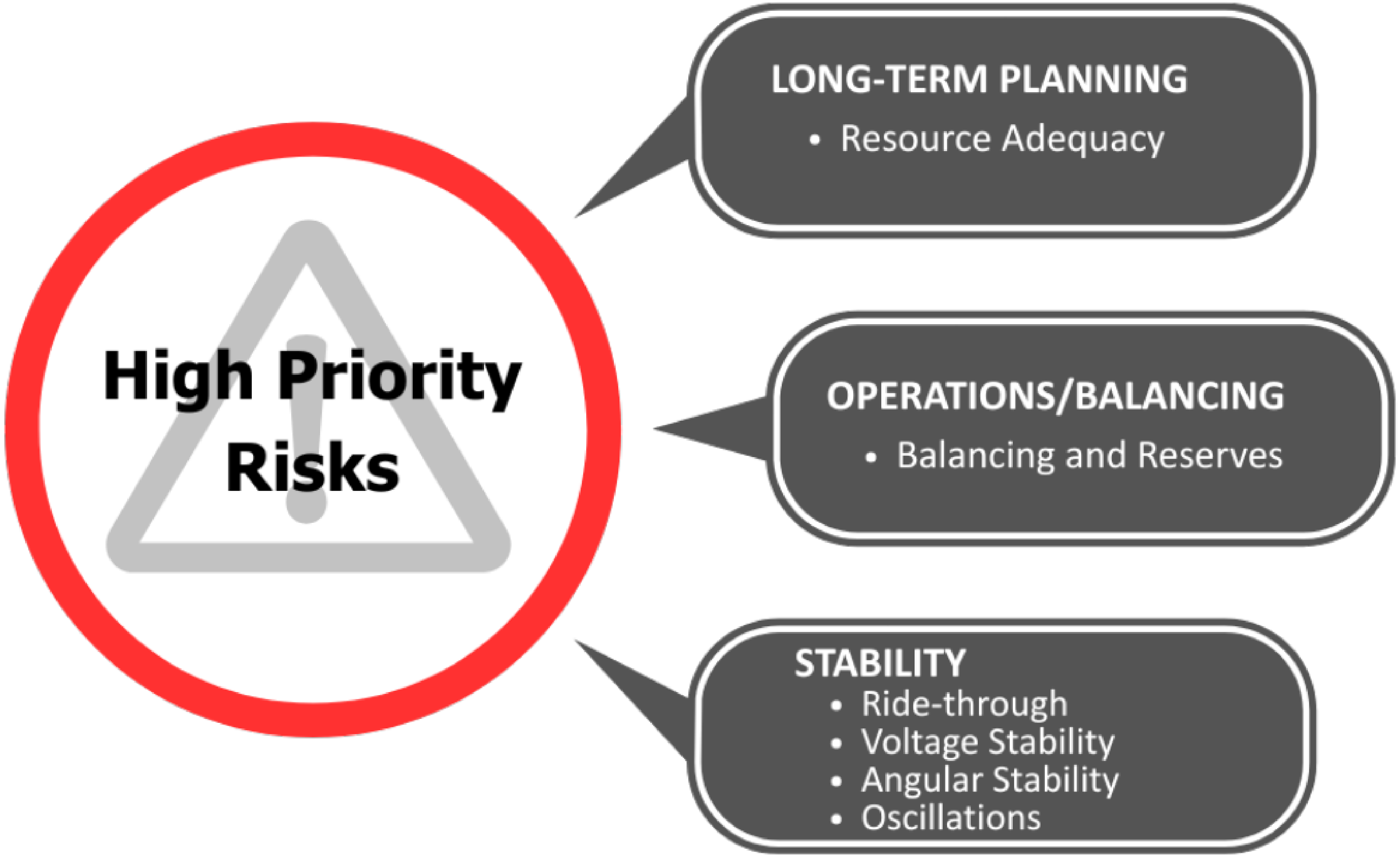
Usage

- *100 MW **solar** for 8 hours (800 MWh)*
- *400 MW **storage** for 4 hour discharge (1600 MWh)*

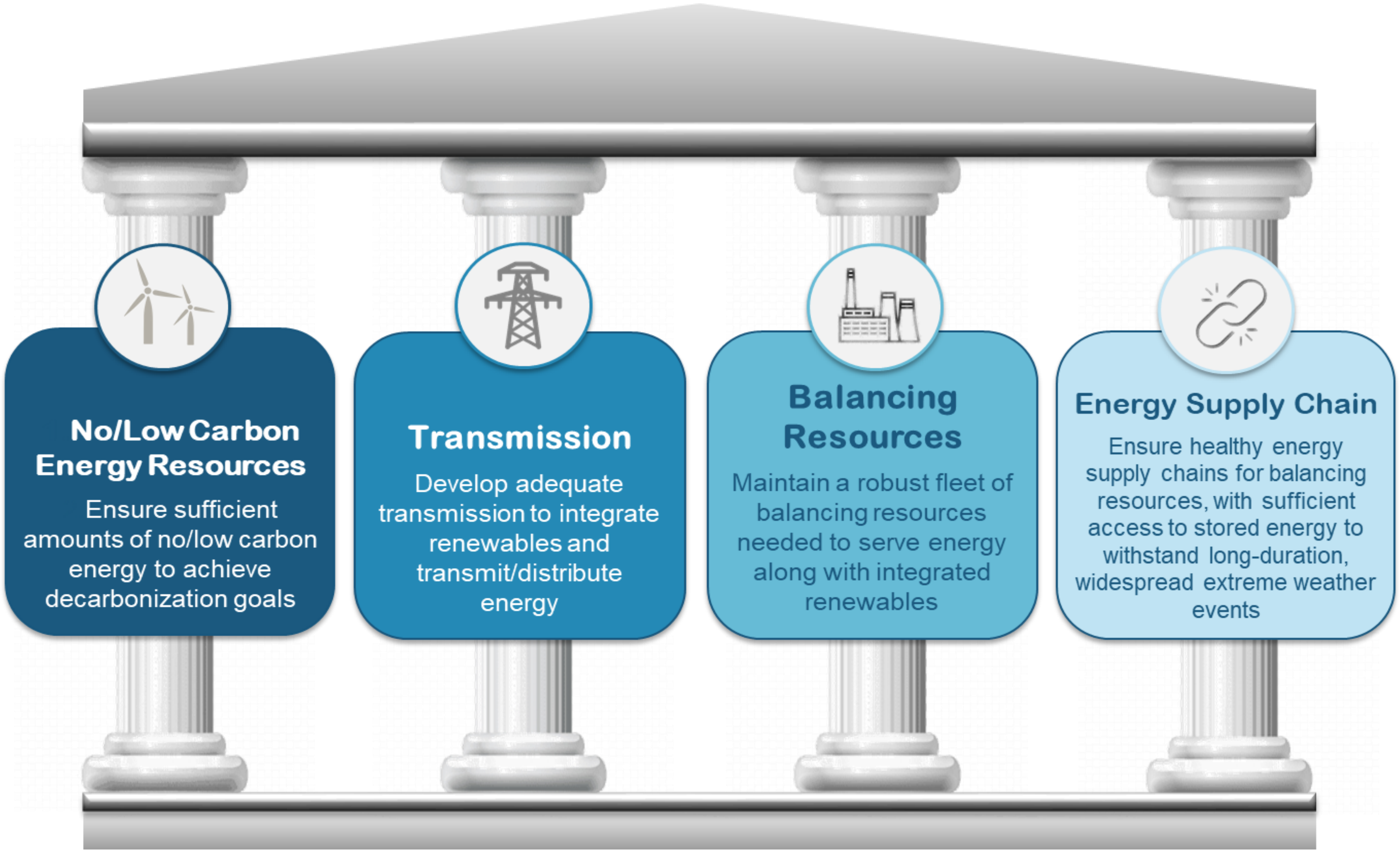
Storage

- *200 MW **solar** to charge storage 8 hours (1600 MWh)*

High Priority Risks to the Bulk Power System



Moving Forward: The Four Pillars of the Energy Transition



A Changing Context for the BPS

Distributed

Decarbonized

Digitized

<u>Must Wins:</u>

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

Cyber challenges

- Most Inverter-based Resources (IBRs) and large loads have remote connectivity
- Many not subject to current CIP standards
- Many “controlled” outside North America
- Common cyber vulnerability can take out multiple MW (both generation and load)

Impact for Standards

- Continue developing IBR standards
- Determine registration impacts for new large loads
- Based on Large Load Task Force work, begin developing appropriate standards
- Evaluate CIP standards for applicability

Questions and Answers