SYSTEM RESERVES

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PJM RCSTF

November 18, 2025

RELIABILITY FIRST

AGENDA

BALANCING STANDARDS

RELIABILITY INSIGHTS – SHIFT TO ENERGY ADEQUACY

WHAT'S CHANGED SINCE 2006

SYSTEM EVENTS/RENEWABLE VARIABILITY

OPPORTUNITIES TO ENSURE ENERGY ADEQUACY

KEY TAKEAWAY

SYSTEM RESERVES

Maintain sufficient Frequency Response as a "first line of defense" to arrest deviations and stabilize grid

- R2 & R4: Must meet IFRO (Interconnection Frequency Response Obligation)

Maintain sufficient Contingency Reserve as a "second line of defense" to recover from sudden, unexpected losses of generation or transmission

- R1: Contingency Reserve must be equal to or greater than its MSSC (Most Severe Single Contingency)
- Contingency Reserve must be deployed within timeframe to return ACE to 0 *and* have 90 minutes to restore to the minimum required reserve level

BAL-003-2 – Frequency Response and Frequency Bias Setting

A. Introduction

1. **Title: Frequency Response and Frequency Bias Setting**
2. **Number:** **BAL-003-2**
3. **Purpose:** To require sufficient Frequency Response from the Balancing Authority (BA) to maintain Interconnection Frequency within predefined bounds by arresting frequency deviations and supporting frequency until the frequency is restored to its scheduled value. To provide consistent methods for measuring Frequency Response and determining the Frequency Bias Setting.

BAL-002-3 – Disturbance Control Standard – Contingency Reserve for Recovery from a Balancing Contingency Event

A. Introduction

1. **Title:** Disturbance Control Standard – Contingency Reserve for Recovery from a Balancing Contingency Event
2. **Number:** BAL-002-3
3. **Purpose:** To ensure the Balancing Authority or Reserve Sharing Group balances resources and demand and returns the Balancing Authority's or Reserve Sharing Group's Area Control Error to defined values (subject to applicable limits) following a Reportable Balancing Contingency Event.

RELIABILITY GUIDELINE

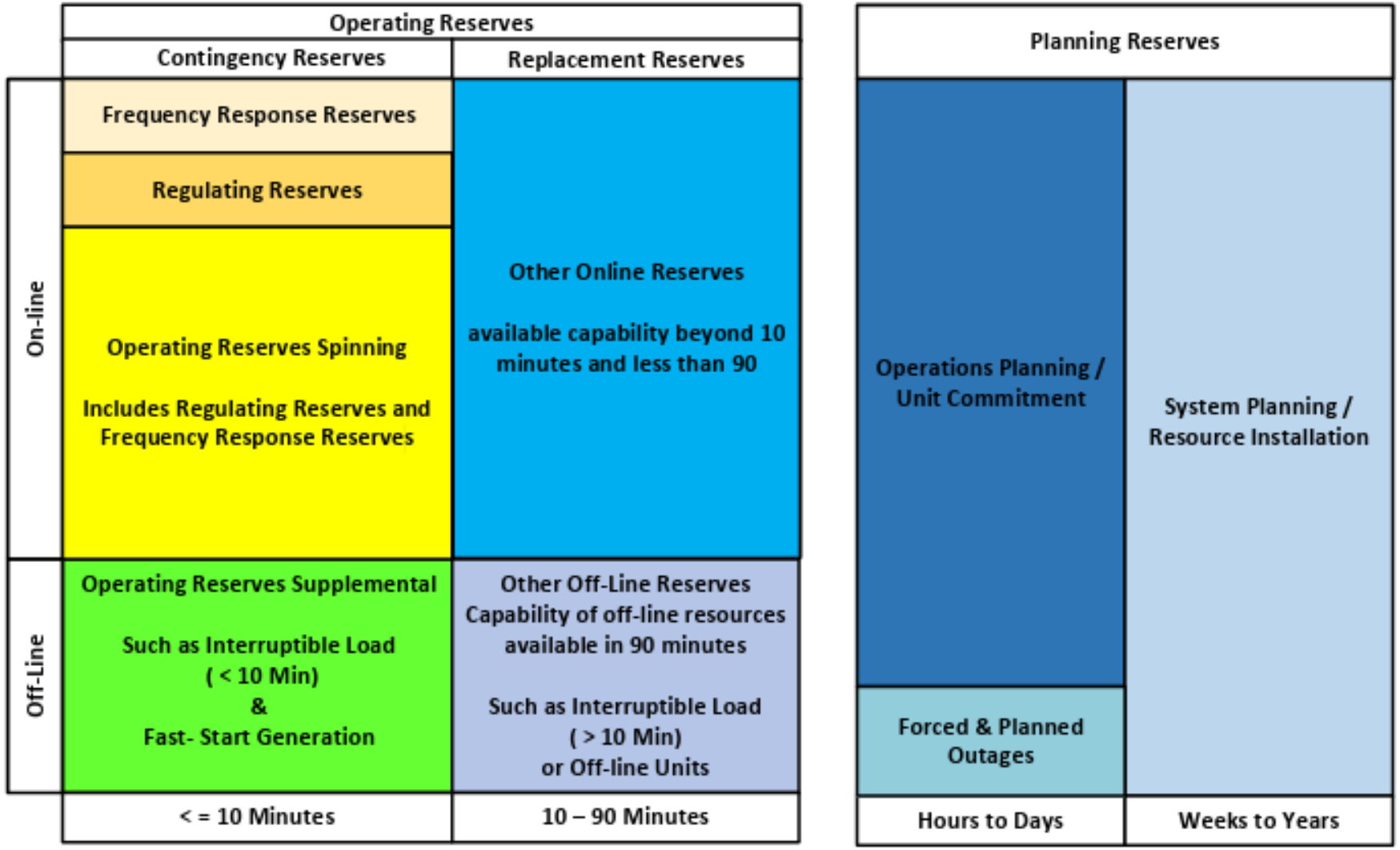


Figure 1.1: Operating Reserves

RELIABILITY INSIGHTS - SYSTEM ADEQUACY

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

MIDWEST RELIABILITY ORGANIZATION
NPCC, Inc.
RELIABILITY FIRST
SERC
TEXAS RE
Ensuring electric reliability for Texans
WECC

Reliability Insights

New Approaches Needed to Ensure System Adequacy

June 2025

Traditional Resource Adequacy Methods Are No Longer Enough

Nearly 400 million North Americans depend on an adequate and reliable supply of continuous electrical energy that is supplied by an electric grid increasingly reliant on weather-dependent and just-in-time fuel resources. Ensuring reliability is made more challenging by increasing uncertainty in future supply and demand, especially with high load growth. Overcoming these challenges through system planning and operations is key to ensuring energy adequacy. Adequacy, as it relates to the grid, is traditionally measured by whether capacity can meet peak demand; however, this approach, which is focused on capacity-based reserve margins and deterministic planning, is no longer sufficient by itself.

THE GRID: 20 YEARS OF PROGRESS SINCE THE 2003 NORTHEAST BLACKOUT

2006-2007

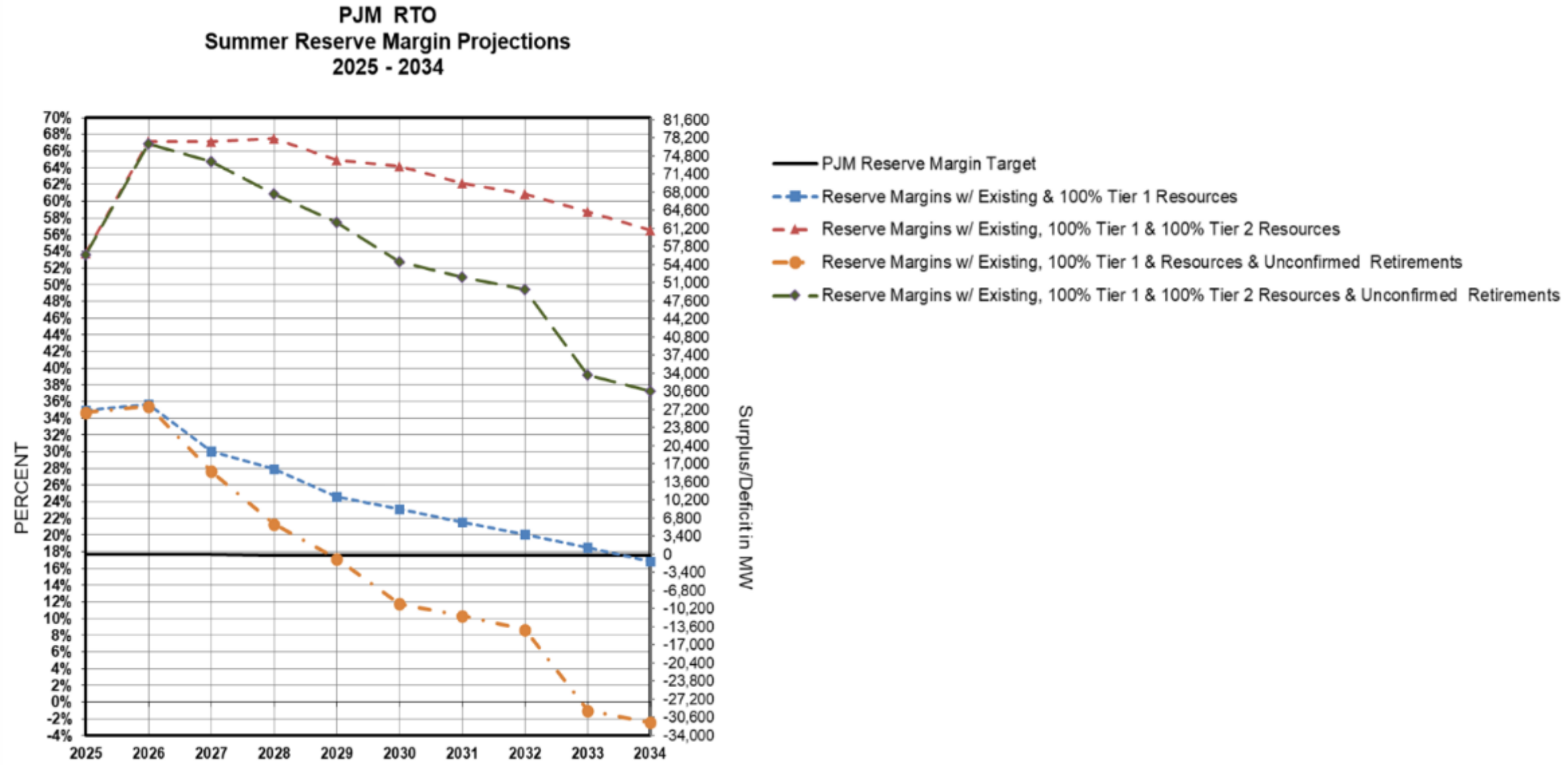
- 2006: NERC files > 100 reliability standards with FERC
- 2006: FERC certifies NERC as the Electric Reliability Organization (ERO)
- 2007: NERC standards become mandatory and enforceable
- 2007: NETFLIX streaming
- 2007: First iPhone launch

DECLINING EXCESS CAPACITY

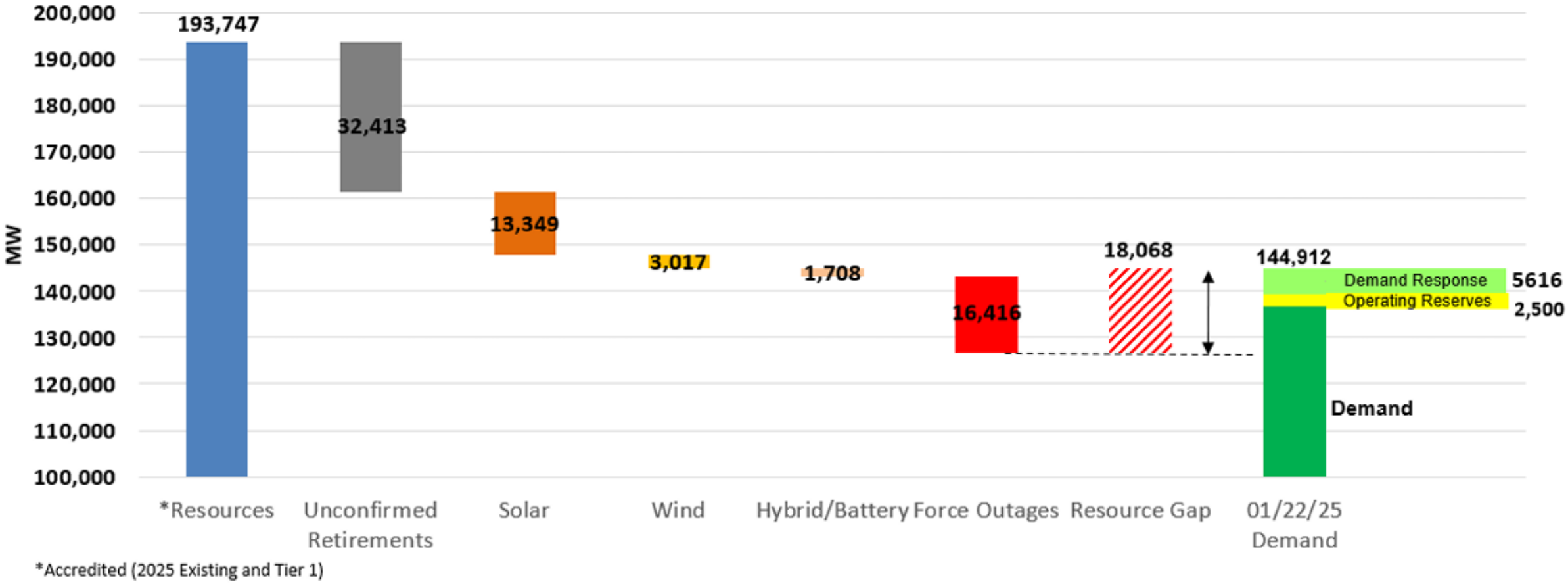
2030 Resource Adequacy Scenarios, UCAP Basis

	2026 Projected Surplus	Minus Load Growth	Plus New Generation	Minus Deactivations	Plus DR and Load Flexibility	2030 Projected Surplus/Deficit
Scenario 1	0.3 GW	(22.9 GW)	6.6 GW	(8.1 GW)	0.0 GW	**(24.1 GW)**
Scenario 2	0.3 GW	(29.2 GW)	12.2 GW	(8.1 GW)	0.0 GW	**(24.7 GW)**
Scenario 3	0.3 GW	(22.9 GW)	12.2 GW	0.0 GW	0.0 GW	**(10.4 GW)**
Scenario 4	0.3 GW	(22.9 GW)	12.2 GW	0.0 GW	3.3 GW	**(7.1 GW)**
Scenario 5	0.3 GW	(22.9 GW)	12.2 GW	0.0 GW	10.4 GW	**0.0 GW**

RF LTRA (2024 DATA)



WINTER ENERGY ADEQUACY



*Accredited (2025 Existing and Tier 1)

Figure 2: PJM 2029/30 Winter Risk Scenario (using Jan 2025 Peak Conditions)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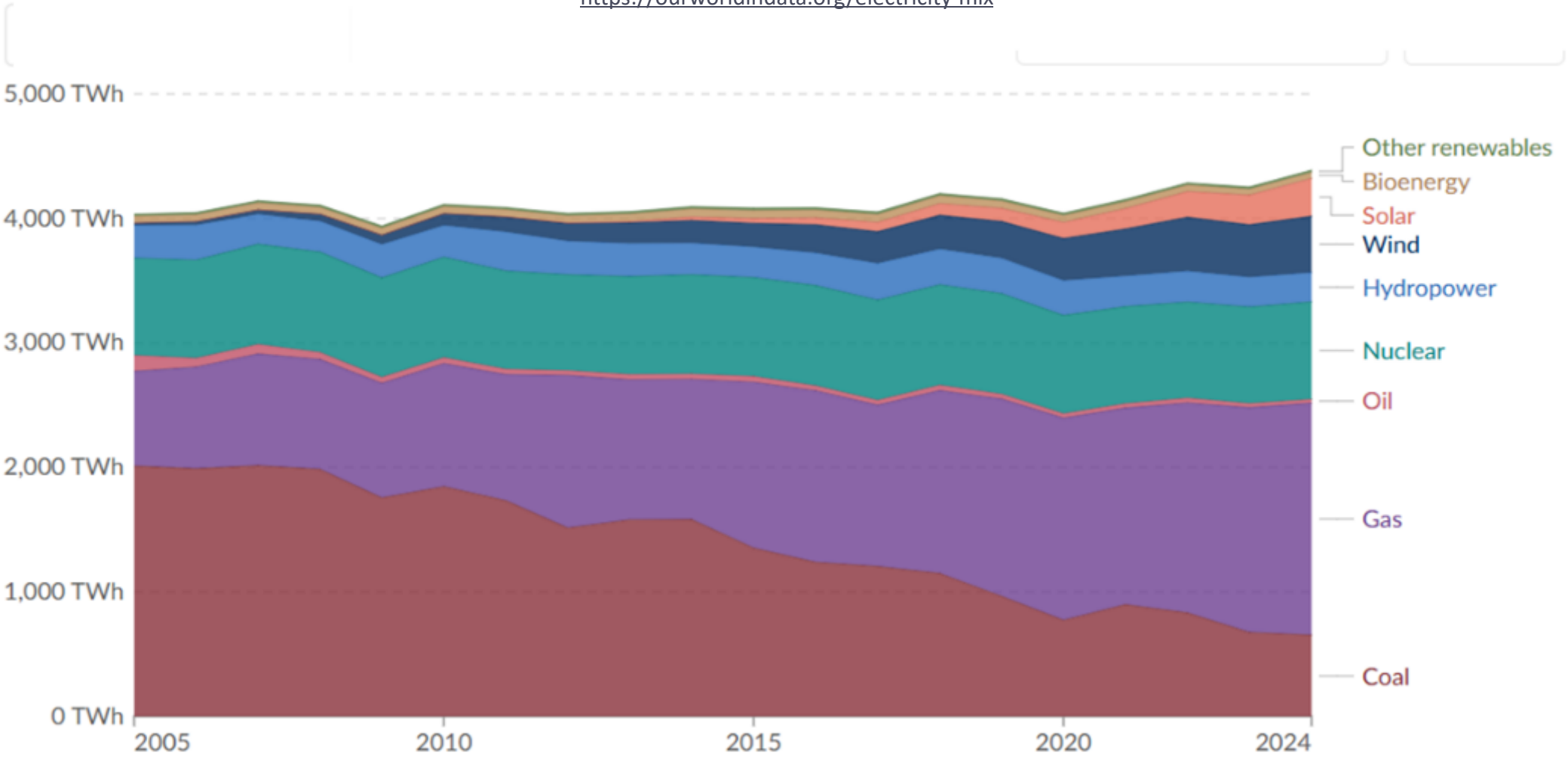
RENEWABLE MIX

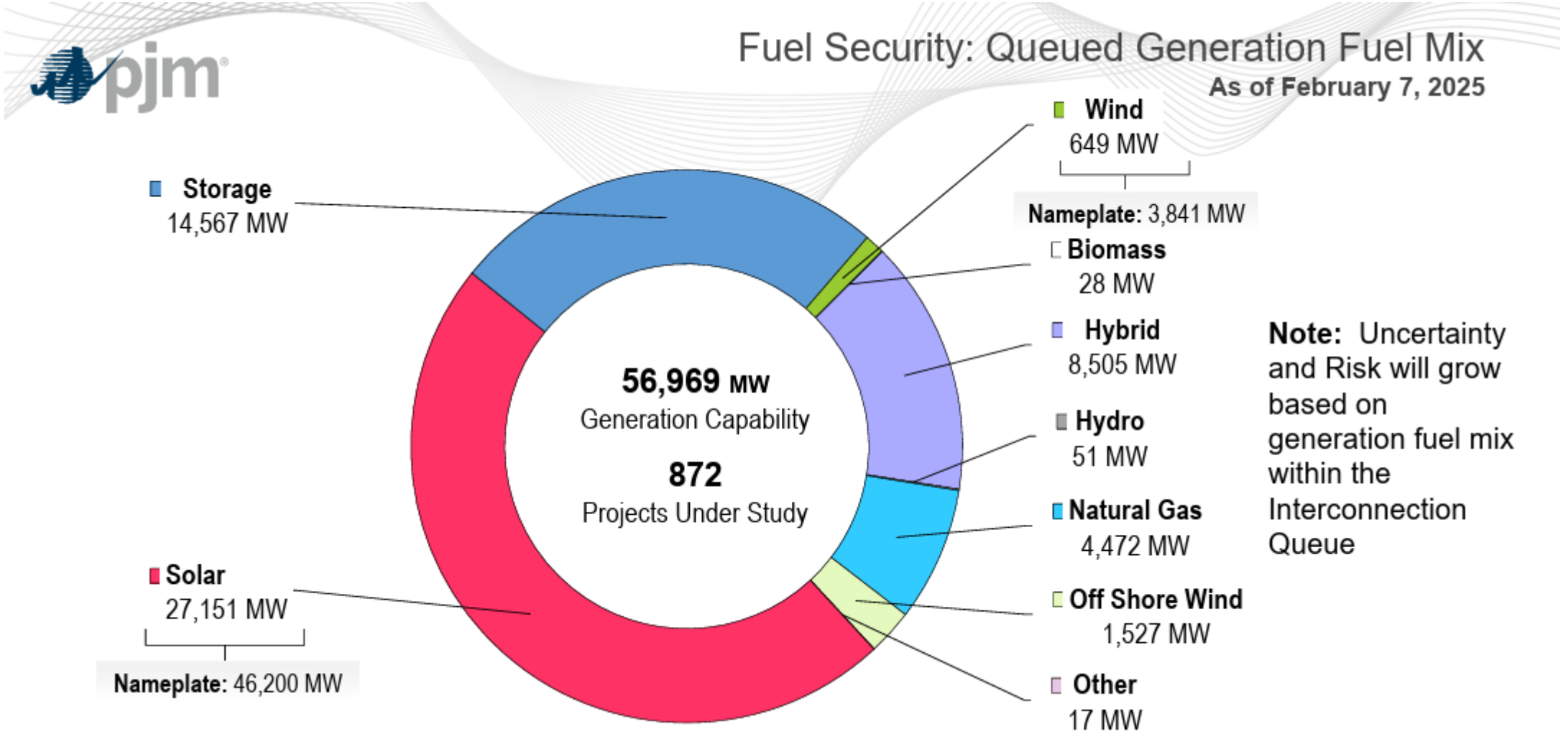
Electricity production by source, United States

Measured in terawatt-hours.

https://ourworldindata.org/electricity-mix

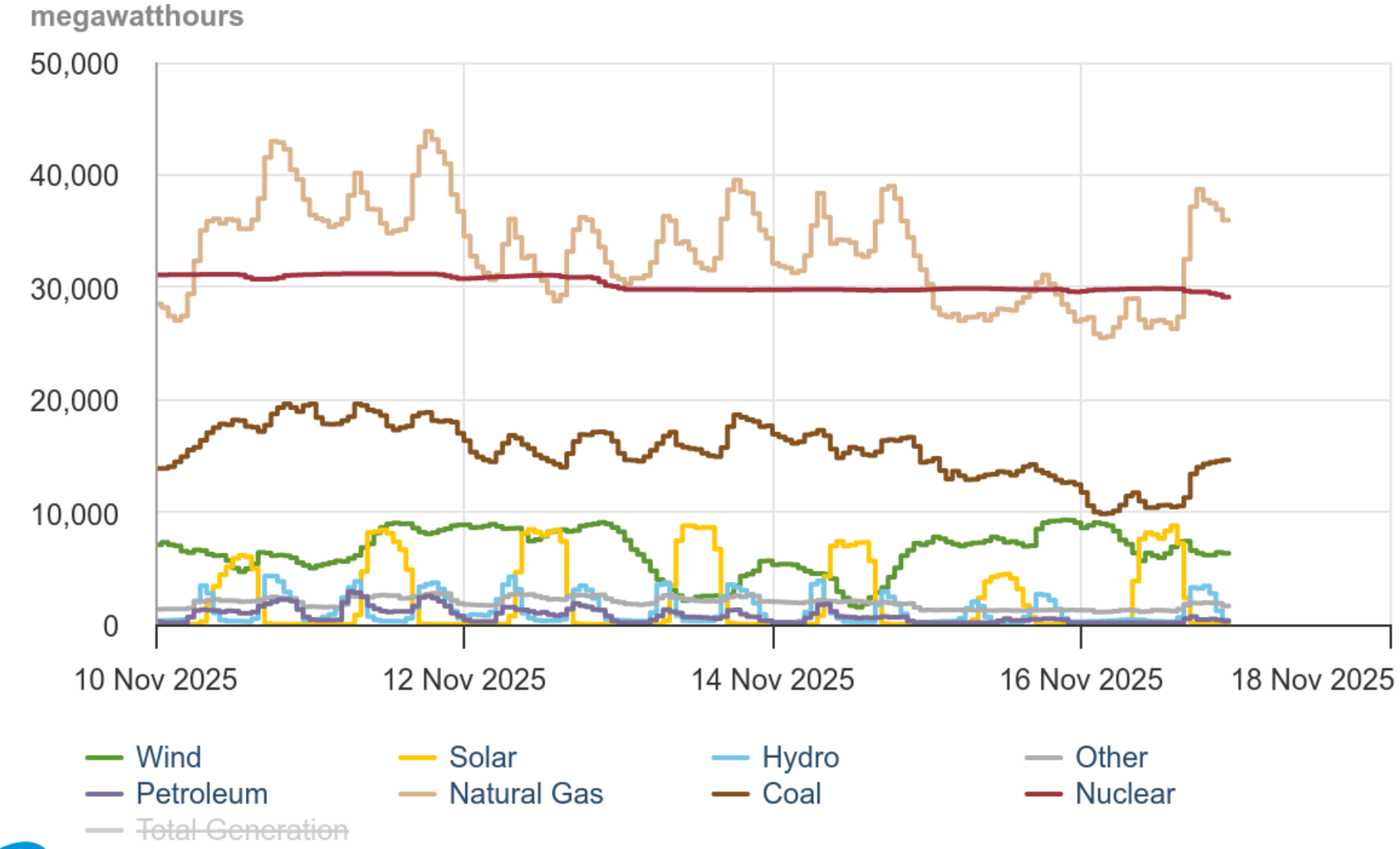


RENEWABLE MIX



PJM Day-Ahead Uncertainty and Risk Framework Overview_RCSTF_August 2025

PJM Interconnection, LLC (PJM) electricity generation by energy source 11/10/2025 – 11/17/2025, Eastern Time



eia Data source: U.S. Energy Information Administration

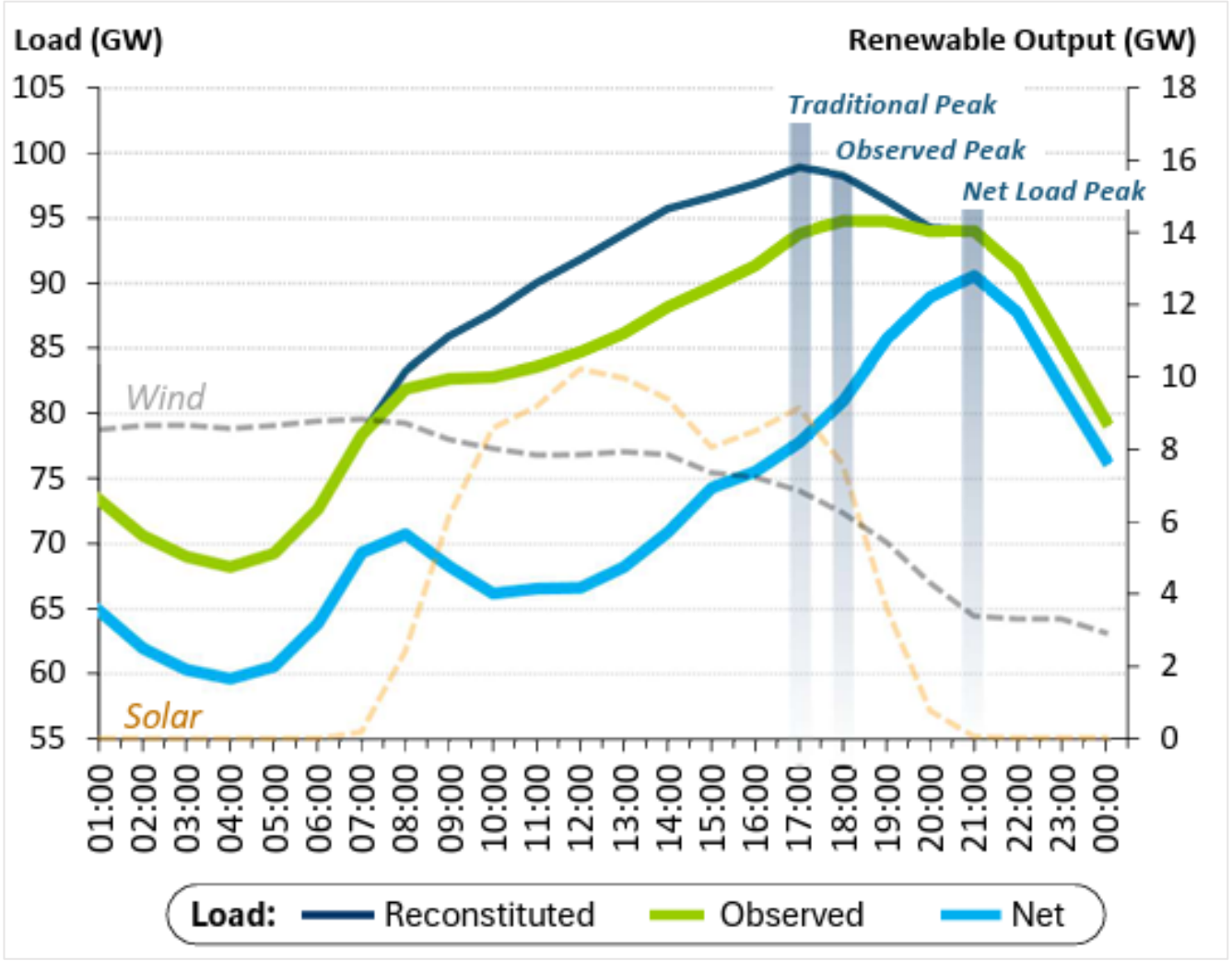
NET LOAD PREDICTABILITY

What Is Net Load?

Historically, system operators relied on the projected load, the total electricity demand at any moment, to determine how much generation was required. With intermittent wind and solar now a large share of the resource mix, this no longer fully reflects system needs.

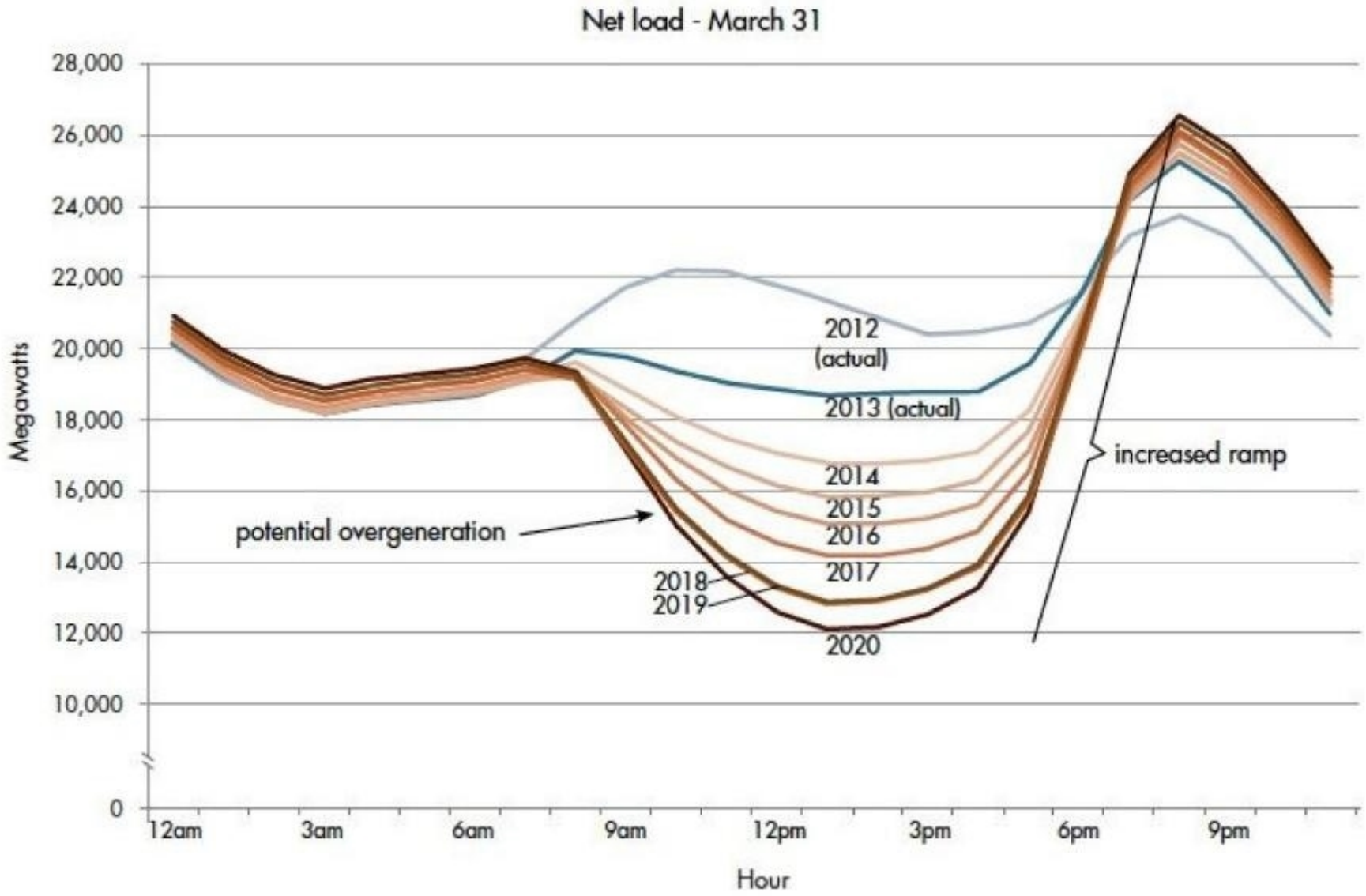
***Net load* has become the key measure of what must be served by non-intermittent resources:**

Source: Understanding Net Load PJM September 2025

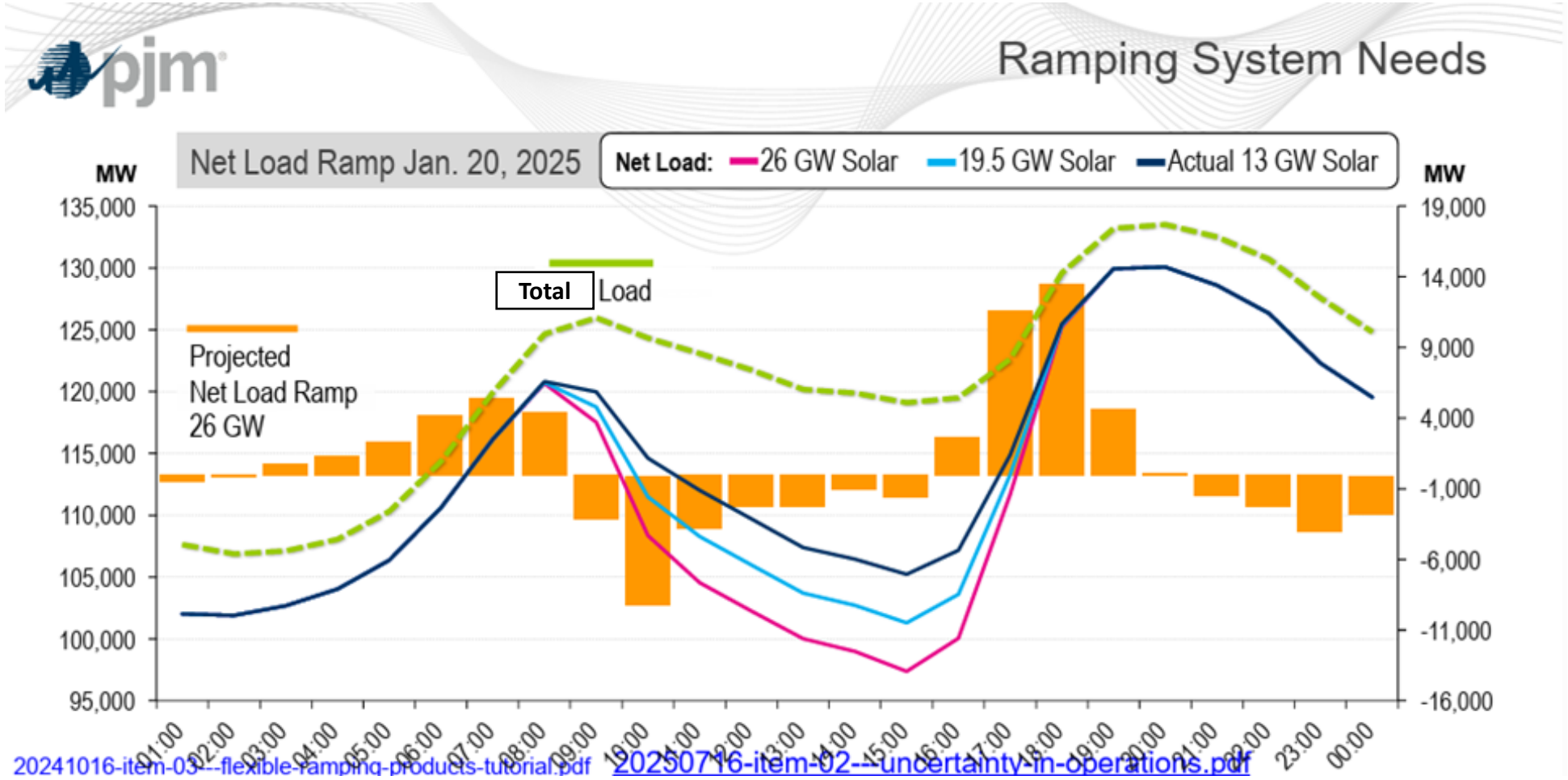


Net Load = Observed Load – Grid-Connected Solar – Grid-Connected Wind

CAISO DUCK CURVE

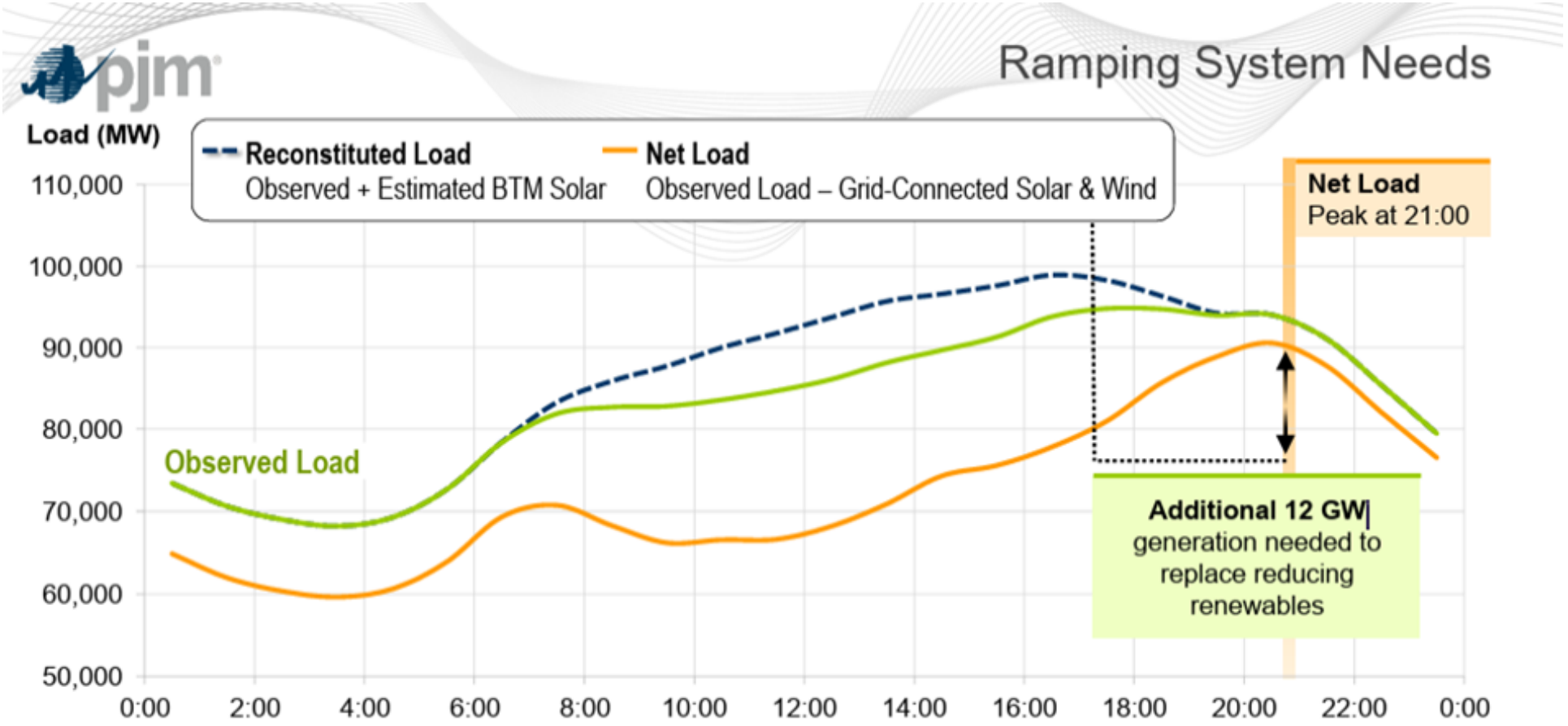


PJM NET LOAD RAMP JANUARY 2025



PJM RCSTF Proposal Update October 2025

PJM RAMPING APRIL 29, 2025



PJM RCSTF Proposal Update October 2025

EVENTS/RENEWABLE VARIABILITY

Applying Past Learning to Future Planning

Today's grid faces higher volatility, lower predictability, and more severe consequences when things go wrong. Simply maintaining reserve margins may give a false sense of security as evidenced during several recent, significant events:

- **Texas (Winter Storm Uri, 2021):** At the time of this event, the ERCOT area was considered "resource adequate" by the targets set by ERCOT and the Public Utility Commission of Texas, but extreme cold disrupted gas supply and froze generation of all types. Up to 20,000 MW of emergency firm load shed was required over multiple days due to extreme demand, low renewable output, and a huge amount of thermal generation forced off-line.
- **Midwest (June 2023):** More than 60,000 MW of wind capacity dropped to 300 MW during a widespread low-wind event also known as a dunkelflaute (see Figure 1). Fortunately, the system was lightly loaded for spring conditions, and excess generation from the area and

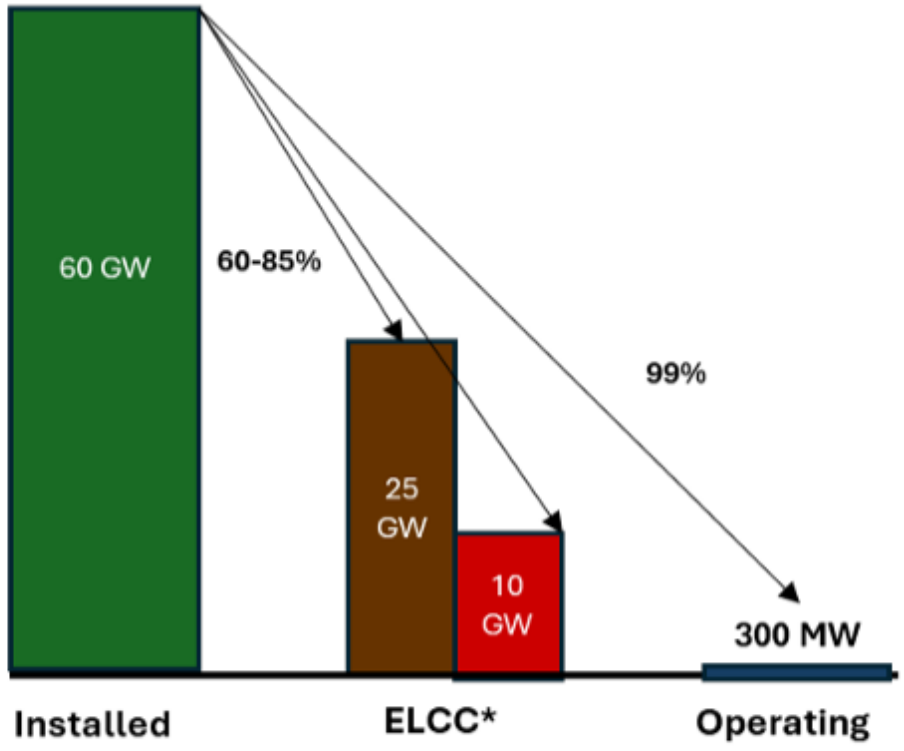


Figure 1: June 6, 2023, Wind Production North American Mid Continent

OPPORTUNITIES TO ENSURE ENERGY ADEQUACY

- Risk-informed market procurement, including probabilistic and scenario-based risk assessment - all hours and seasons and under stress conditions, such as extreme weather or fuel supply interruptions *
- Value all required reliability attributes - essential reliability services (e.g., ramping, frequency and frequency response, voltage support) *
- Set an agreed design basis for the future grid - 1-event-in-10 years using traditional synchronous generation, vs. modeling of fuel and renewable capacity performance to assess reliability risk *

* Summary from Page 3 from NERC Reliability Insights on New Approaches to Ensure System Adequacy; June 2025

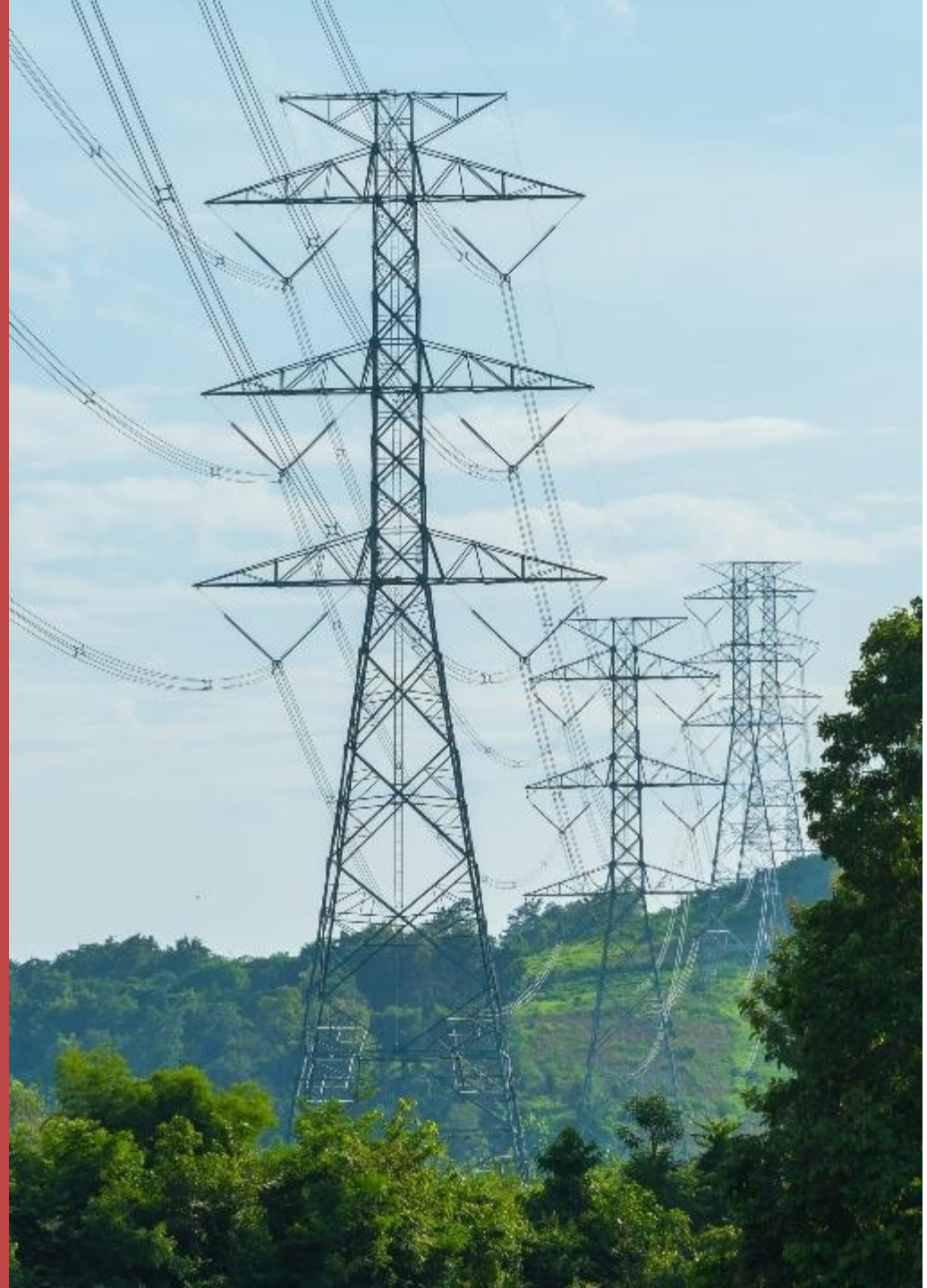
Reliability Insights

New Approaches Needed to Ensure System Adequacy

June 2025

Traditional Resource Adequacy Methods Are No Longer Enough

"Industry and policymakers must guide a transition from a capacity-based approach to an energy-based one. This transition entails modernizing planning practices; investing in and retaining flexible and secure fuel resources that are less than firm; and supporting standardized, probabilistic approaches with scenario-based assessments that properly reflect the realities of today's evolving resource mix that has vastly different reliability attributes."



FORWARD TOGETHER RELIABILITYFIRST

QUESTIONS & ANSWERS

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