PJM Interconnection
An Overview

Asim Z. Haque
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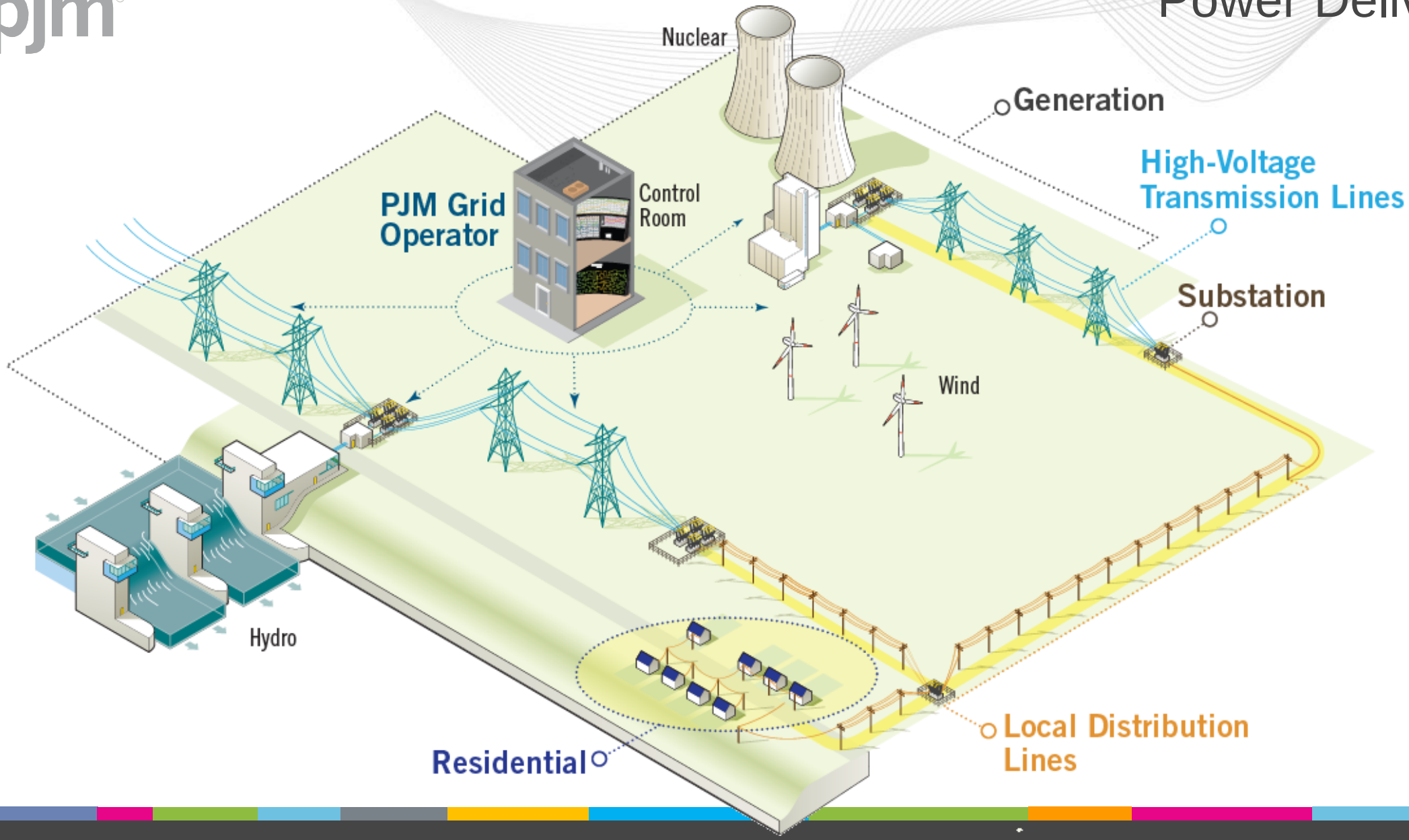
PJM Interconnection, LLC

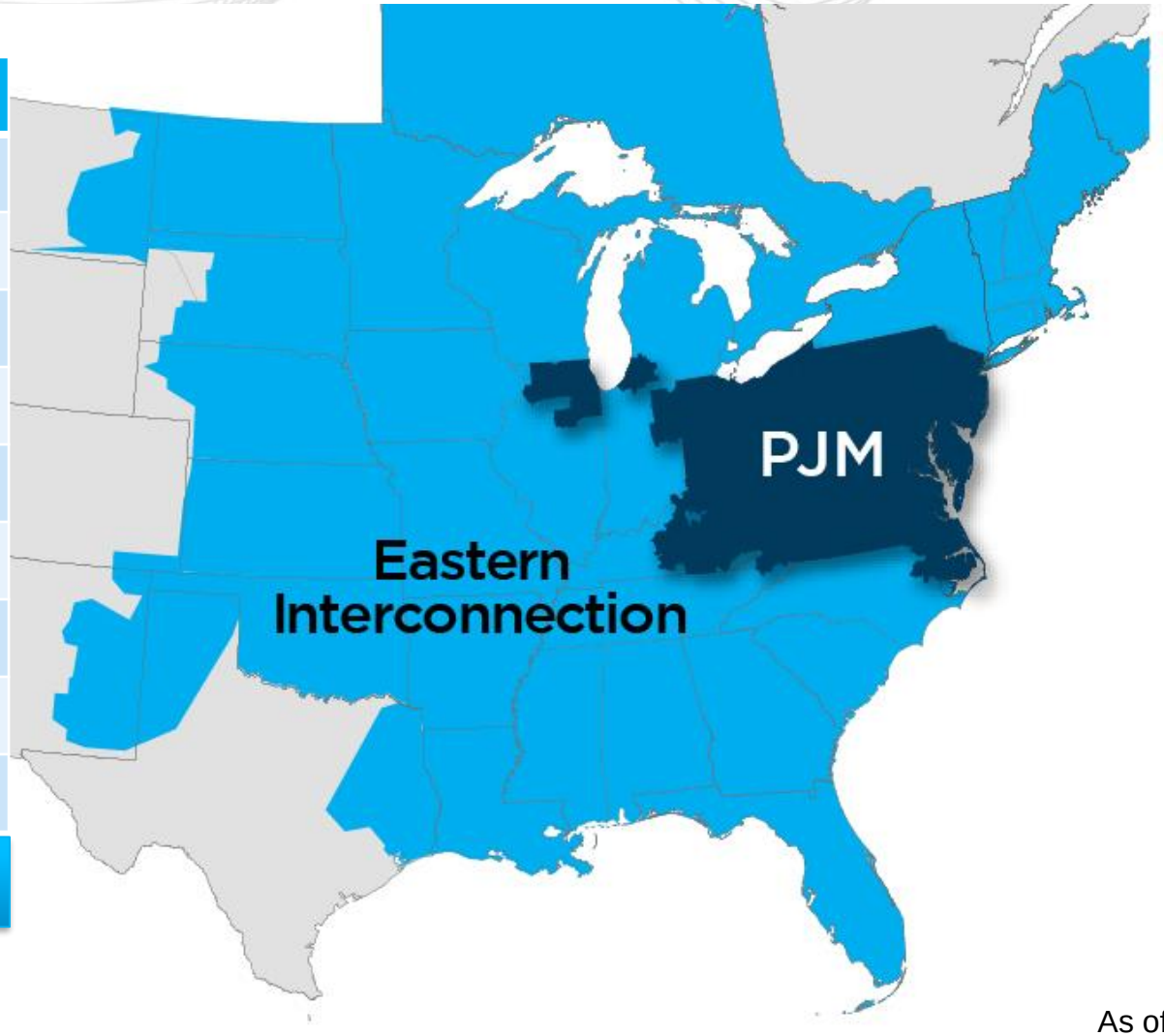
Power Delivery



PJM as Part of the Eastern Interconnection

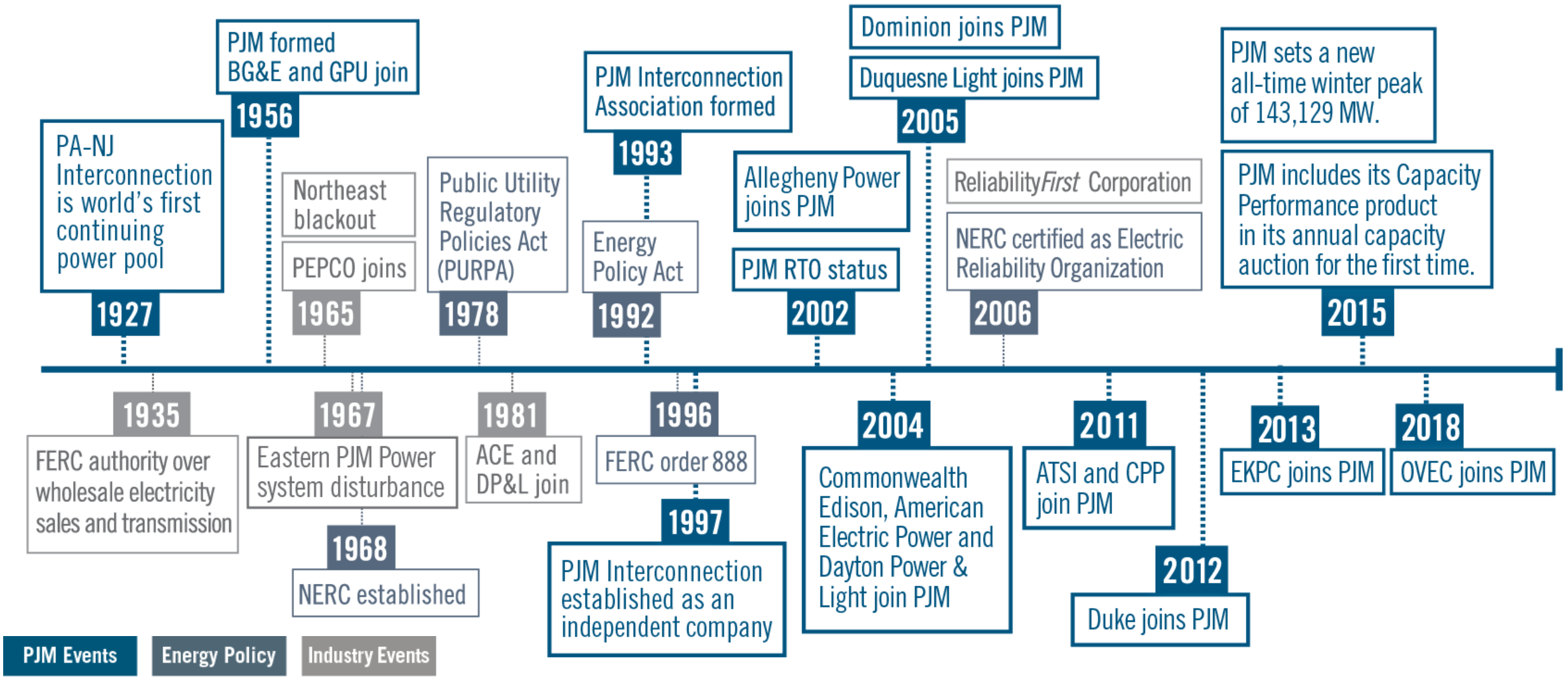
Key Statistics	
Member companies	1,110+
Millions of people served	65+
Peak load in megawatts	165,563
Megawatts of generating capacity	183,254
Miles of transmission lines	88,115
2020 gigawatt hours of annual energy	795
Generation sources	1,419
Square miles of territory	368,906
States served	13 + DC

21% of U.S. GDP produced in PJM



As of 2/2023

The History of PJM



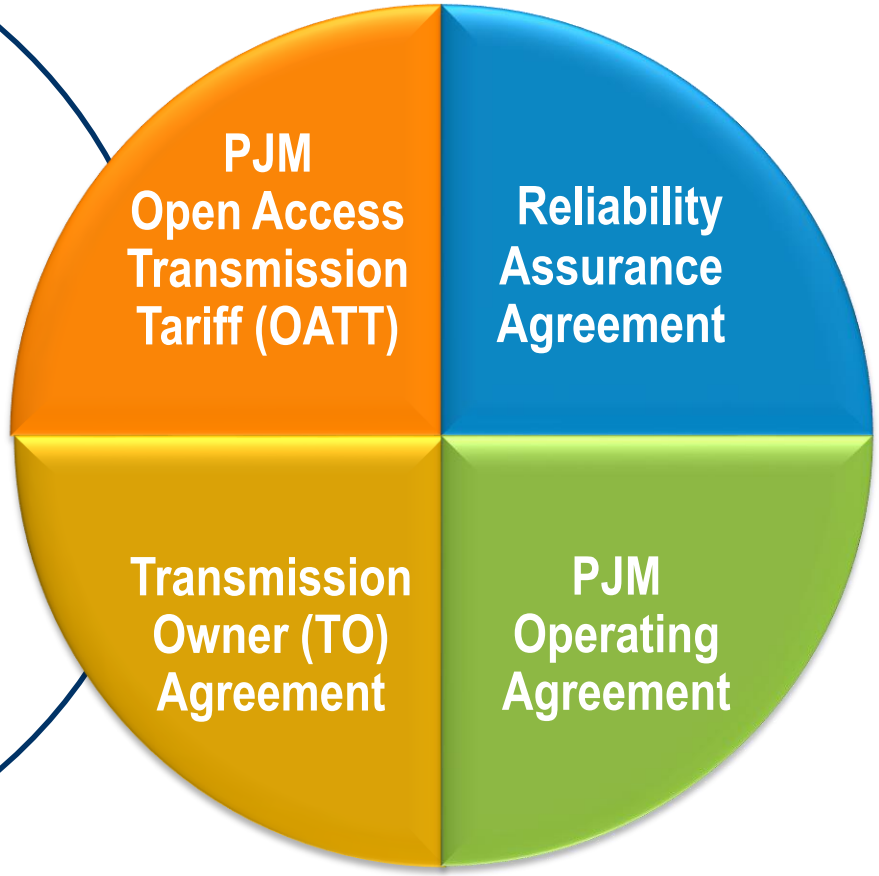
How Is PJM Different from Other Utility Companies?

PJM Does:

- Direct operation of the transmission system
- Remain profit-neutral
- Maintain independence from PJM members
- Coordinate maintenance of grid facilities

PJM Does *NOT:*

- Own any transmission or generation assets
- Function as a publicly traded company with shareholders and concerns around "earnings"
- Perform maintenance on generators or transmission systems (e.g., repair power lines)
- Serve or direct any end-use customers (retail)



PJM – Primary Focus

RELIABILITY

PJM's Role as a Regional Transmission Organization

PLANNING

Planning for the future like...

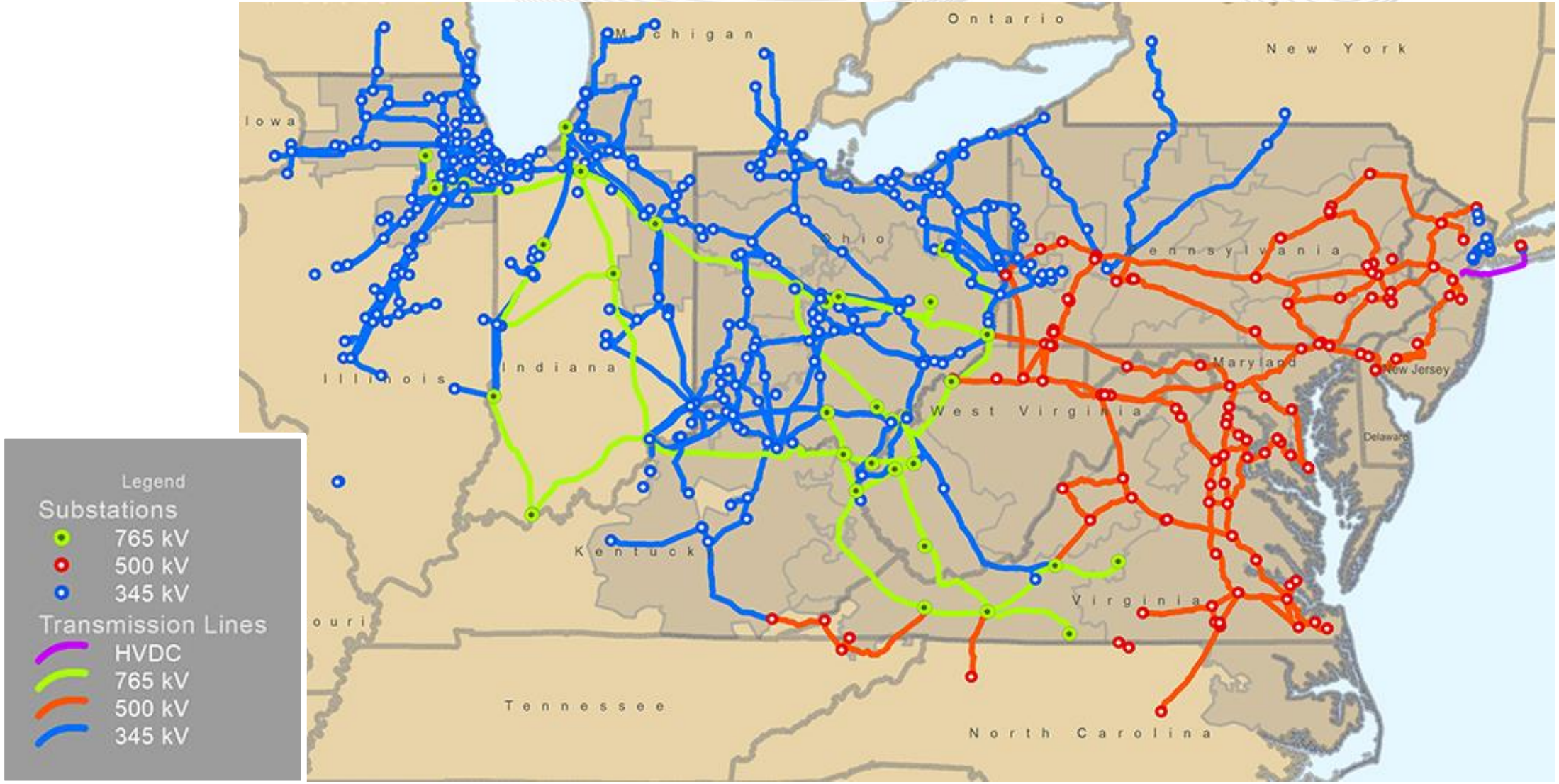
OPERATIONS

Matches supply with demand like...

MARKETS

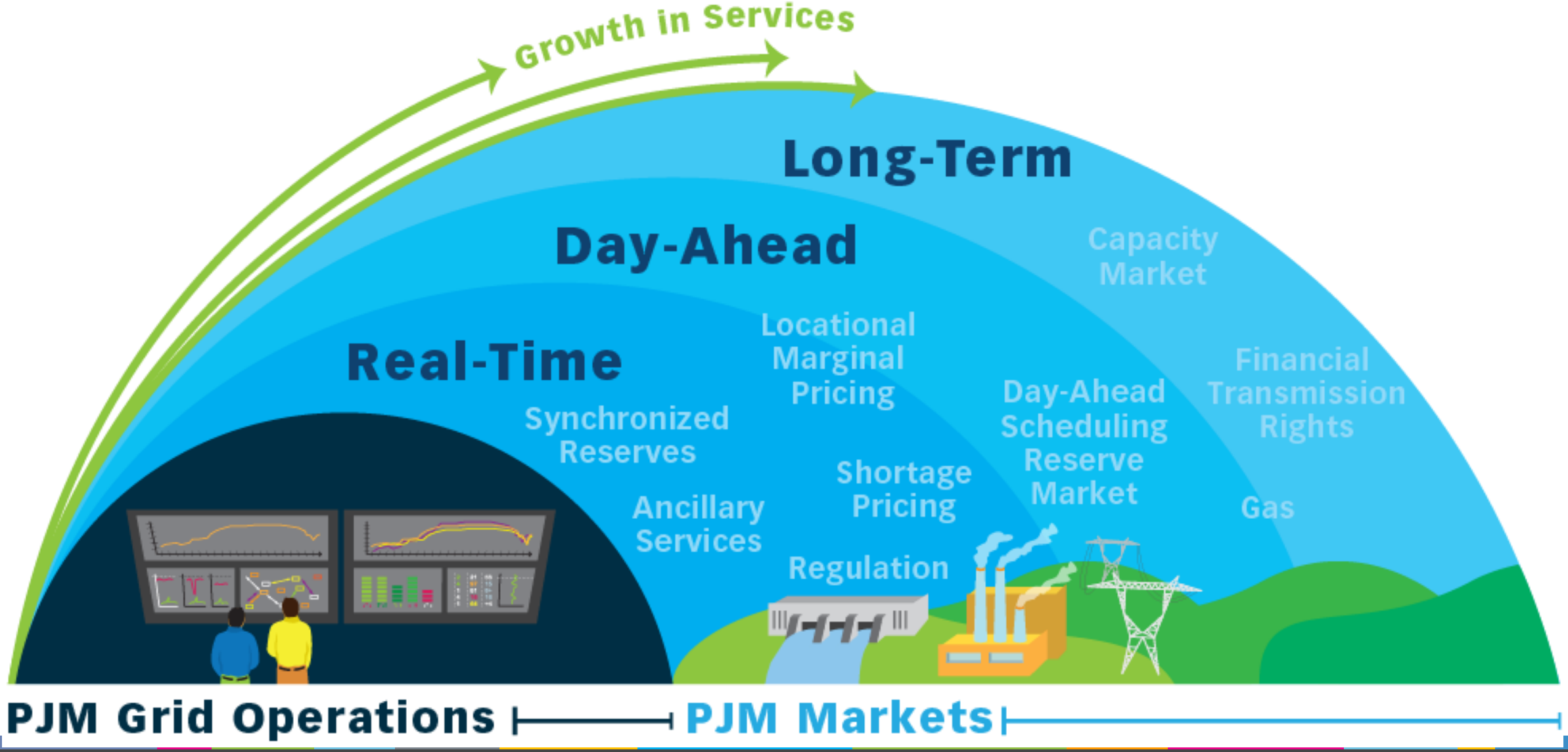
Energy Market Pricing like...

Transmission Planning

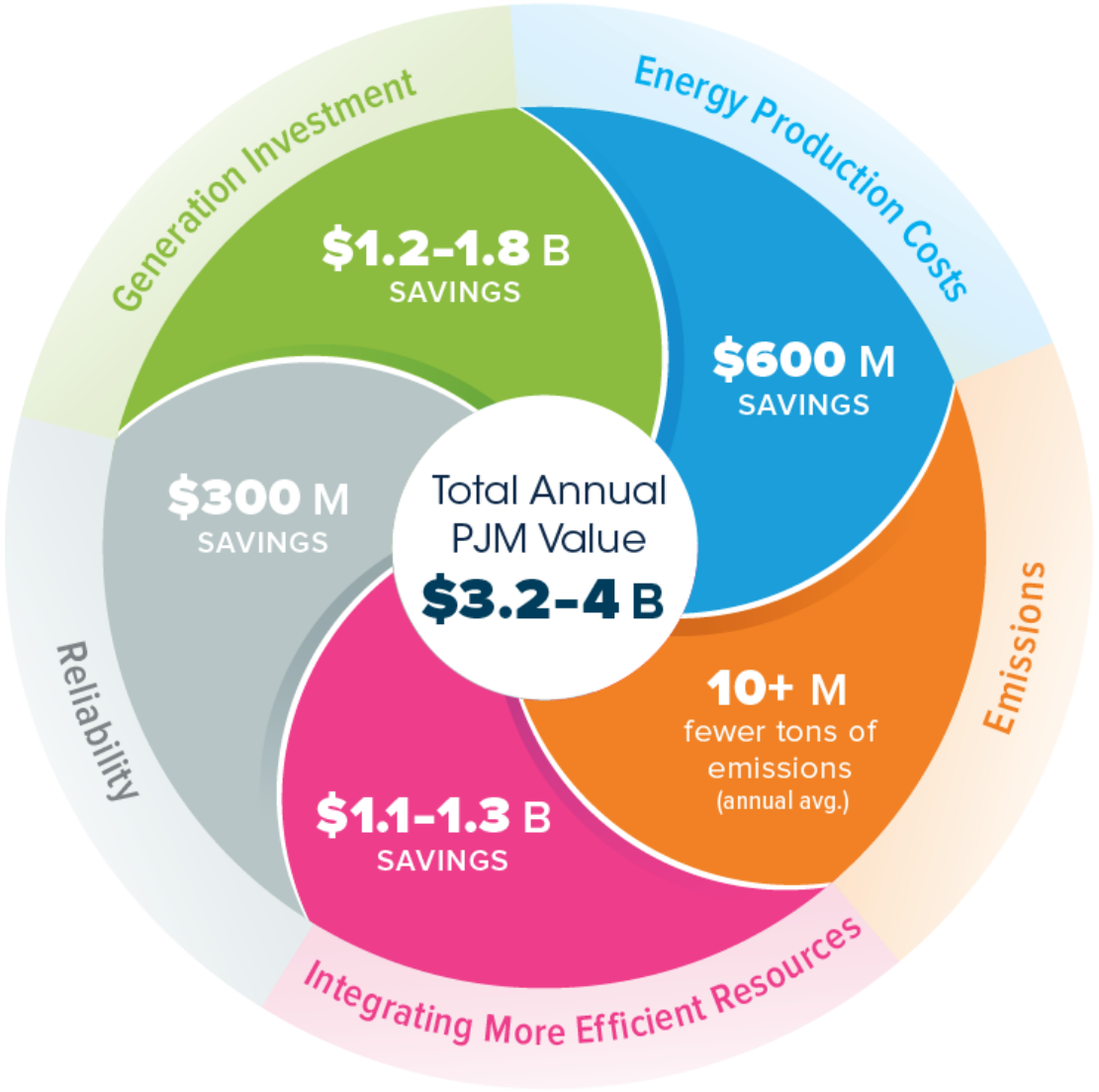


System Operations

Markets

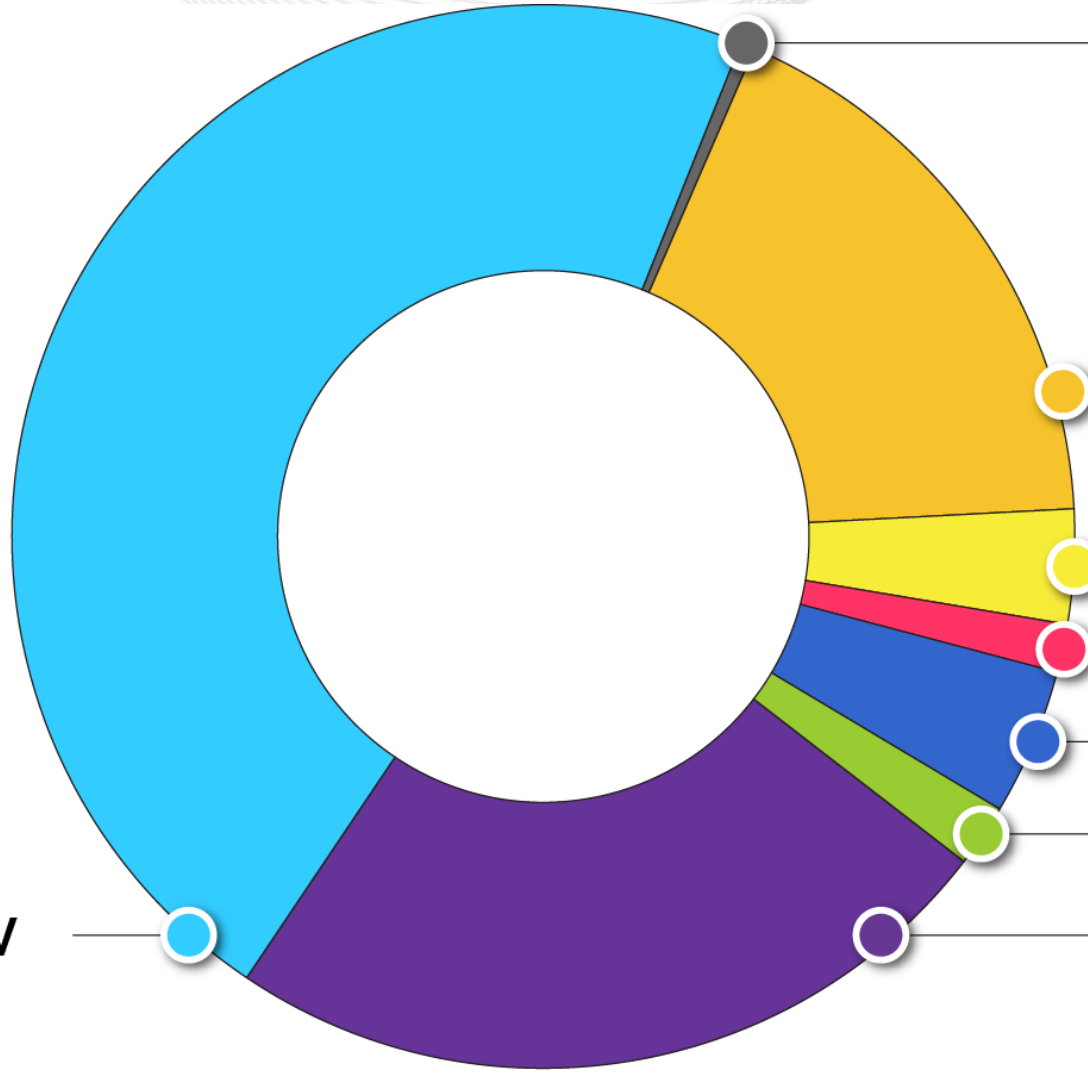


Value Proposition



All numbers are estimates.

PJM Existing RPM-Eligible Installed Capacity Mix



Waste, **802 MW**

Nuclear, **32,649 MW**

Oil, **6,424 MW**

Solar, **2,707 MW**

Hydro, **8,238 MW**

Wind, **3,508 MW**

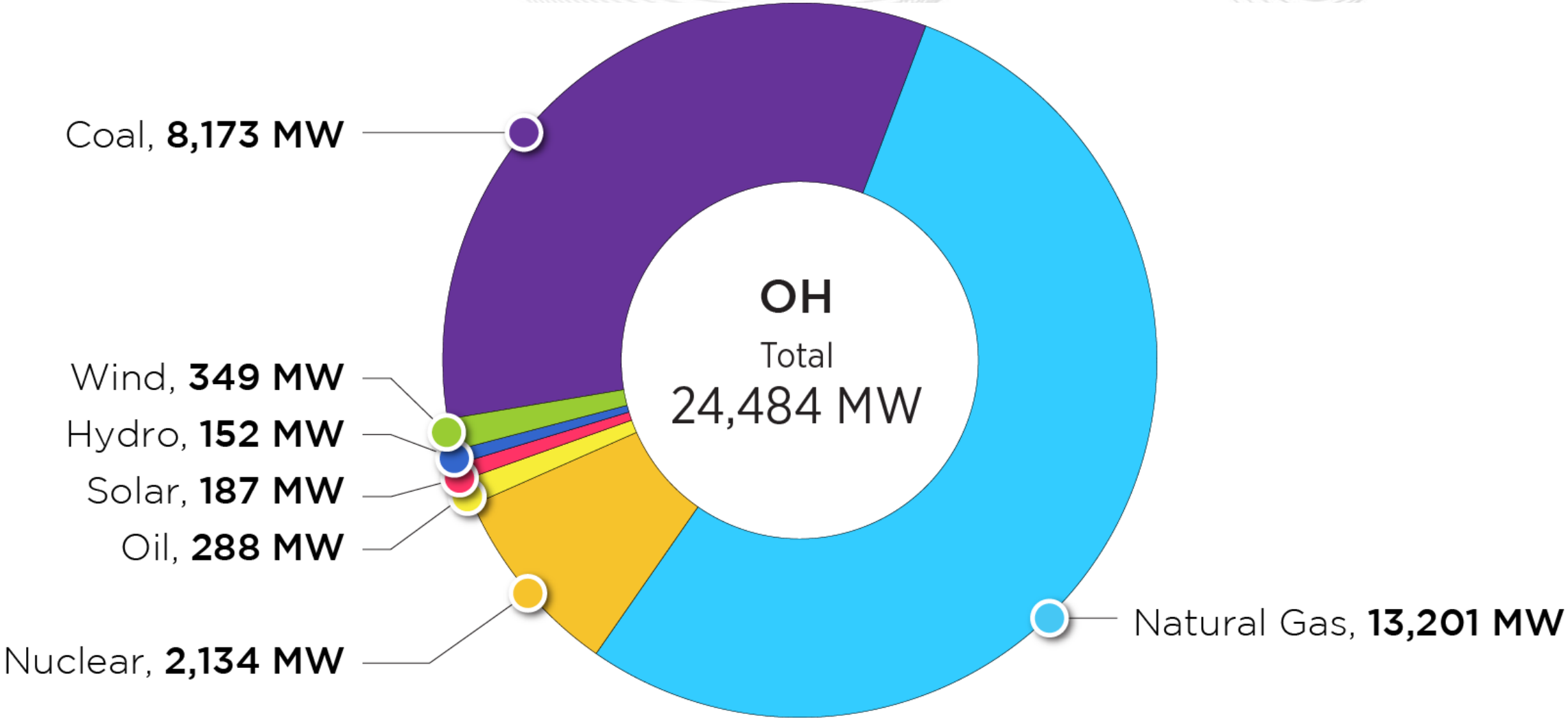
Coal, **44,293 MW**

Natural Gas, **86,212 MW**

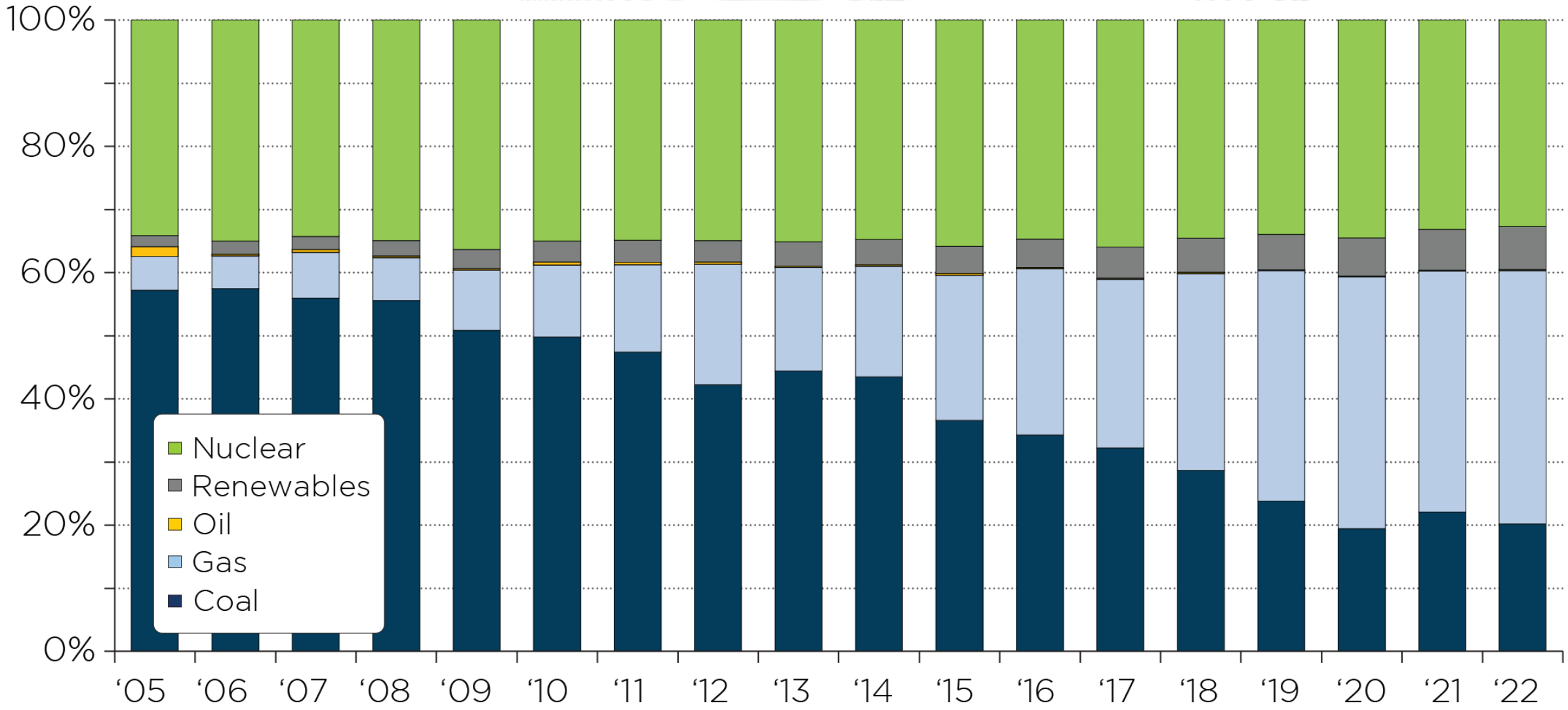
As of Dec. 31, 2022

Ohio – Existing Installed Capacity

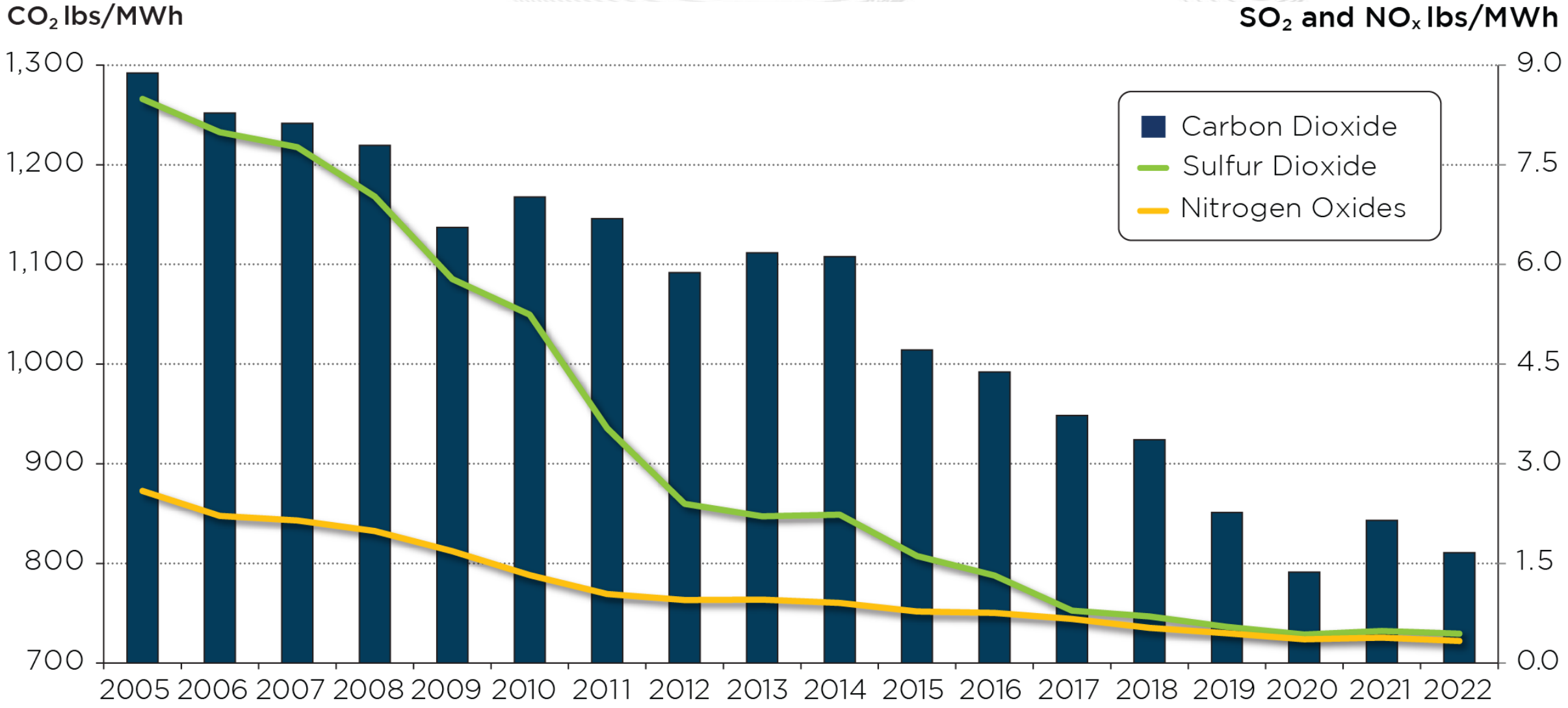
(CIRs – as of Dec. 31, 2022)



2005–2022 Annual Fuel Mix

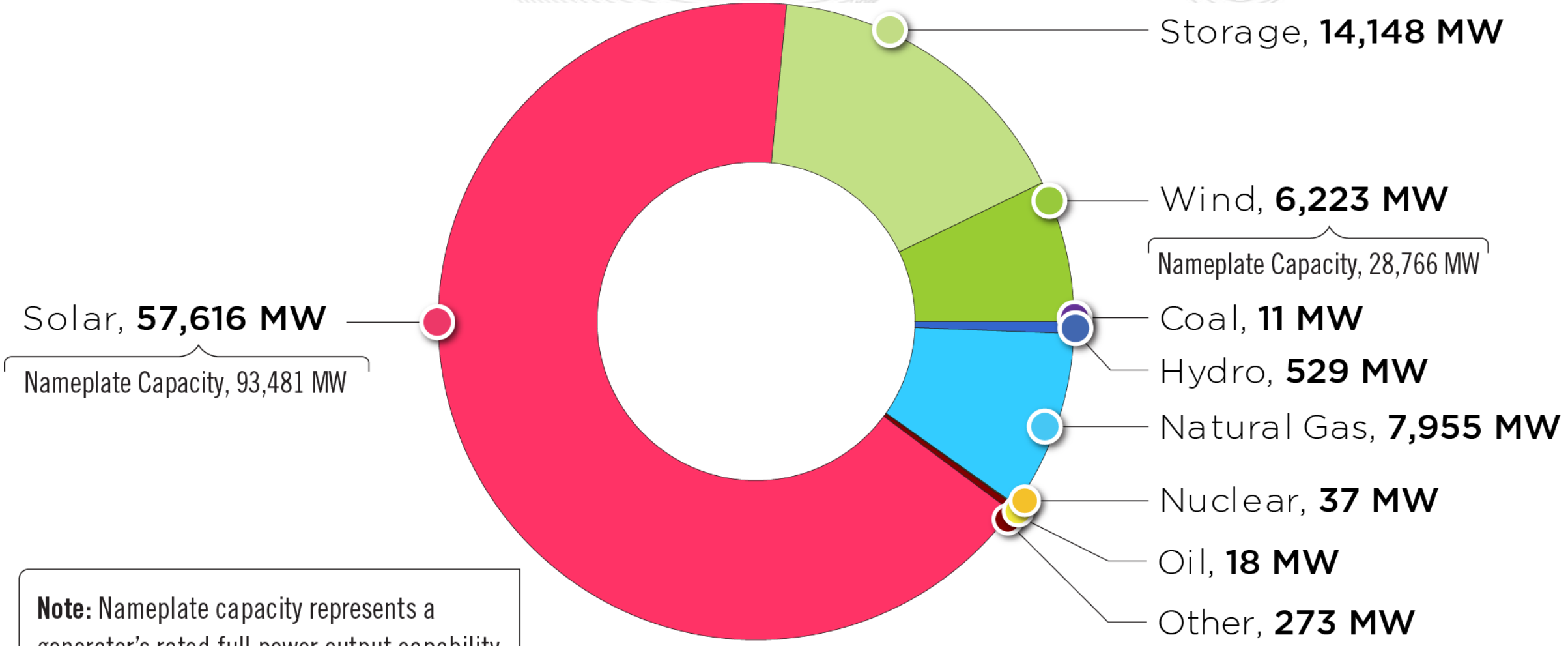


PJM System Average Emission Rates



Queued Generation Fuel Mix –

Requested Capacity Interconnection Rights

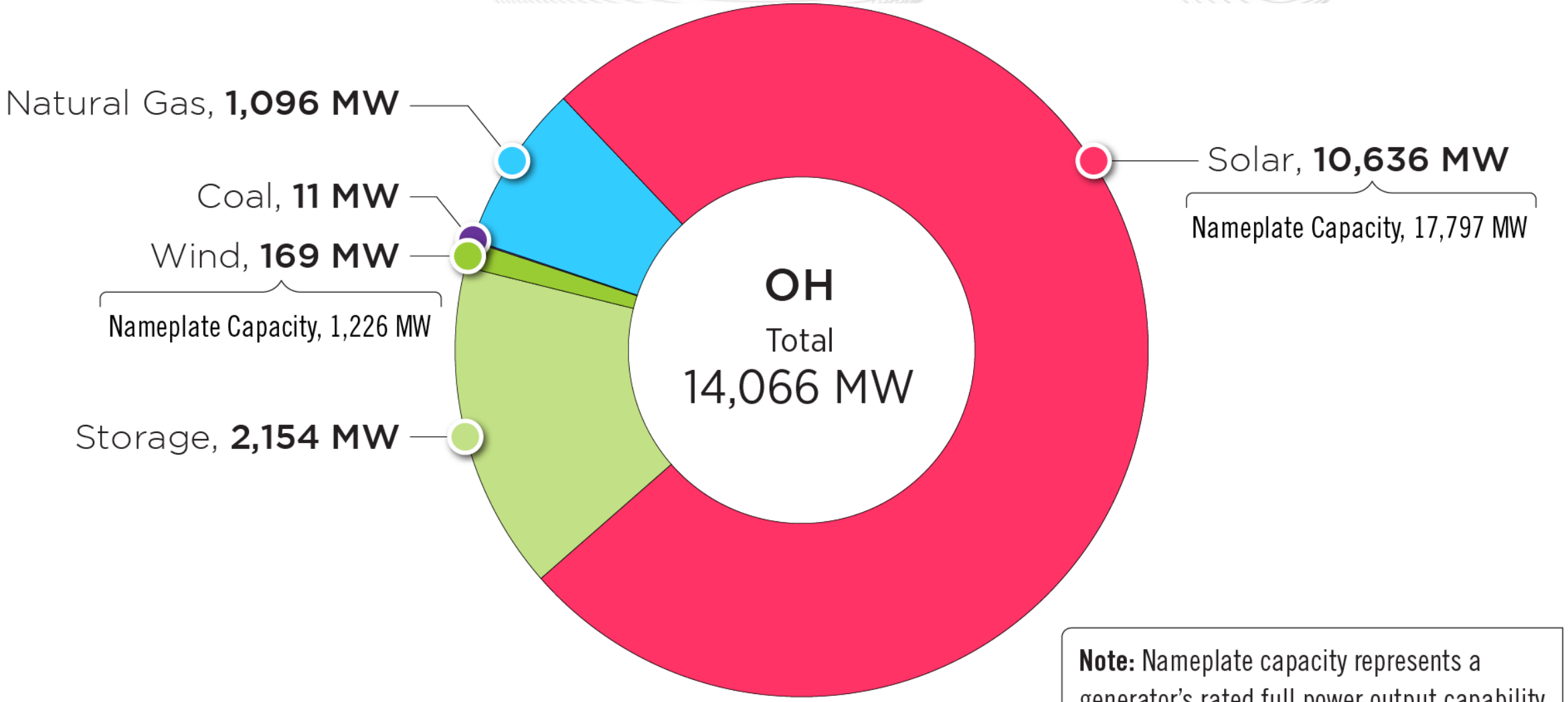


Note: Nameplate capacity represents a generator's rated full power output capability.

As of Dec. 31, 2022

Ohio – Queued Capacity (MW) by Fuel Type

(Requested CIRs – as of Dec. 31, 2022)



Note: Nameplate capacity represents a generator's rated full power output capability.

Why a Paper on Reliability?

- **To educate!** Reliability needs to be kept in the forefront during the significant change in the energy industry.
- Recognition that we will need to adapt our practices as well.
- It is a mutual interest among all policymakers and stakeholders.

Building Blocks of Reliability

Adequate Supply

Resources to reliably power the system and meet customer demand

Accurate Forecasting

Projection of future customer demand and system needs

Robust Transmission

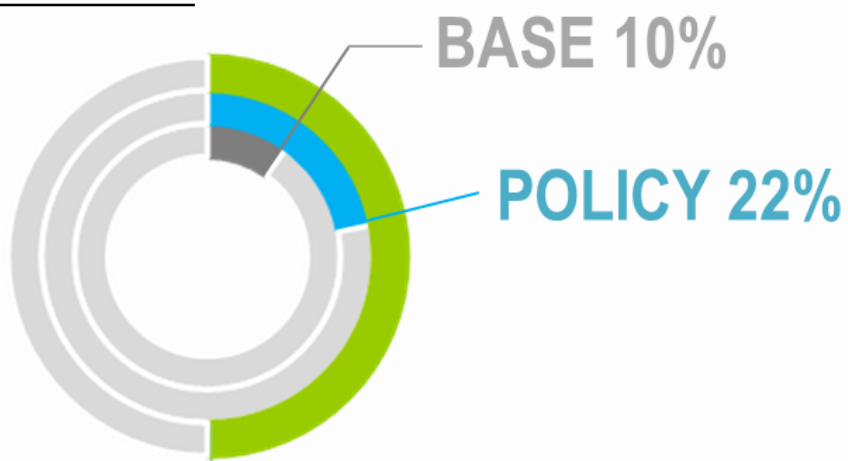
Reliable delivery of power across the grid and to customers via local distribution companies

Reliable Operations

Monitoring and dispatch of the system by trained operators

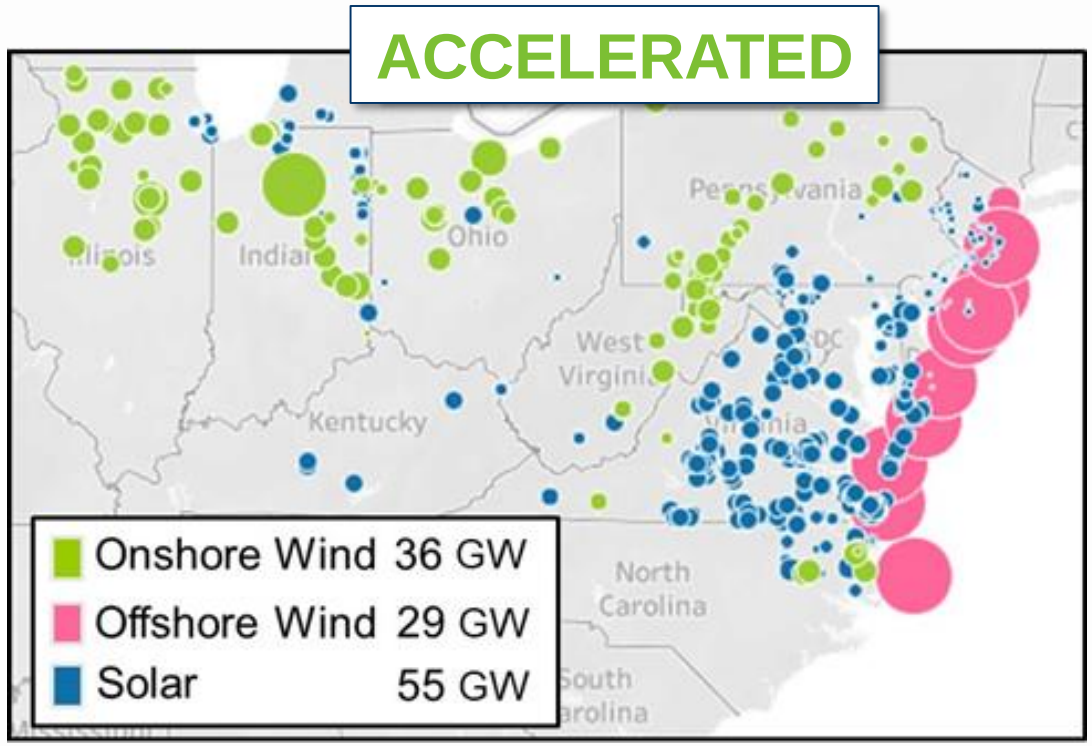
Energy Transition in PJM 1.0

"Living study" to identify gaps and opportunities. The initial findings should not be regarded as expected outcomes, but as bookends to be refined as the study progresses.



Renewable Scenarios
(Annual Energy)

- 130% Instantaneous peak
- 70% Carbon-free



Note: Policies and Market rules "as-is" April 2020.

Energy Transition in PJM Study 1.0 – Initial Findings

Correctly Calculating Capacity Contribution of Generators is Essential

Flexibility Becomes Increasingly Important with Growing Uncertainty

Thermal Generators Provide Essential Reliability Services & an Adequate Supply will be Need Until a Substitute is Deployed at Scale

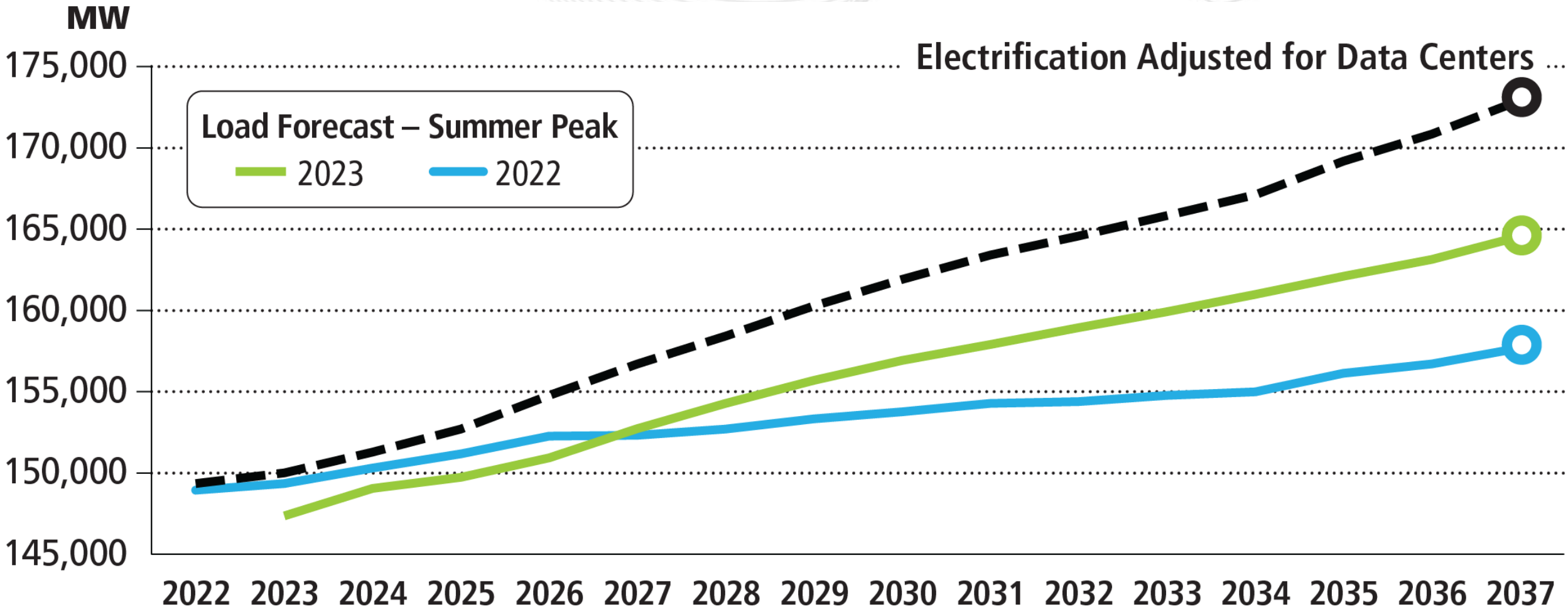
Regional Markets Facilitate a Reliable and Cost-Effective Energy Transition

Reliability Standards Must Evolve

PJM Energy Transition: Resource Retirements, Replacements and Risks (4R)

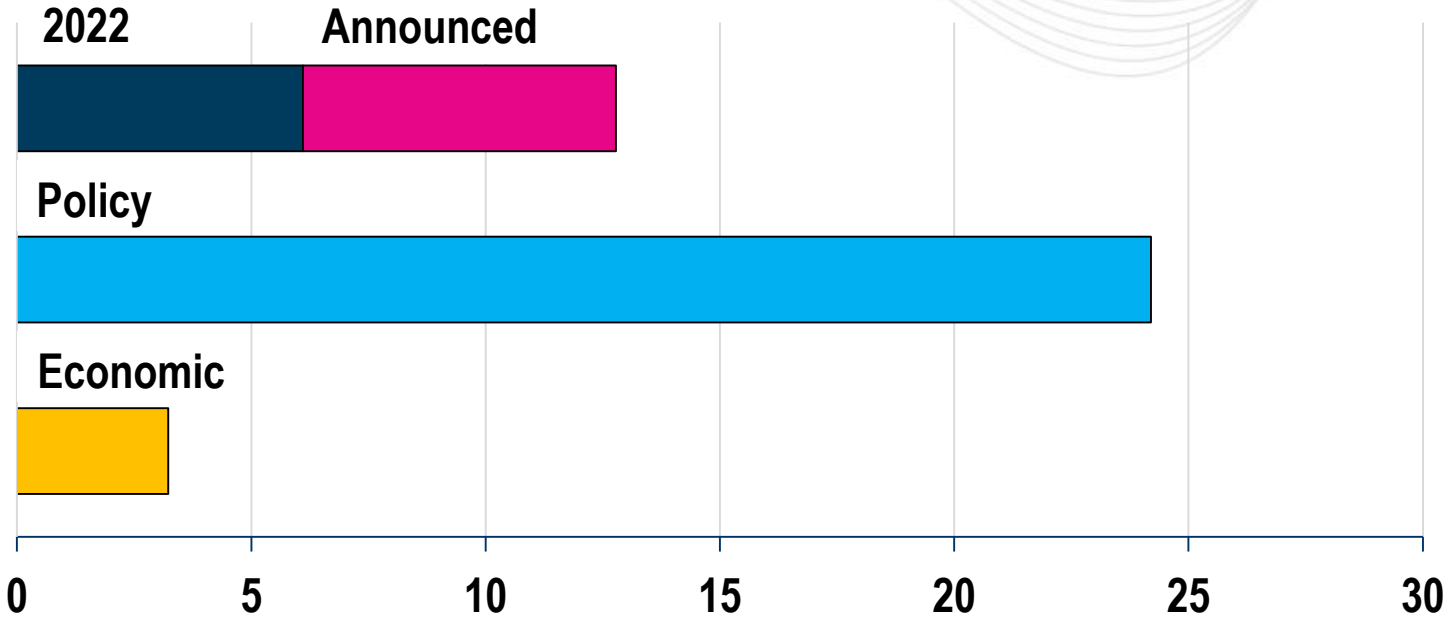
Release whitepaper
February 24

Load Growth Forecasts

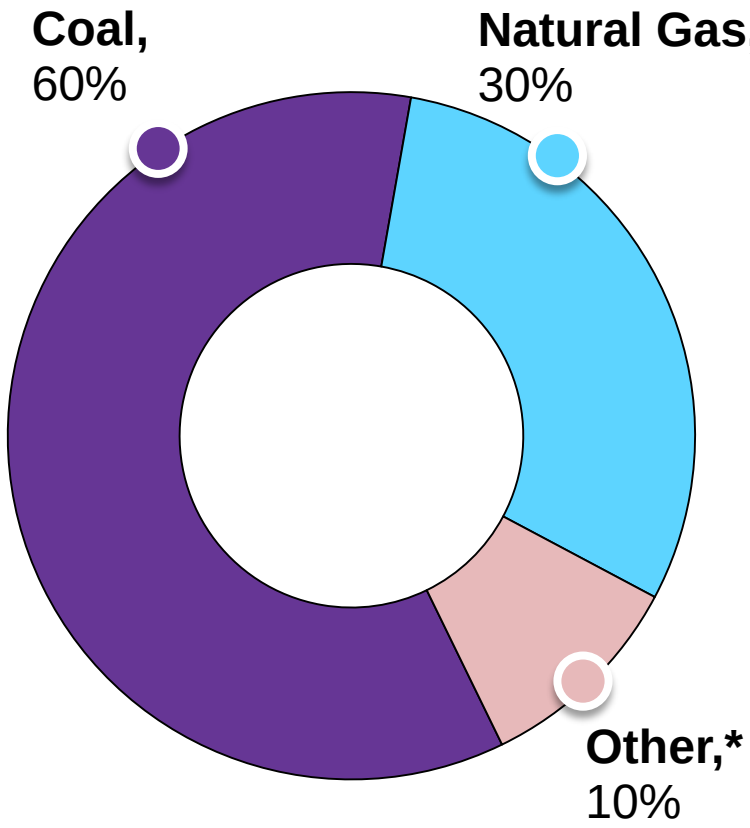


Forecasted Retirements (2022–2030)

Total Forecasted Retirement Capacity (GW)

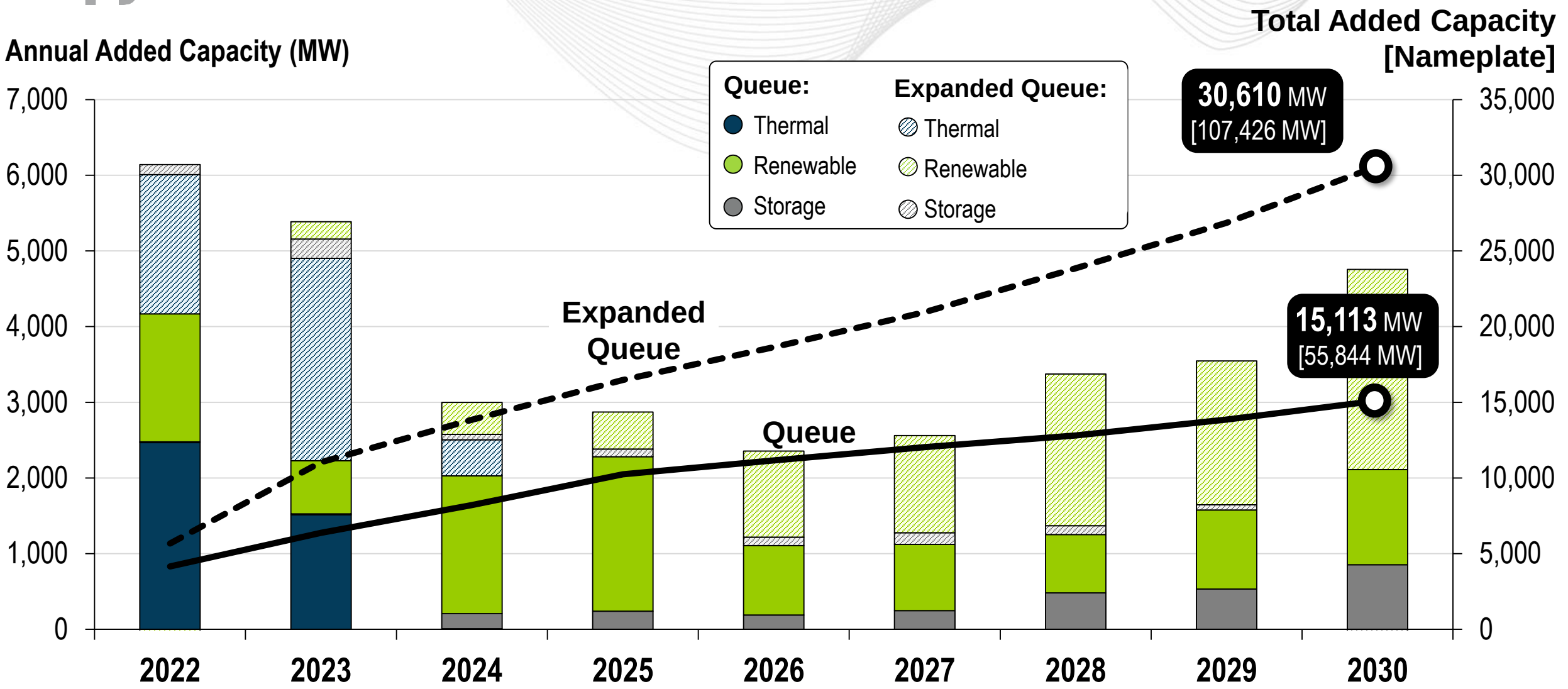


This **40 GW** represents
21% of PJM's current
192 GW of installed generation



*Other includes diesel, etc.

PJM Forecasted New Entry (2022–2030)



Energy Transition in PJM 2.5 - Findings

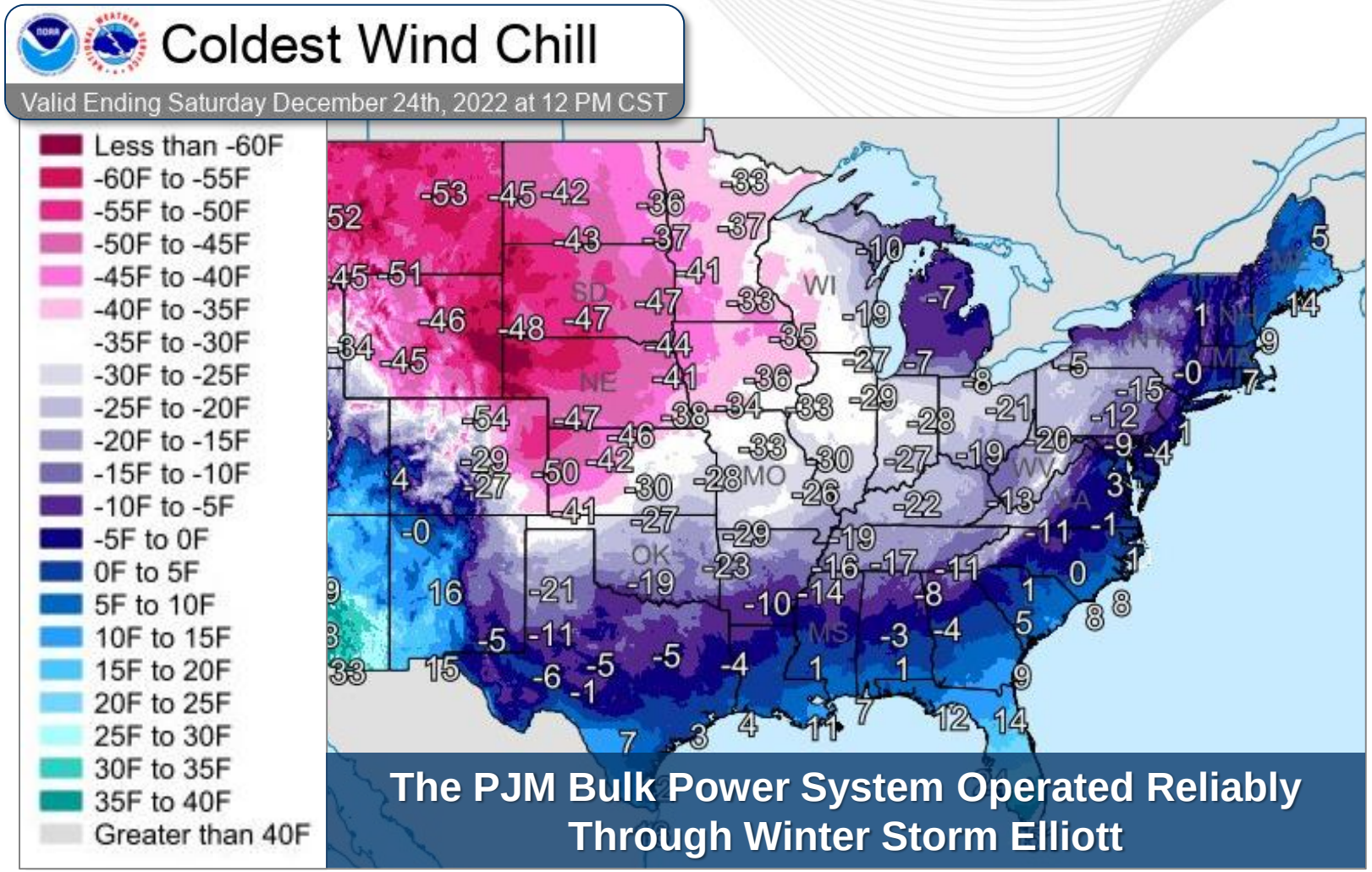
The composition and performance characteristics of the resource mix will ultimately determine PJM's ability to maintain reliability.

Resource retirements and load growth could potentially outpace new entry (at the current pace of new entry, resource adequacy risks could emerge by 2028-2030).

There is a need, and a sense of urgency, for continued actions to shape the future of resource adequacy and maintain reliability:

- Resource Adequacy Senior Task Force
- Clean Attribute Procurement Senior Task Force
- Interconnection Process Subcommittee

Winter Storm Elliott

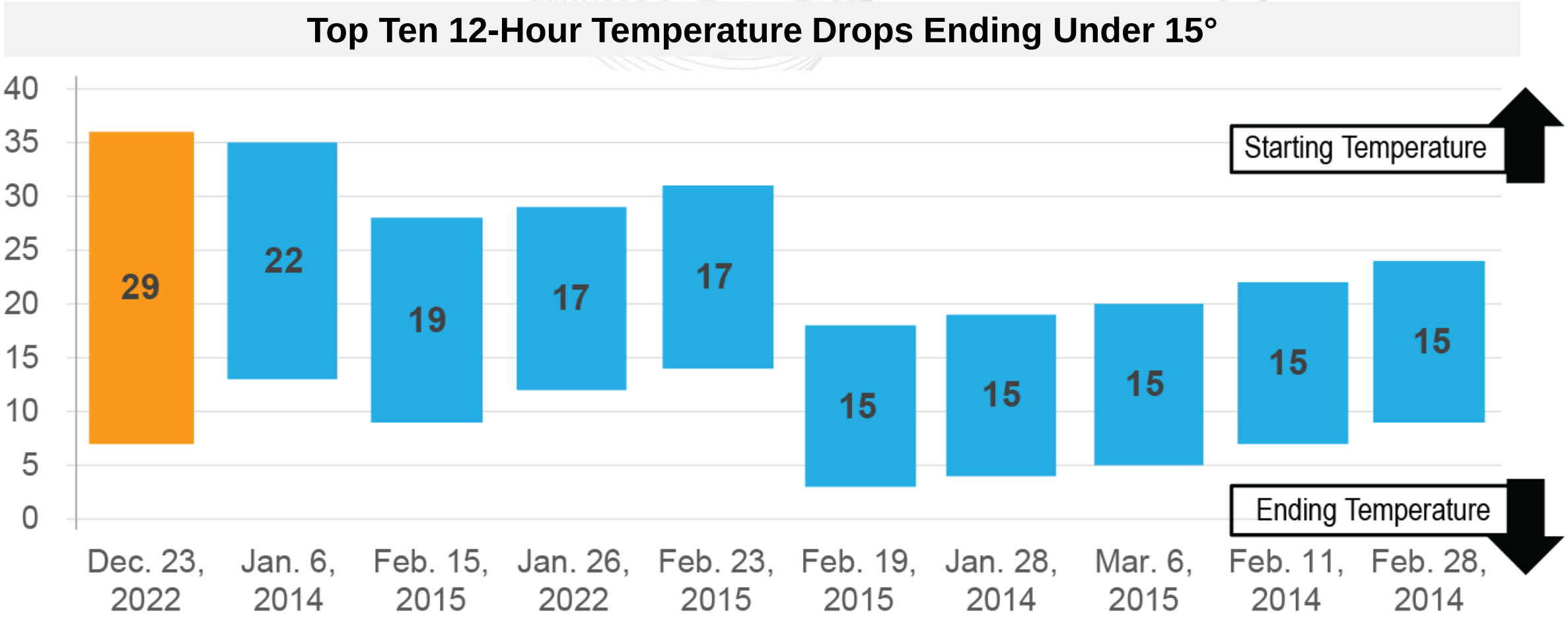


Source: NOAA

Temperatures across the RTO plummeted beginning on Dec. 23 and lasted into the morning of Dec. 25 with record lows in some areas as well as record drops in some regions.

Source: NOAA and the National Weather Service; Graphic created on Dec. 21, 2022.

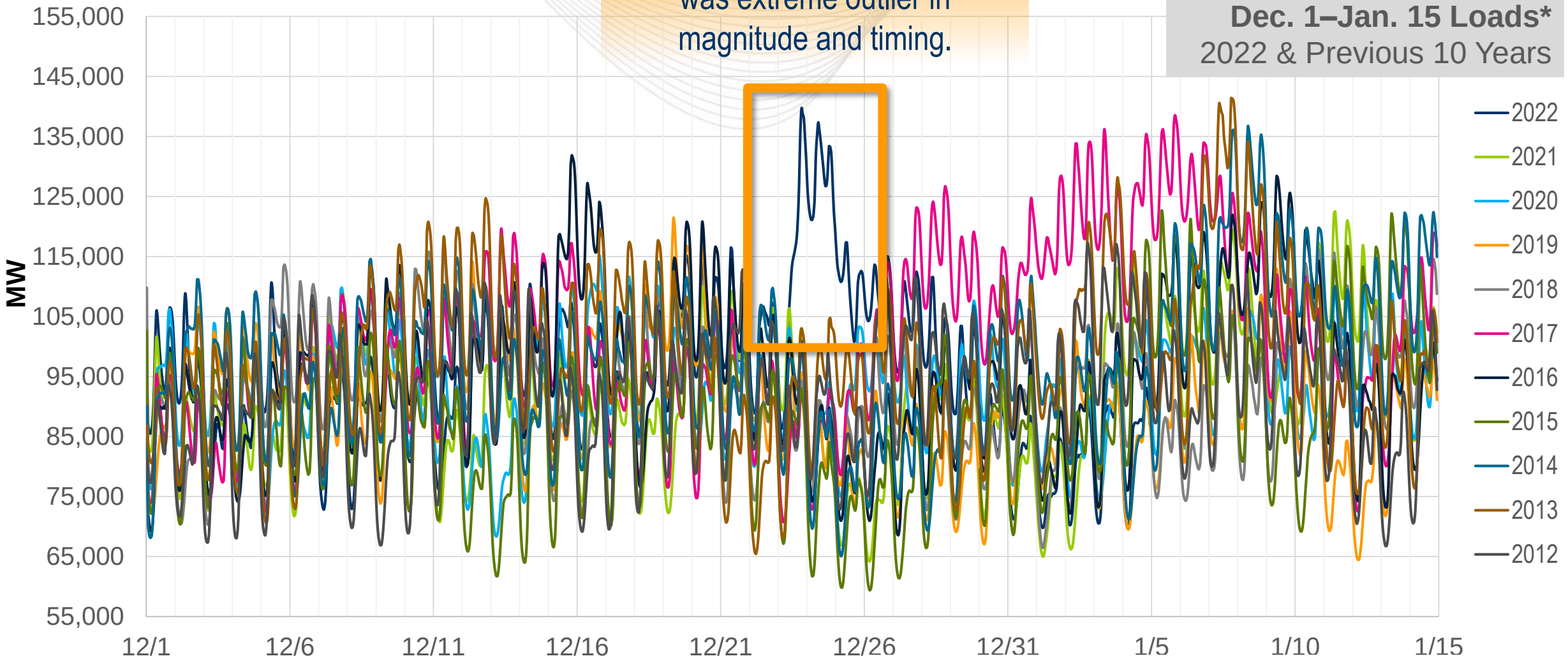
Most Drastic Temperature Drop in a Decade



2022 Holiday Load
(Preliminary Data)

2022 holiday weekend load was extreme outlier in magnitude and timing.

Dec. 1–Jan. 15 Loads*
2022 & Previous 10 Years



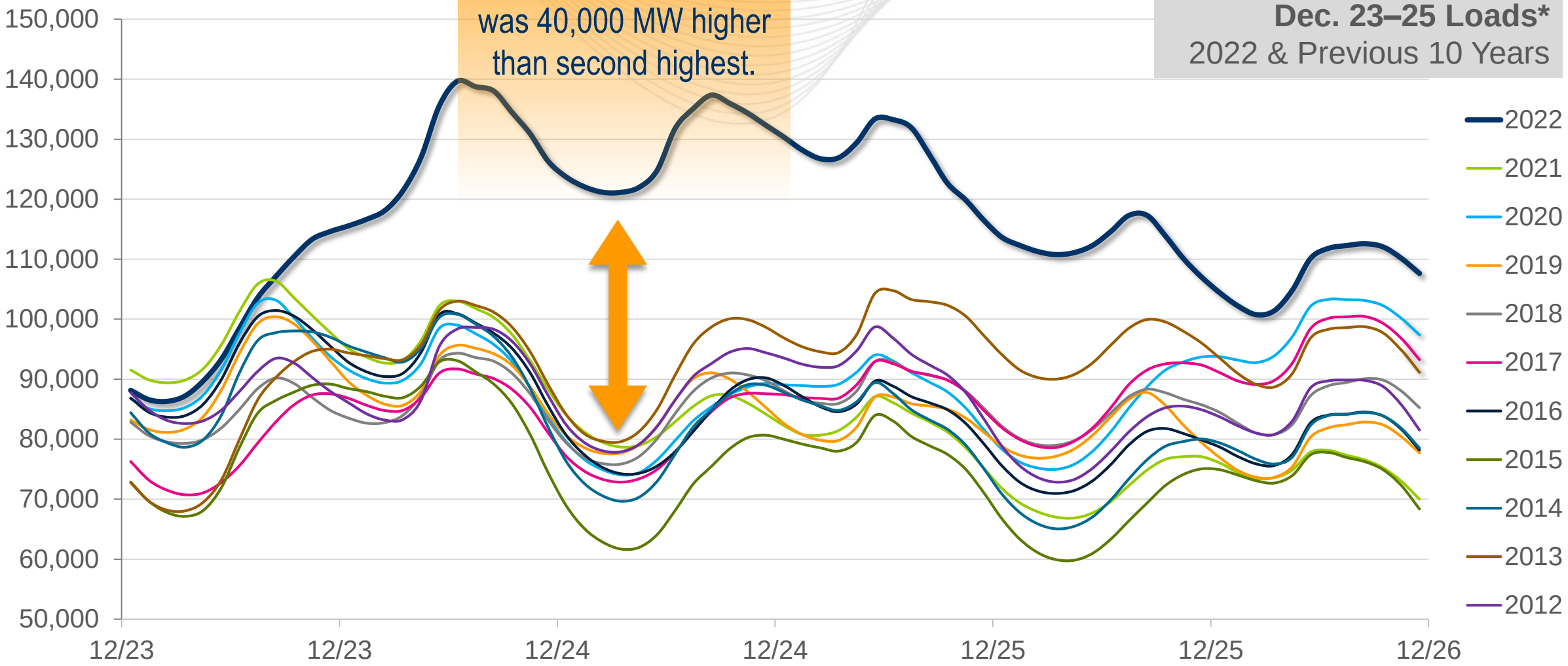
*Note: Load values include the estimated demand response (DR) added back.

Load Stayed Unusually High Overnight

(Preliminary Data)

Christmas Eve valley was 40,000 MW higher than second highest.

Dec. 23–25 Loads*
2022 & Previous 10 Years



*Note: Load values include the estimated demand response (DR) added back.

PJM Prepares Extensively for the Winter

Winter readiness assessments: data collection on fuel inventory, supply and delivery characteristics, emissions limitations, and minimum operating temperatures

Meetings with federal and state regulators and neighboring systems to review winter preparations; weekly operational review meetings with major natural gas pipeline operators

PJM's Cold Weather Preparation Guideline and Checklist for generation owners includes everything from increasing staffing for weather emergencies to performing required maintenance activities.

April 2023 NERC winterization standard implementation is important. PJM feedback to NERC and FERC: New reliability standards need to be stronger and implemented sooner.

Prior to Storm, PJM Issued Winter Advisory and Alerts

Dec. 20, 2022

Cold Weather Advisory for Western Region From Dec. 23–26 (Later Expanded to Entire RTO)

- Prepare to take freeze-protection actions, such as erecting temporary windbreaks or shelters, positioning heaters, verifying heat trace systems, or draining equipment prone to freezing.
- Review weather forecasts, determine any forecasted operational changes, and notify PJM of any changes.
- Members are to update PJM with operation limitations associated with cold weather preparedness. Operating limitations include: generator capability and availability, fuel supply and inventory concerns, fuel switching capabilities, environmental constraints, generating unit minimums.

Dec. 21, 2022

Cold Weather Alert Issued for the Western Region for Dec. 23

- Generation dispatchers review fuel supply/delivery schedules in anticipation of greater-than-normal operation of units.
- Generation dispatchers monitor and report projected fuel limitations to PJM dispatcher and update the unit Max Run field in Markets Gateway if less than 24 hours of run time remaining.
- Generation dispatchers contact PJM Dispatch if it is anticipated that spot market gas is unavailable, resulting in unavailability of bid-in generation.

Dec. 23, 2022

Second Cold Weather Alert Issued for the Entire RTO for Christmas Eve, Dec. 24

PJM's Dec. 23 Operating Plan Was Conservative

PJM accounts for uncertainty and unplanned events as it develops the operating plan for every day.

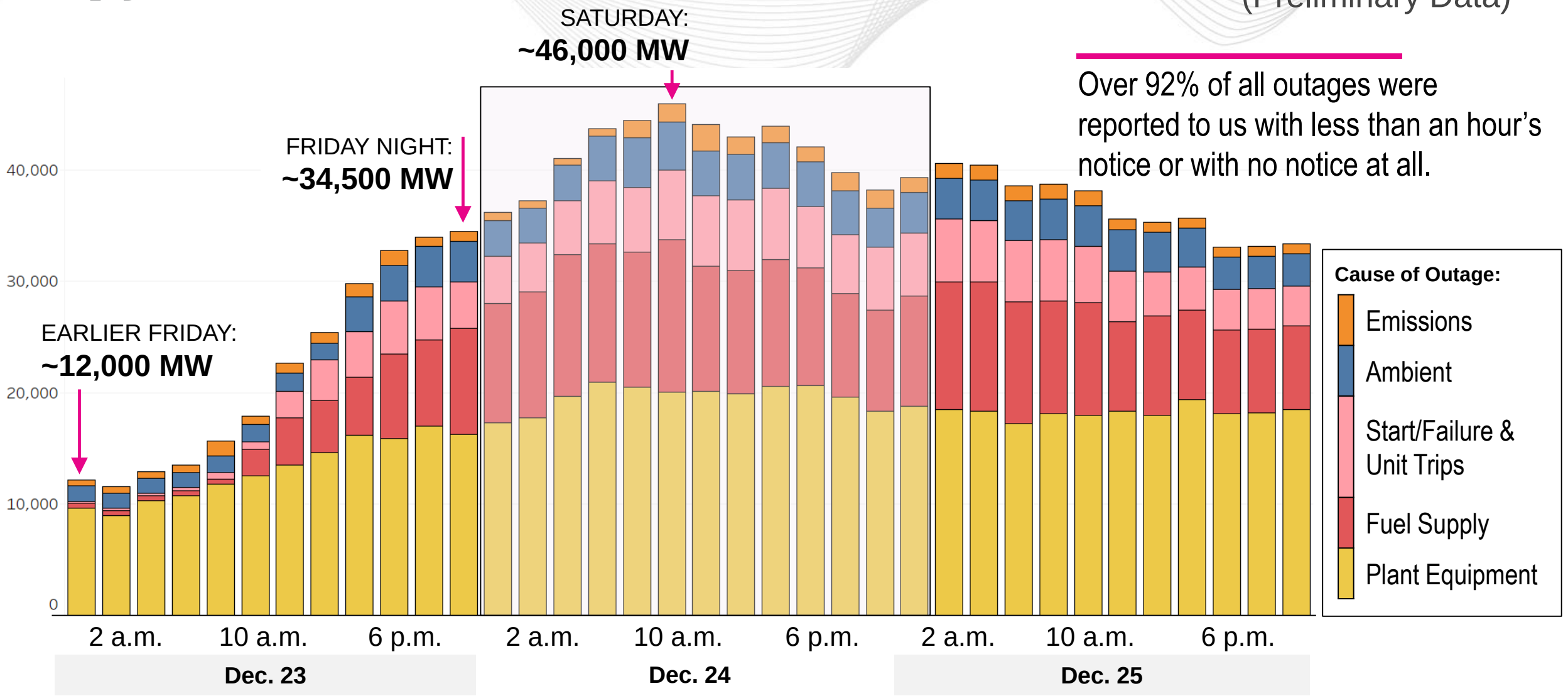
- Given the expected weather, PJM was conservative in developing the operating plans for Dec. 23.
- Forecast load was 126,968 MW.
- PJM called over 155,750 MW into the operating capacity for the day.

Based on generator availability data submitted to PJM, we believed we had almost 29 GW of reserve capacity available to absorb load and generation contingencies and to support our neighboring systems.

Preliminary Data

As We Called Reserves, a Significant Portion of Fleet Failed To Perform

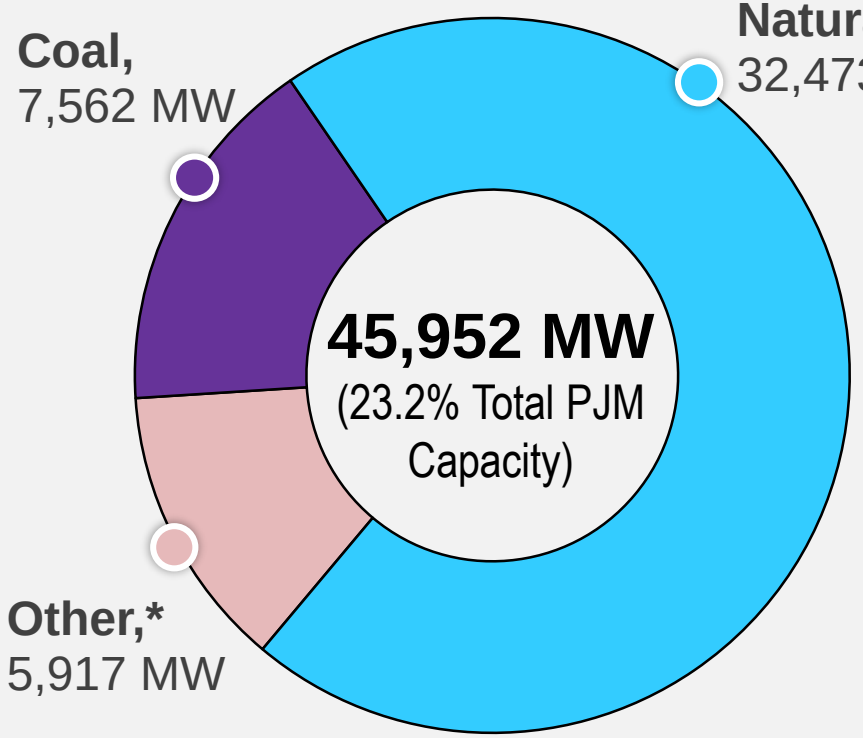
(Preliminary Data)



Over 92% of all outages were reported to us with less than an hour's notice or with no notice at all.

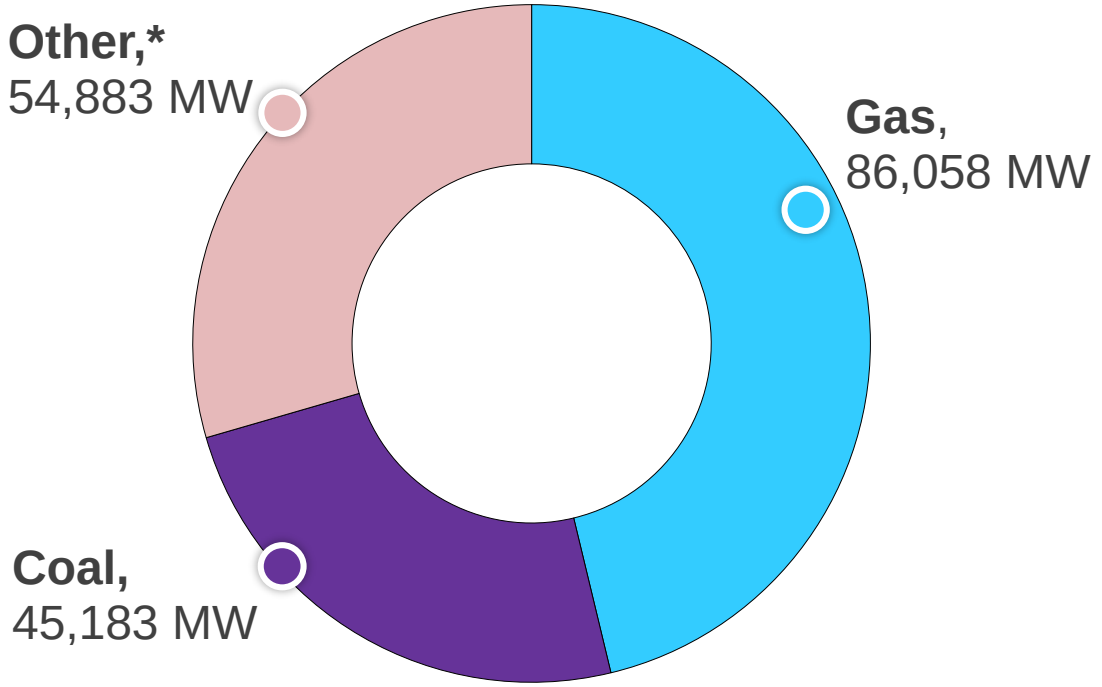
Generator Performance
(Preliminary Data)

TOTAL FORCED OUTAGES – DEC. 24, 2022



*Other = nuclear, oil, wind, solar, etc.

GENERATOR UCAP
2022/2023 DELIVERY YEAR



PJM's Total Fleet Capacity – **186 GW**

Analysis and Lessons Learned

What's next for PJM and members?

Look at some immediate actions to be prepared for the rest of this winter.

- Cold Weather Advisory steps
- Data request from affected resources
- Load forecast approach

PJM is doing a full analysis estimated mid-April.

NERC/FERC has announced a nationwide investigation. PJM has received requests for information from Reliability First and SERC.

Reliability Concerns

1. **Near-Term Reliability: Ensuring Generator Performance**
   We have enough resources and essential reliability services today, but they need to perform (Winter Storm Elliott).
2. **Mid-Term Reliability: Having Enough Resources**
   Resource retirements and load growth could potentially outpace new entry (at the current pace of new entry, resource adequacy risks could emerge by 2028-2030) (PJM Paper: Resource Retirements, Replacements and Risks (4R)).
3. **Long-Term Reliability: Having Enough Resources and Essential Reliability Services**
   Thermal Generators Provide Essential Reliability Services & an Adequate Supply will be Need Until a Substitute is Deployed at Scale (PJM Paper: Energy Transition in PJM 1.0).

PJM Now App Available