

# Overview of Electricity Market Operation

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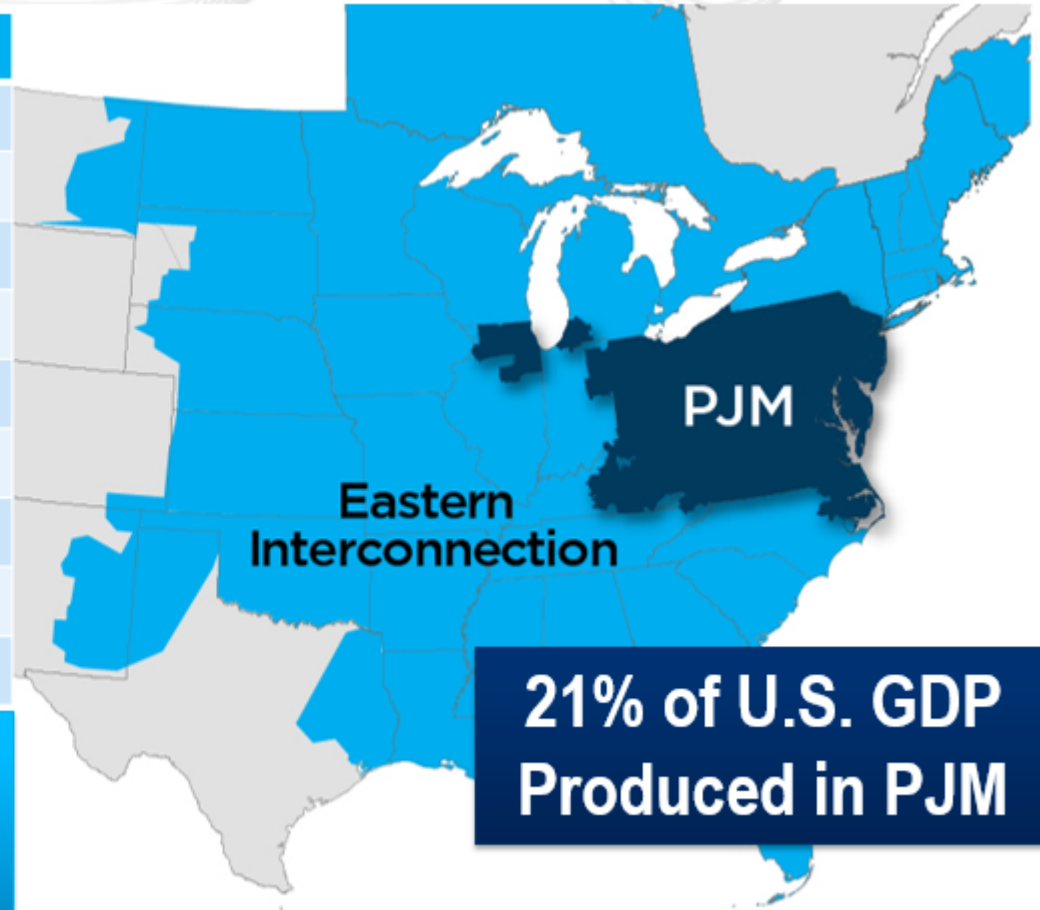
- PJM introduction
- Wholesale electricity markets
- Integrated system and market operation
- Hot topics: uncertainty, renewable, storage, DER
- System operation under extreme weather

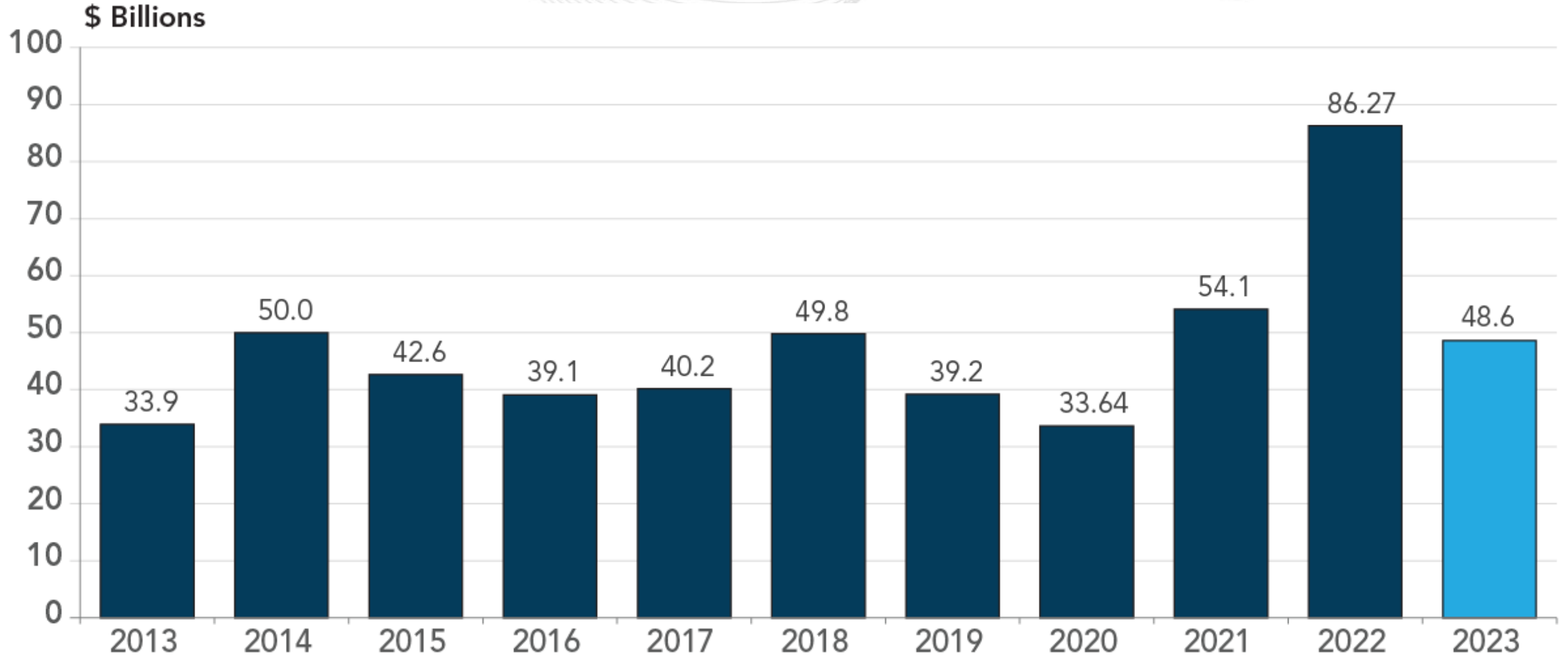
# PJM Introduction

## Key Statistics

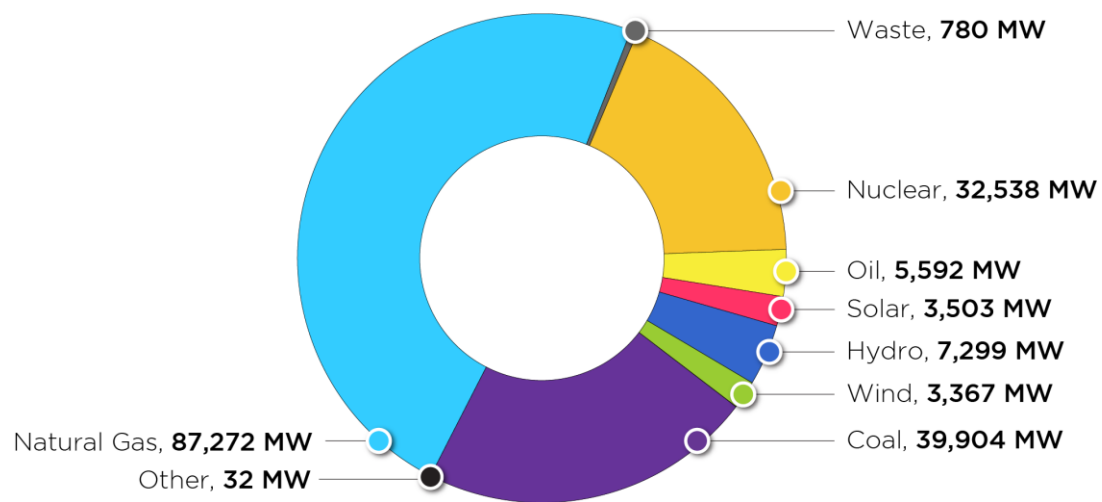
Member companies	1,090
Millions of people served	65+
Peak load in megawatts	165,563
Megawatts of generating capacity	183,254
Miles of transmission lines	88,185
Gigawatt hours of annual energy	770
Generation sources	1,419
Square miles of territory	368,906
States served	13 + DC

- 26% of generation in Eastern Interconnection
- 25% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection

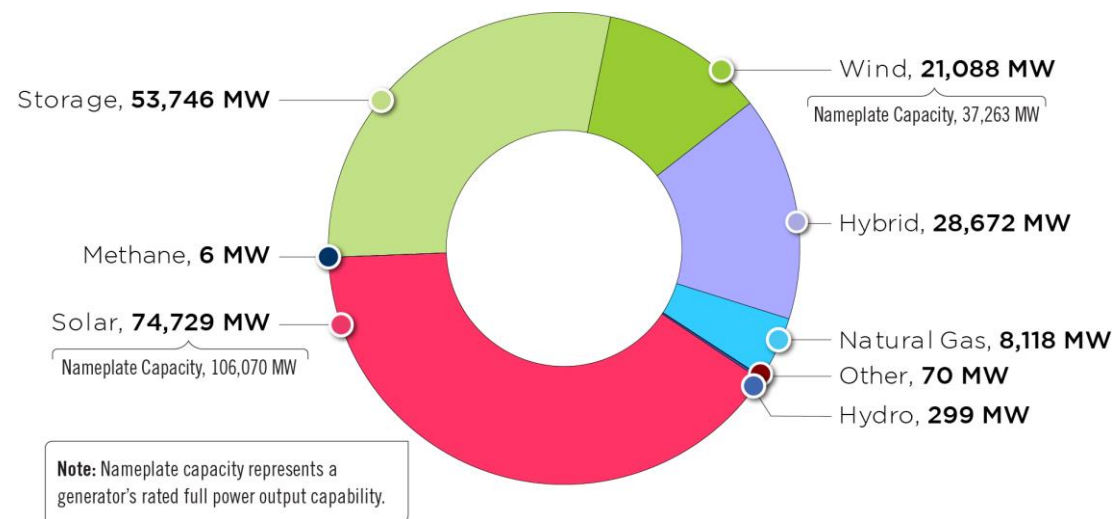




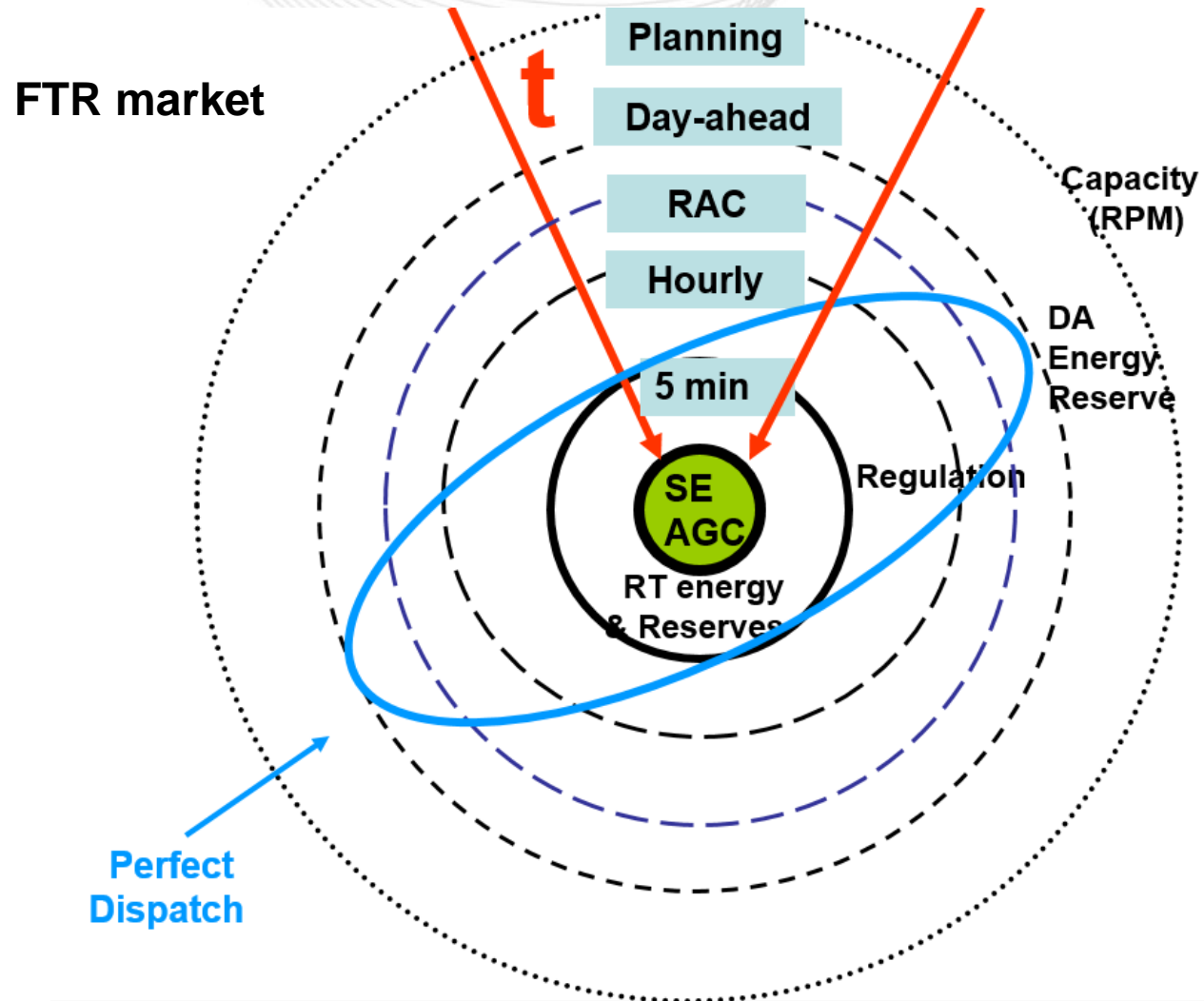
## Existing installed capacity mix



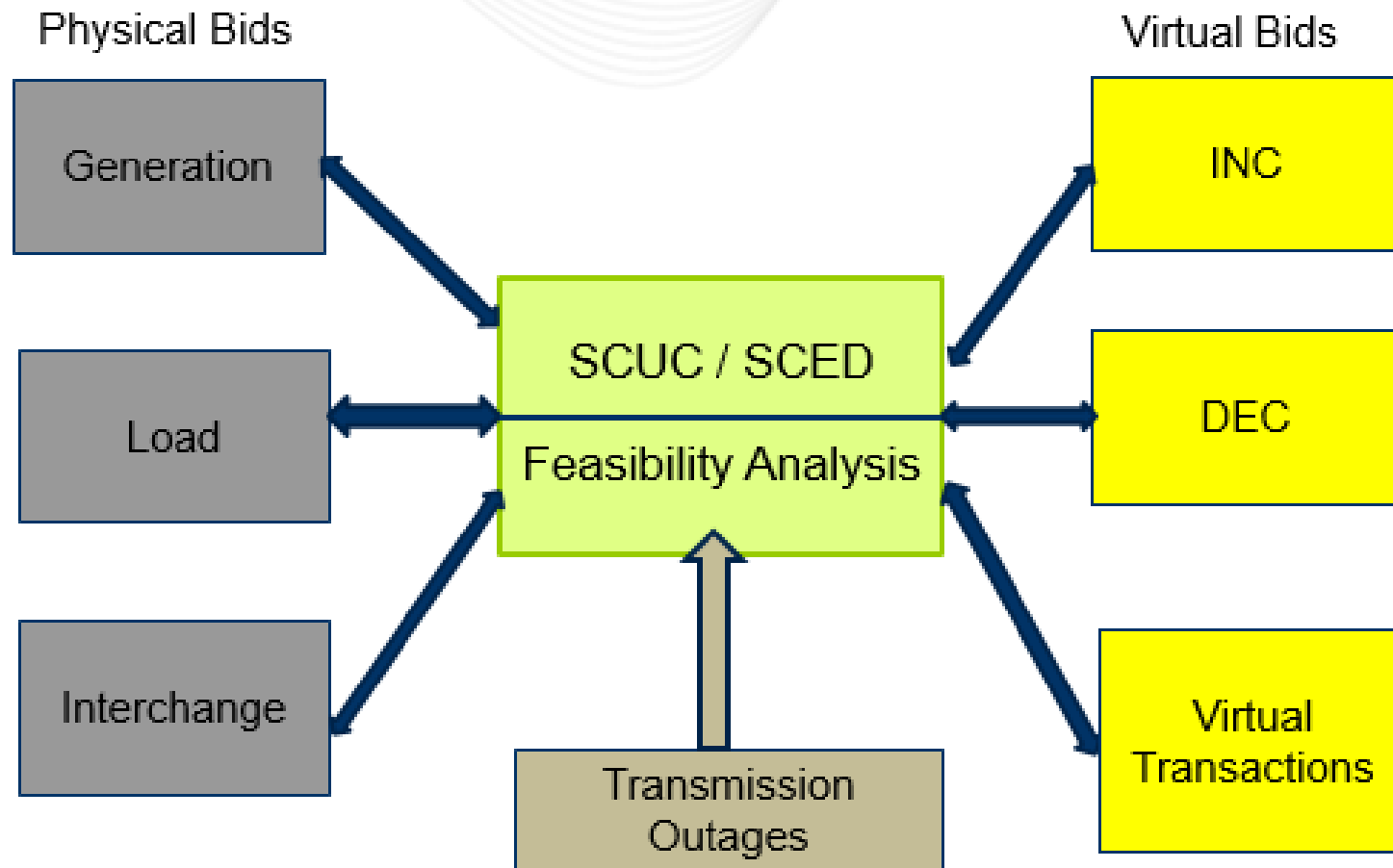
## Queued generation capacity mix

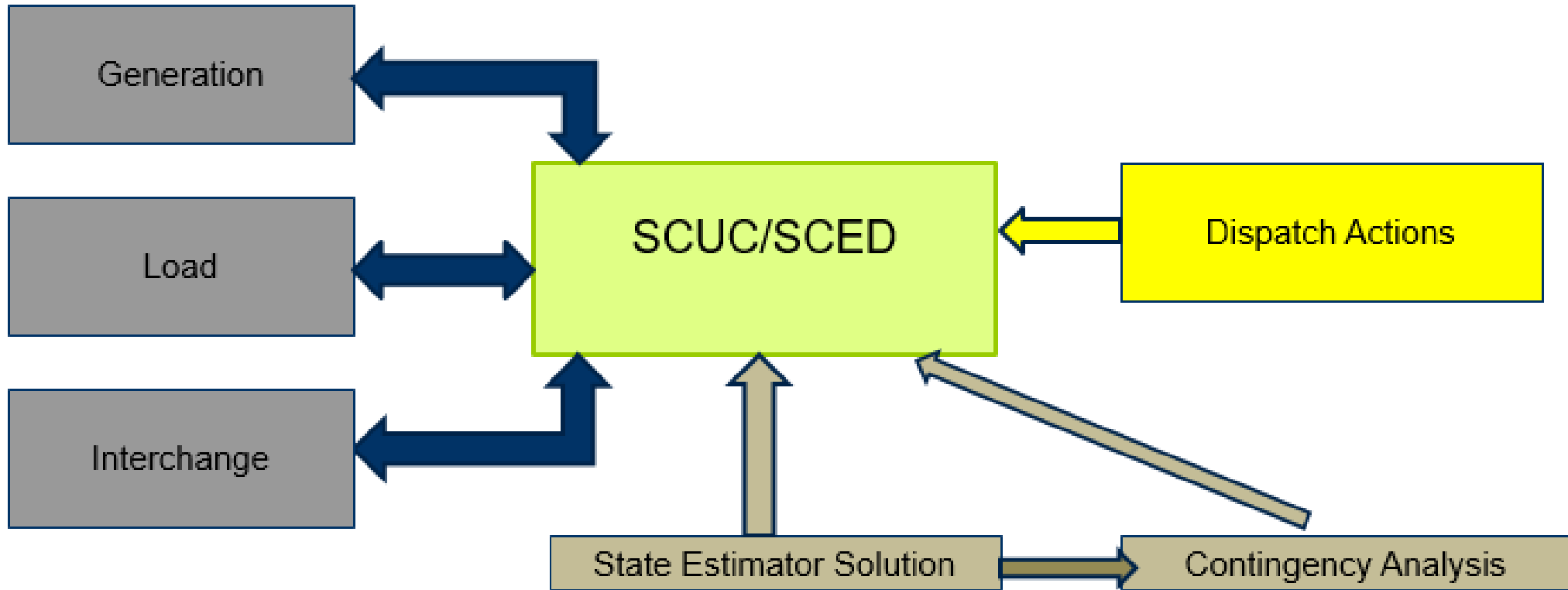


# Wholesale Electricity Markets



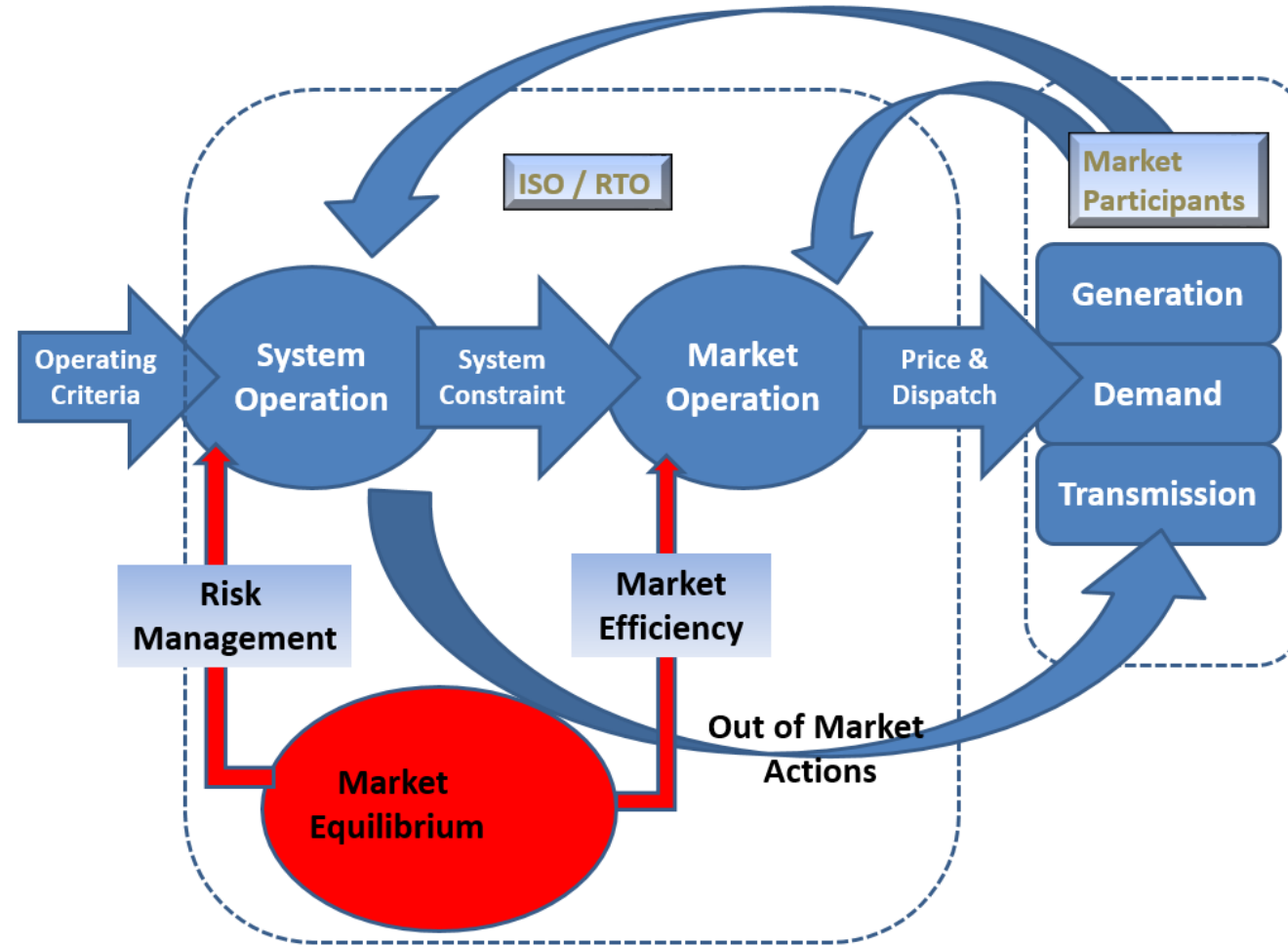






- Objective Function: Maximize social benefit or minimize total production cost
- Constraints:
  - Power balance constraint
  - Reserve requirement constraints
  - Transmission constraints
  - Resource limitation constraints: min, max, ramp restriction etc.
- Inputs: Load and Interchange forecast, bid prices, resource limits, transmission topology and limits, system reliability requirements
- Outputs: energy MW, LMP, reserve MWs, reserve clearing prices

# Integrated System and Market Operation

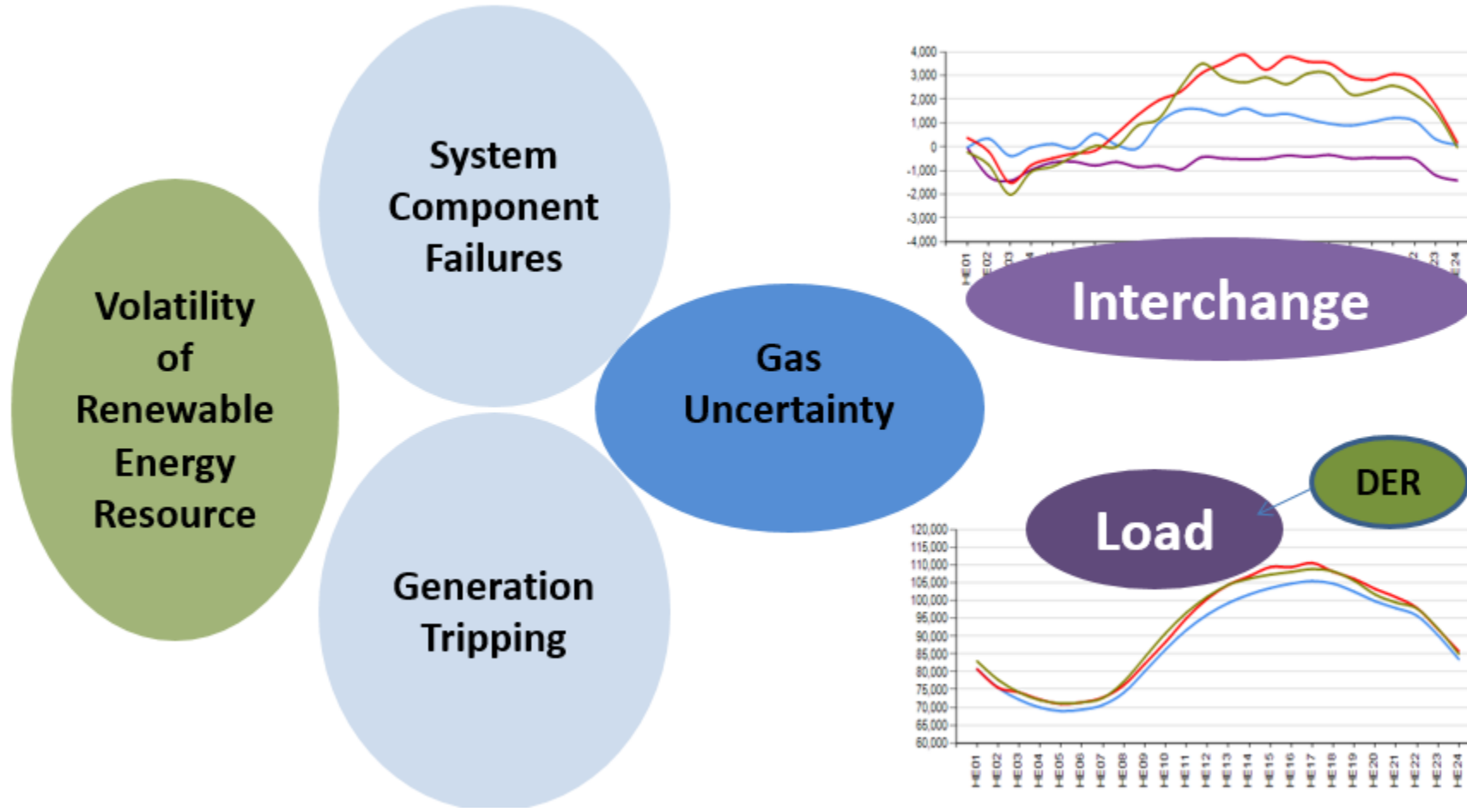




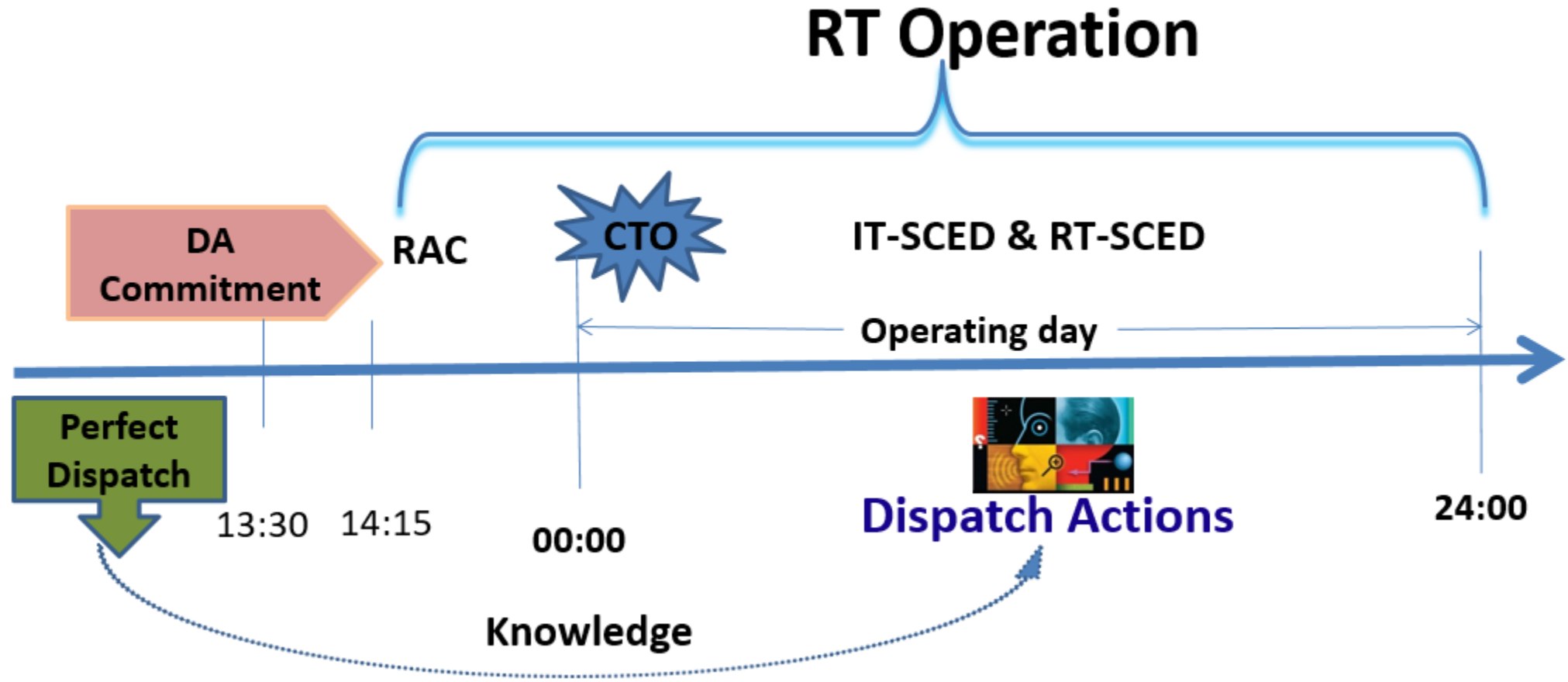
T = Time Interval Following PJM Request

↻ = Reserve Services Procured

# Hot Topics





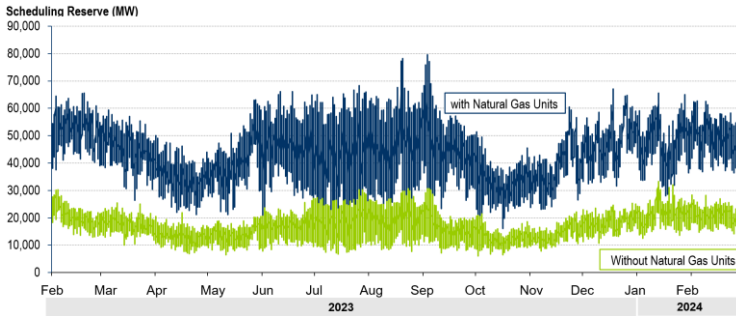


Variability and  
Uncertainty

Inverter Based  
Resources (IBR)

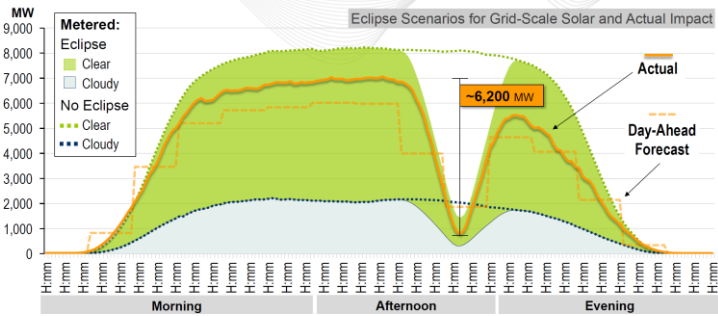
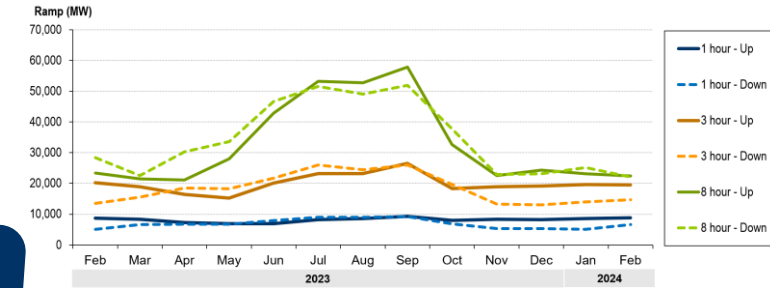
Resource  
Adequacy

Market Design



Generation

Load

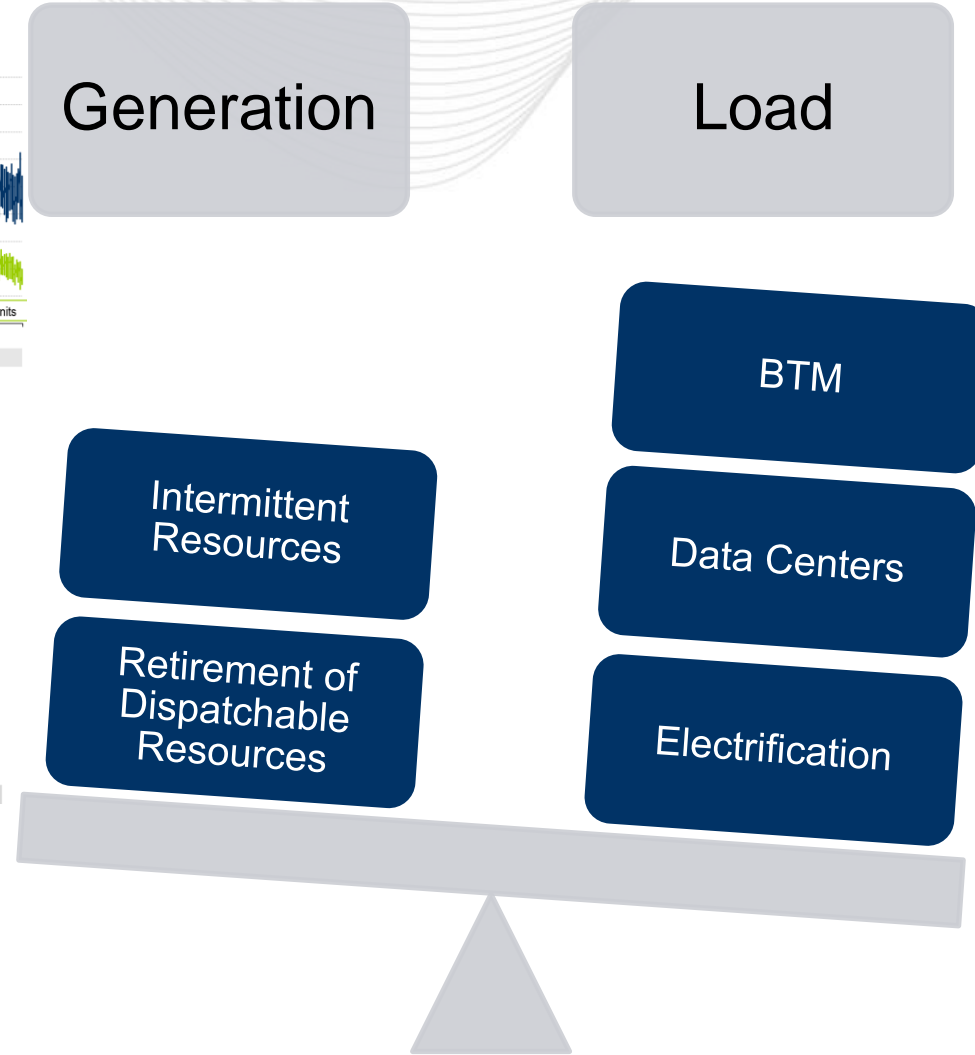
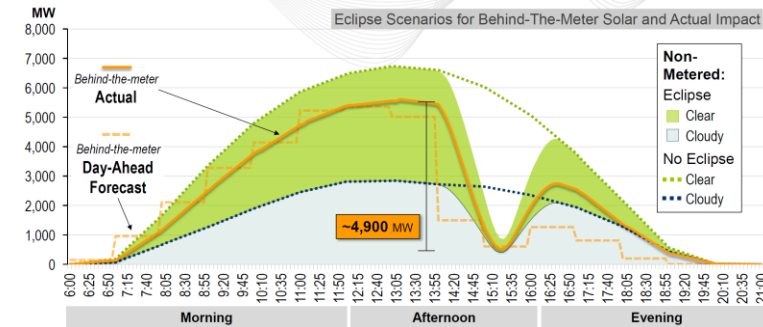


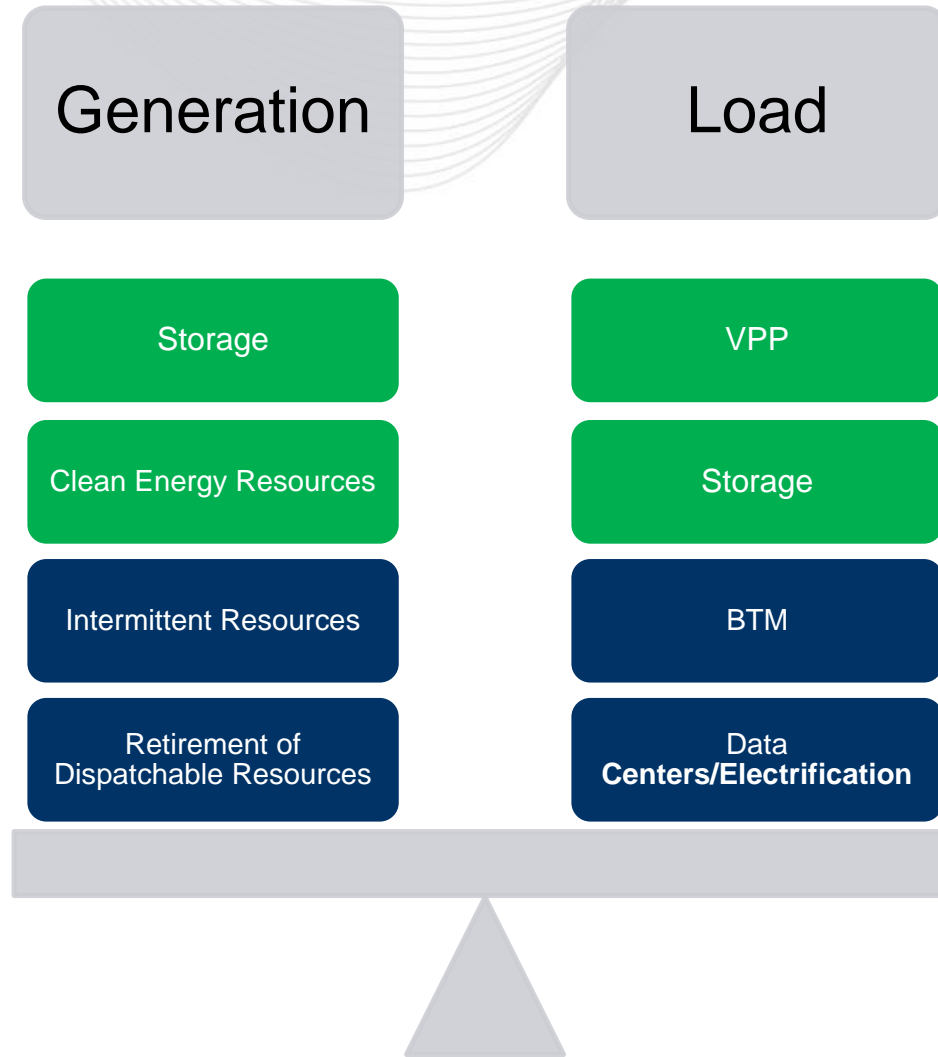
Intermittent Resources

Data Centers

Retirement of Dispatchable Resources

Electrification





# Storage Technologies in PJM



Pumped Storage Hydro



Batteries



Flywheels



Electric Vehicles



Thermal Storage

#

Electric Storage Resource by Technology	Installed Capacity / Qualified Rating (MW)	Capacity	Energy	Ancillary Services
Pumped Storage Hydro (Generation)	5,537	Yes	Yes	Yes
Battery (Generation)	289	No	No	Yes
Flywheel (Generation)	20	No	No	Yes
Battery (Demand-side Resource)	14	Yes	No	Yes

## Wholesale DER

**1 GW**  
Demand Response

**Customer-sited generation:**

Offers into capacity, energy and/or ancillary services markets

**84%**  
Diesel

**15%**  
Natural Gas

**1%**  
Other

Remaining ~8 GW of DR is load modification without any generation (e.g., industrial process management)

**~2 GW**  
Generator

**Front-of-the-meter generation:** Offers into capacity, energy and/or ancillary services markets

Can be sited at customers

**Mostly solar but also other fuels**

## Non-Wholesale DER

**~10 GW**  
DER

- **Solar PV DER:** Retail/rooftop solar
- **Municipal DER:** Municipal electric company distribution-level generators
- **Process DER:** Industrial generators, combined heat and power
- **Resilience DER:** Emergency backup
- **Qualified Facilities:** Direct sales to distribution utilities

# System Operation Under Extreme Weather

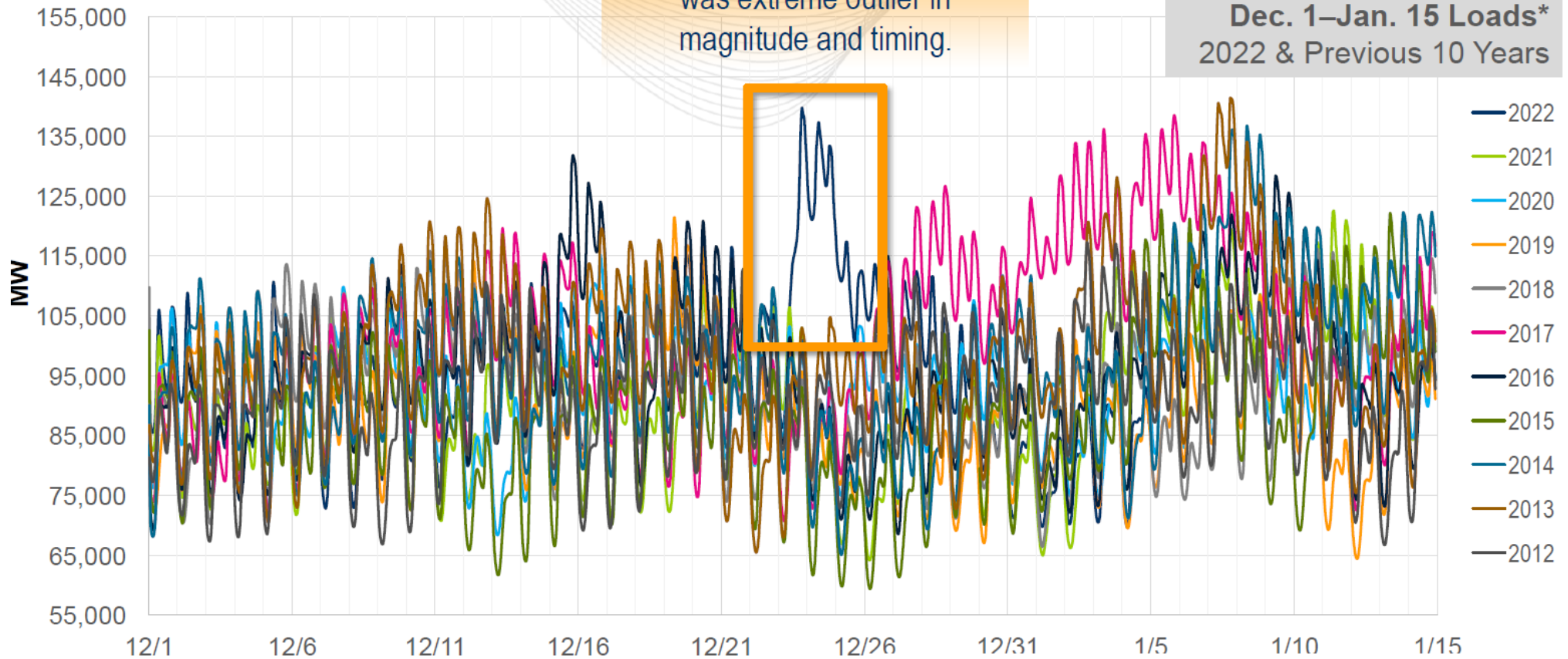




## 2022 Holiday Load (Preliminary Data)

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

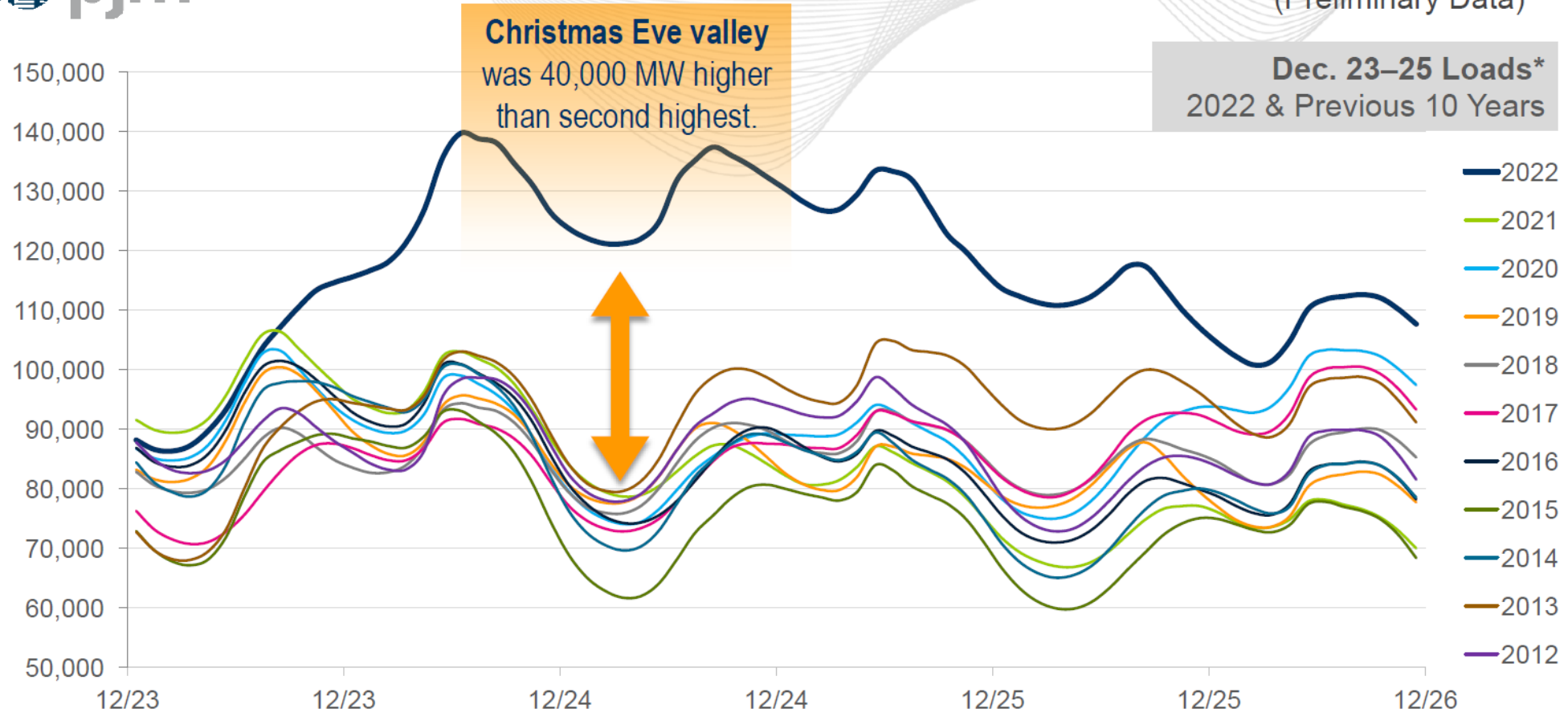
Dec. 1–Jan. 15 Loads\*  
2022 & Previous 10 Years



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

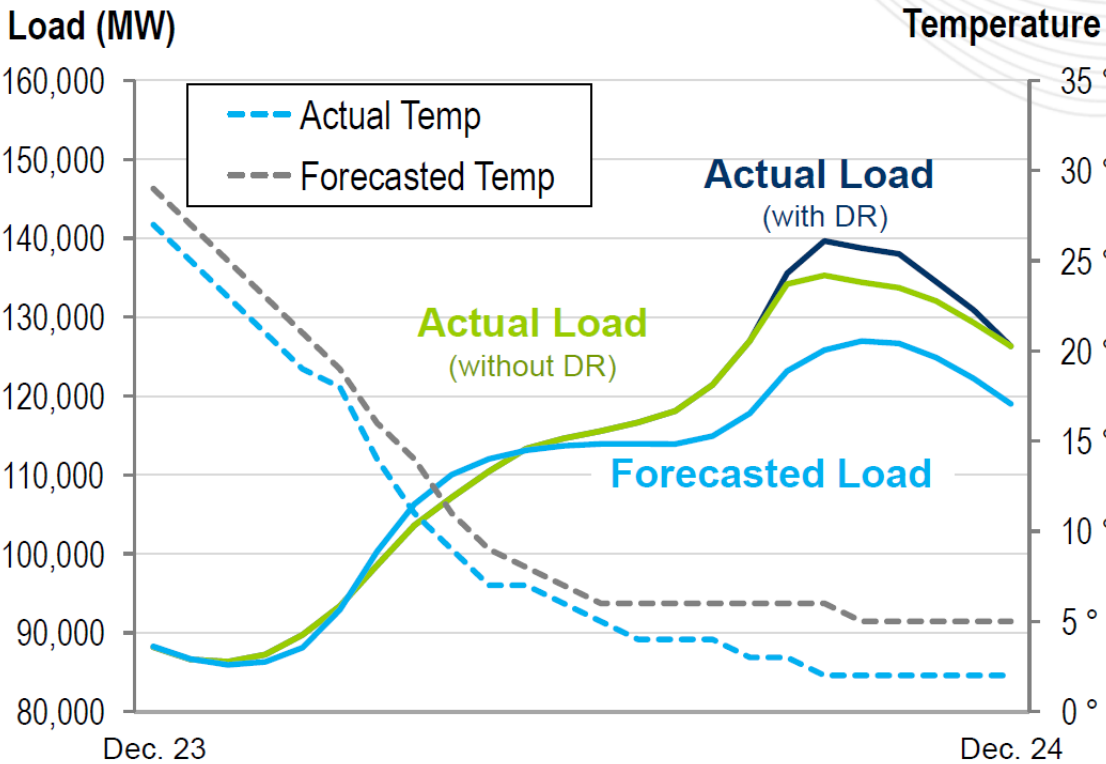


## Load Stayed Unusually High Overnight (Preliminary Data)

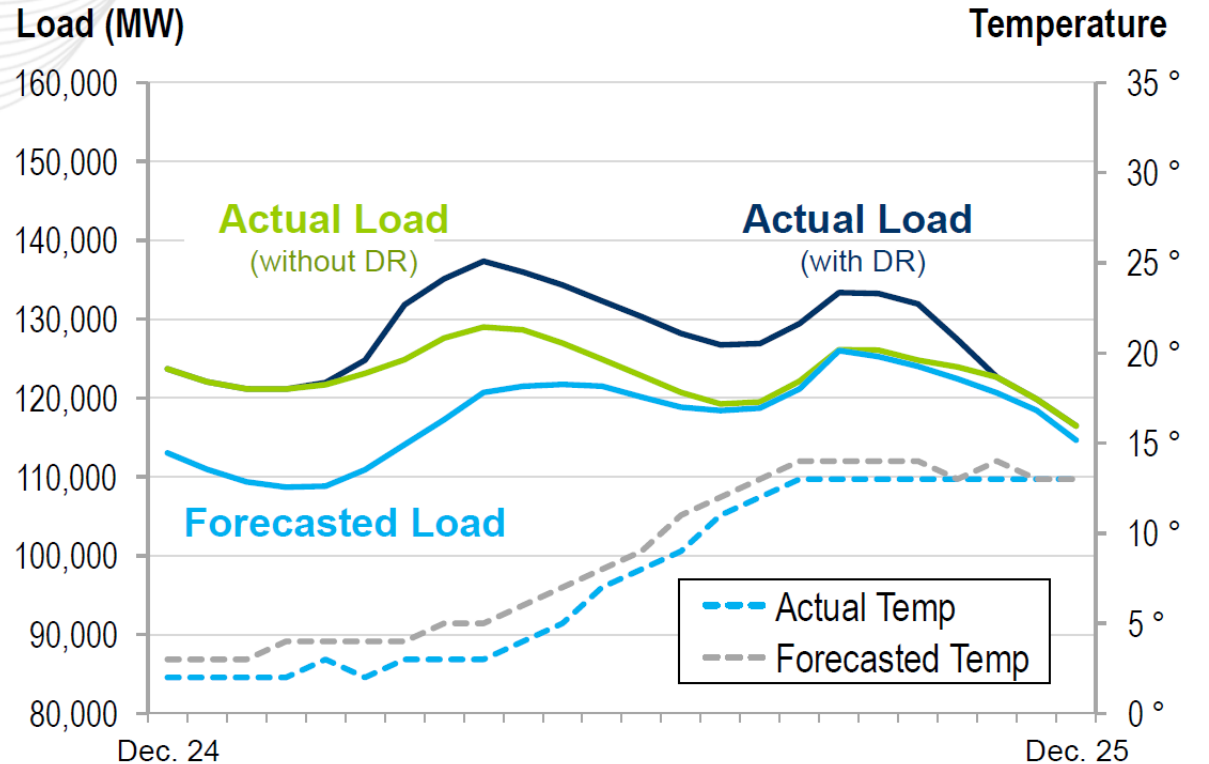


\*Note: Load values include the estimated demand response (DR) added back.

## Dec. 23



## Dec. 24

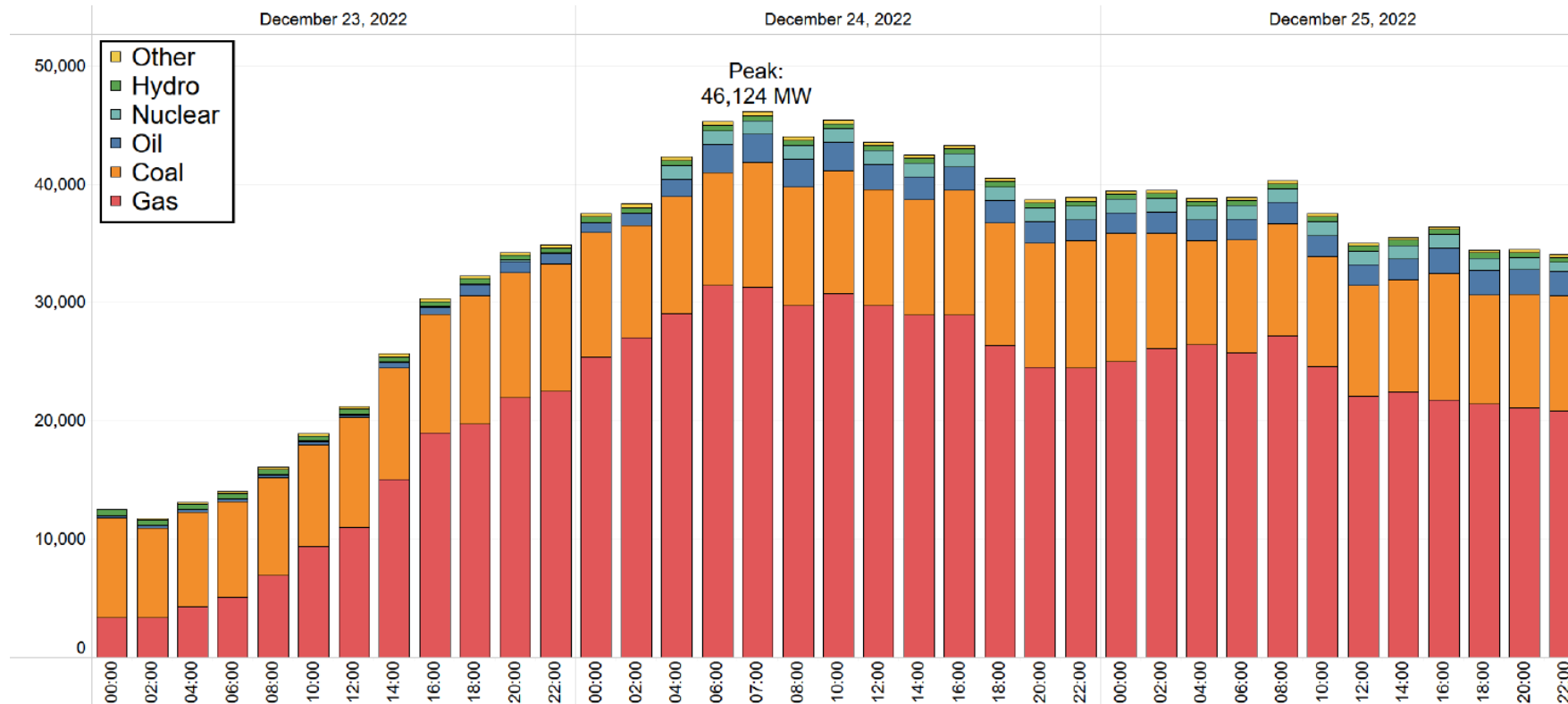


**Actual load came in over 10% over forecast.**

- Severe cold and blizzard conditions
- Most drastic temperature drop in a decade

- Early occurrence of cold weather
- Holiday impacts: rare instance of under-forecasting

## Forced Outages/Derates by Fuel Type



www.pjm.com | Public **Note:** Only even hours are shown for readability with the exception of 12/24/2022 07:00 which was the hour with the largest amount of forced outages and derates 2 Slide uses GADS data pulled 03/01/2023 PJM©2023