OHIO'S ELECTRIC COOPERATIVES

Your Touchstone Energy® Cooperatives

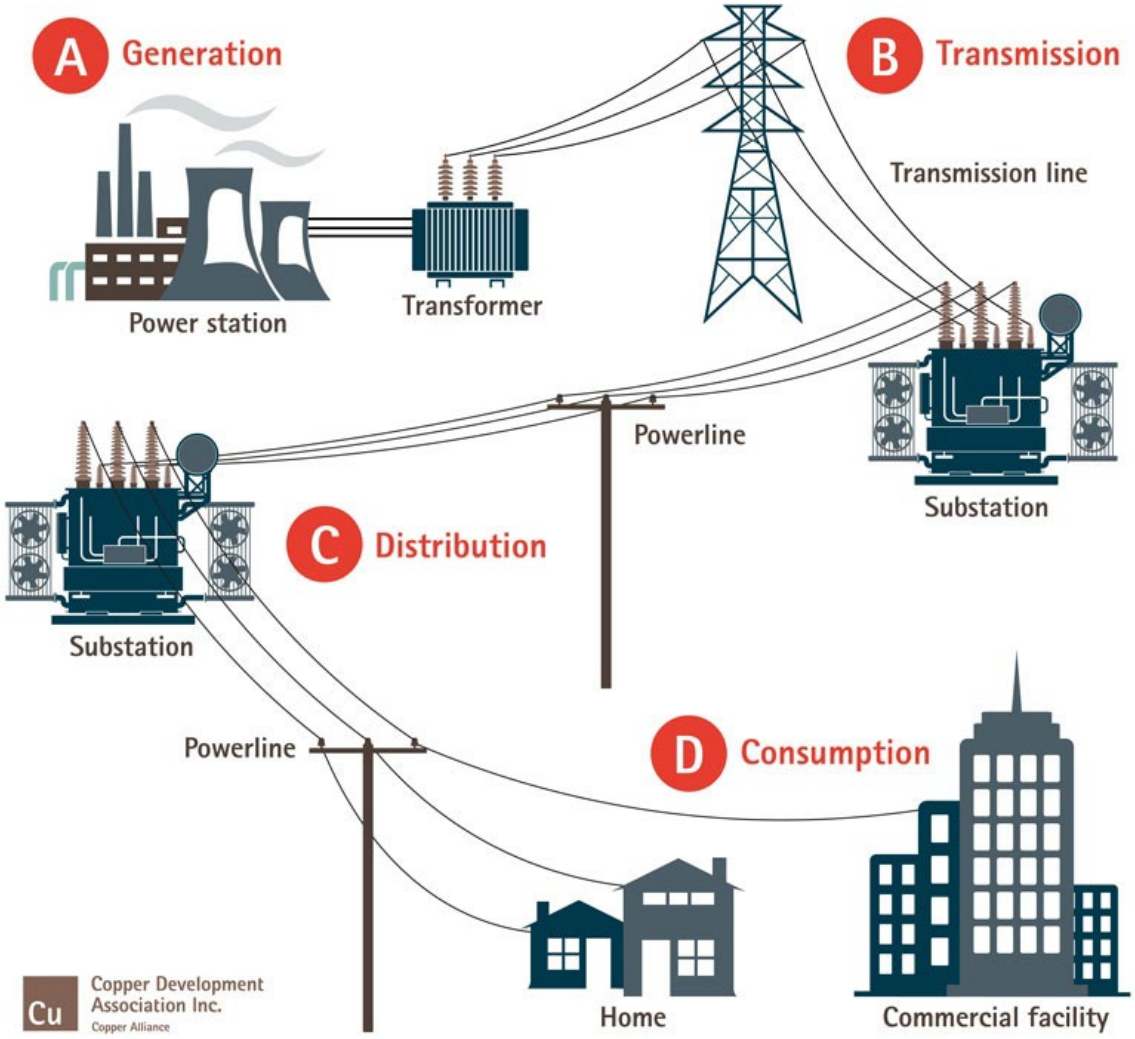
GRID OPERATIONS AND PJM

Kevin Zemanek

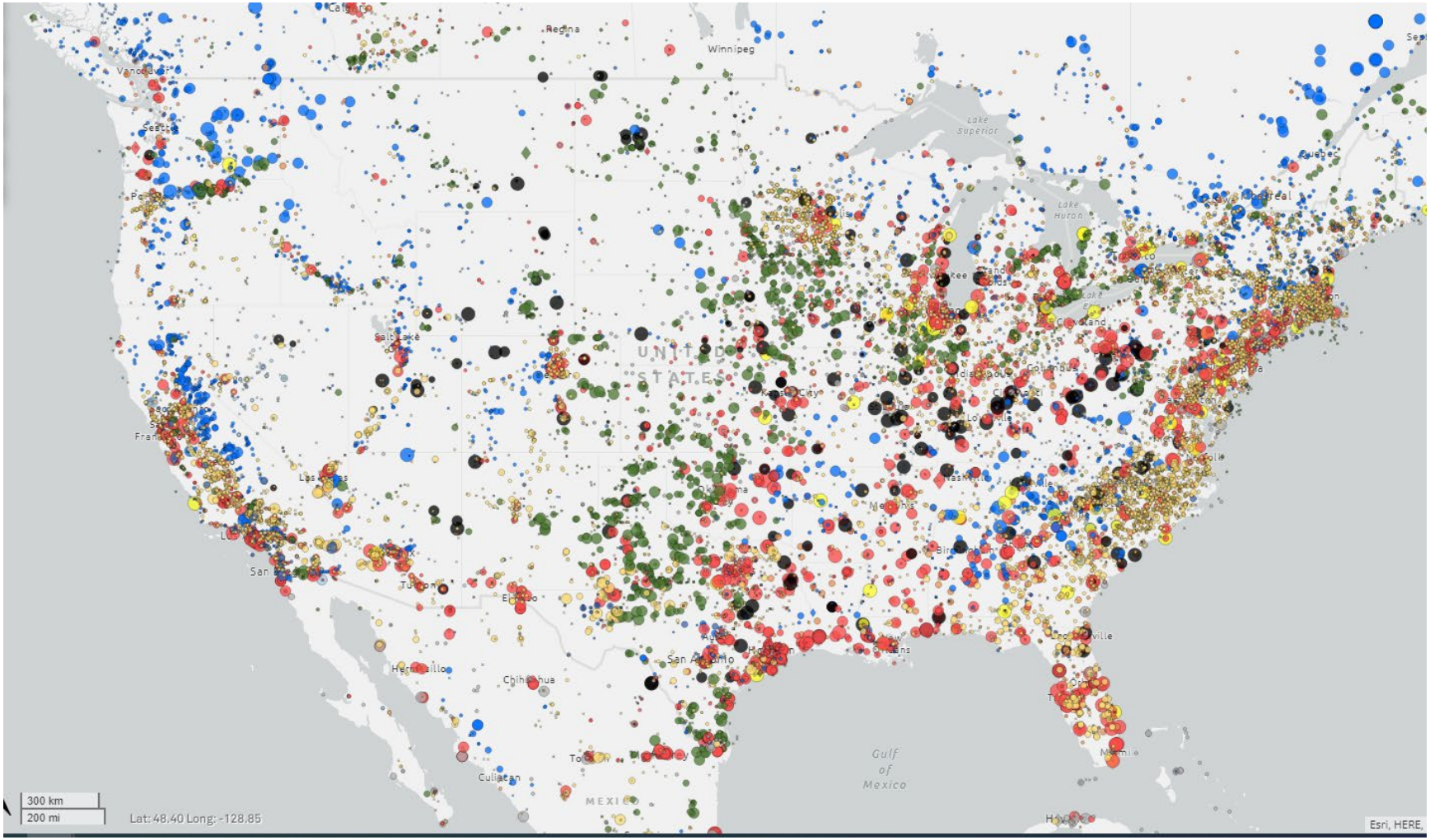
Kara Smith

What is the Grid?

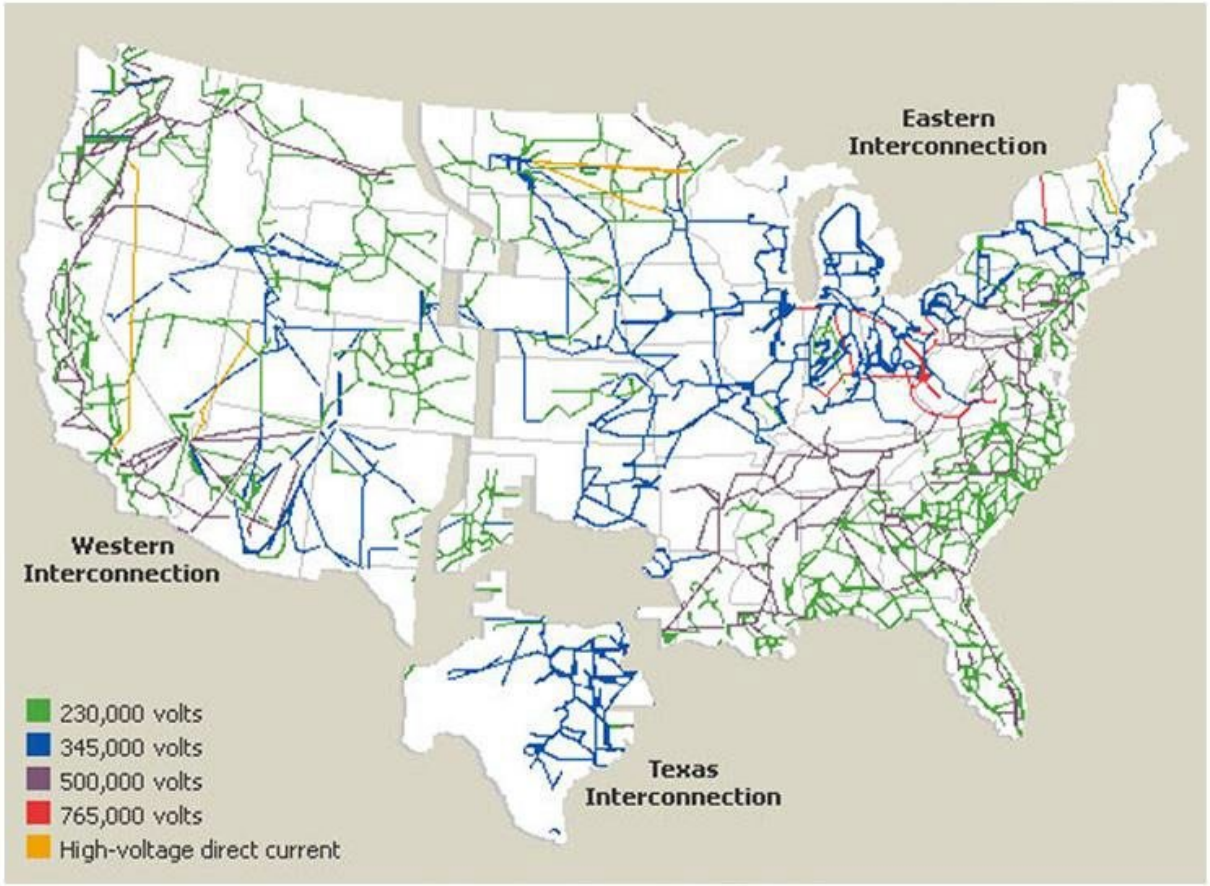
- The Electricity or Power Grid is the term used to describe the system and equipment required to get electric power from where it is made (or generated) to consumers in our homes and businesses.


A Generation
B Transmission
Transmission line
Power station
Transformer
Powerline
Substation
C Distribution
Substation
Powerline
D Consumption
Home
Commercial facility
Copper Development Association Inc.
Copper Alliance

U.S. Generation Resources



High Voltage Transmission Map



High Voltage Transmission (above 69,000 volts)

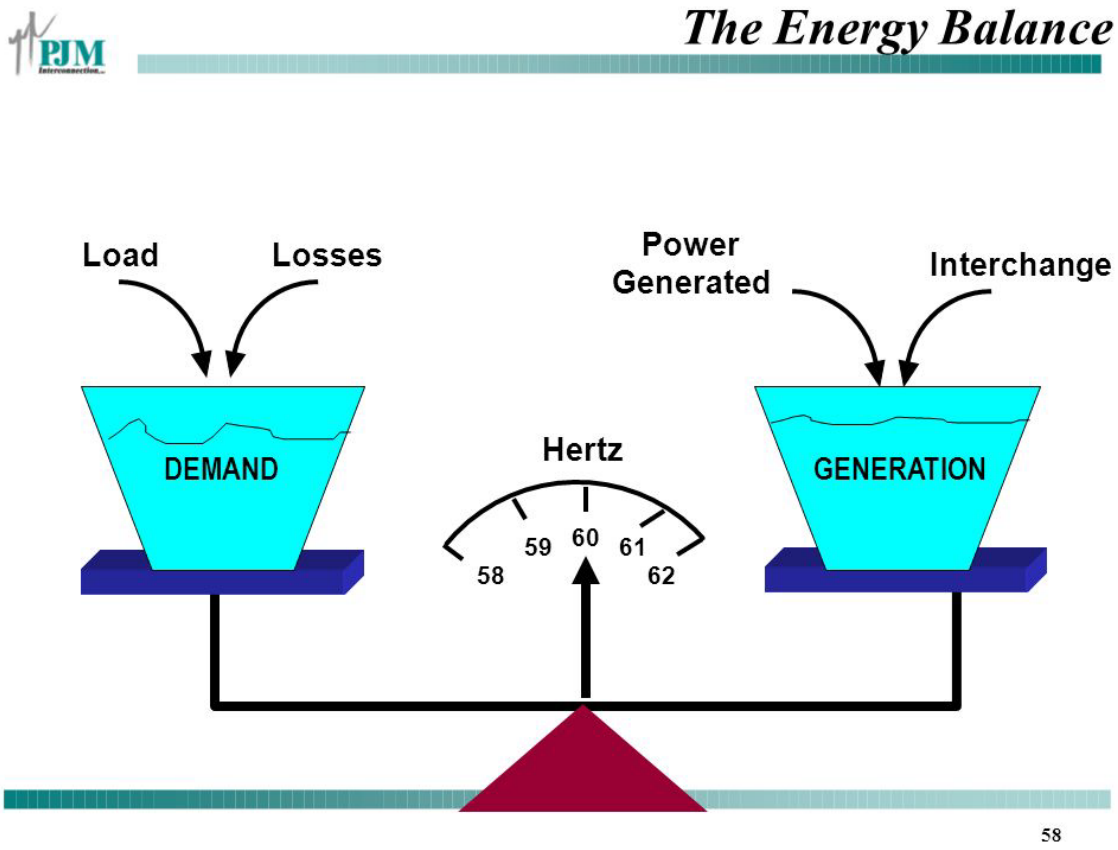
- "**Interstate Highway**"
- Moves bulk electricity from the generator over long distances to substations closer to areas of demand
- Higher voltage = lower current = lower losses

Distribution (69,000 volts and lower)

- Voltage level is reduced, or "stepped down," via transformers and sent through distribution lines, which are then connected to homes and businesses

End-Use Consumer

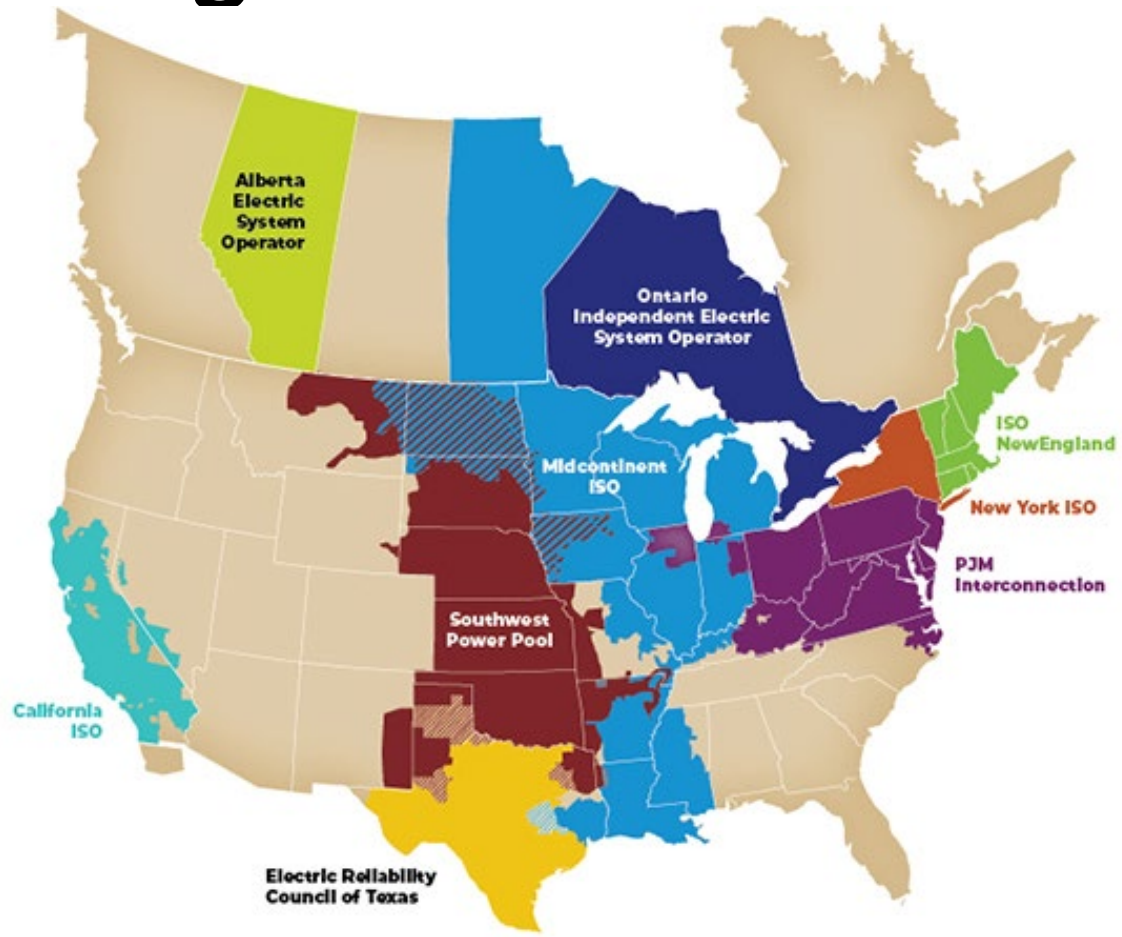
Grid Operations



Balancing Authorities

- A Balancing Authority ensures, in real time, that power system demand and supply are finely balanced. This balance is needed to maintain the safe and reliable operation of the power system.

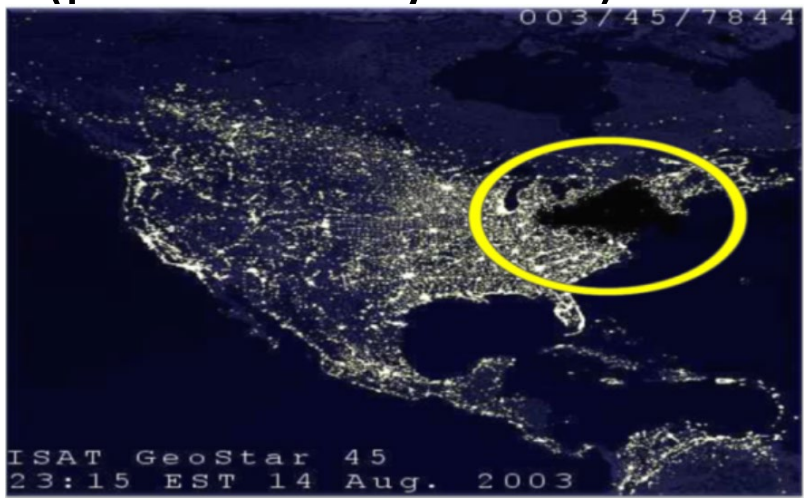
Balancing Authorities



IRC ISO/RTO COUNCIL

What Happens if Generation < Demand?

- Short time period:
  - BA can dispatch additional generation not already online
  - BA can implement load control
- Long time period:
  - Grid becomes unstable
  - Generators begin to trip offline (protection systems)
  - Relays begin shedding load
  - Full system blackout possible
    - 2003 Northeast blackout
    - 2021 Texas blackout



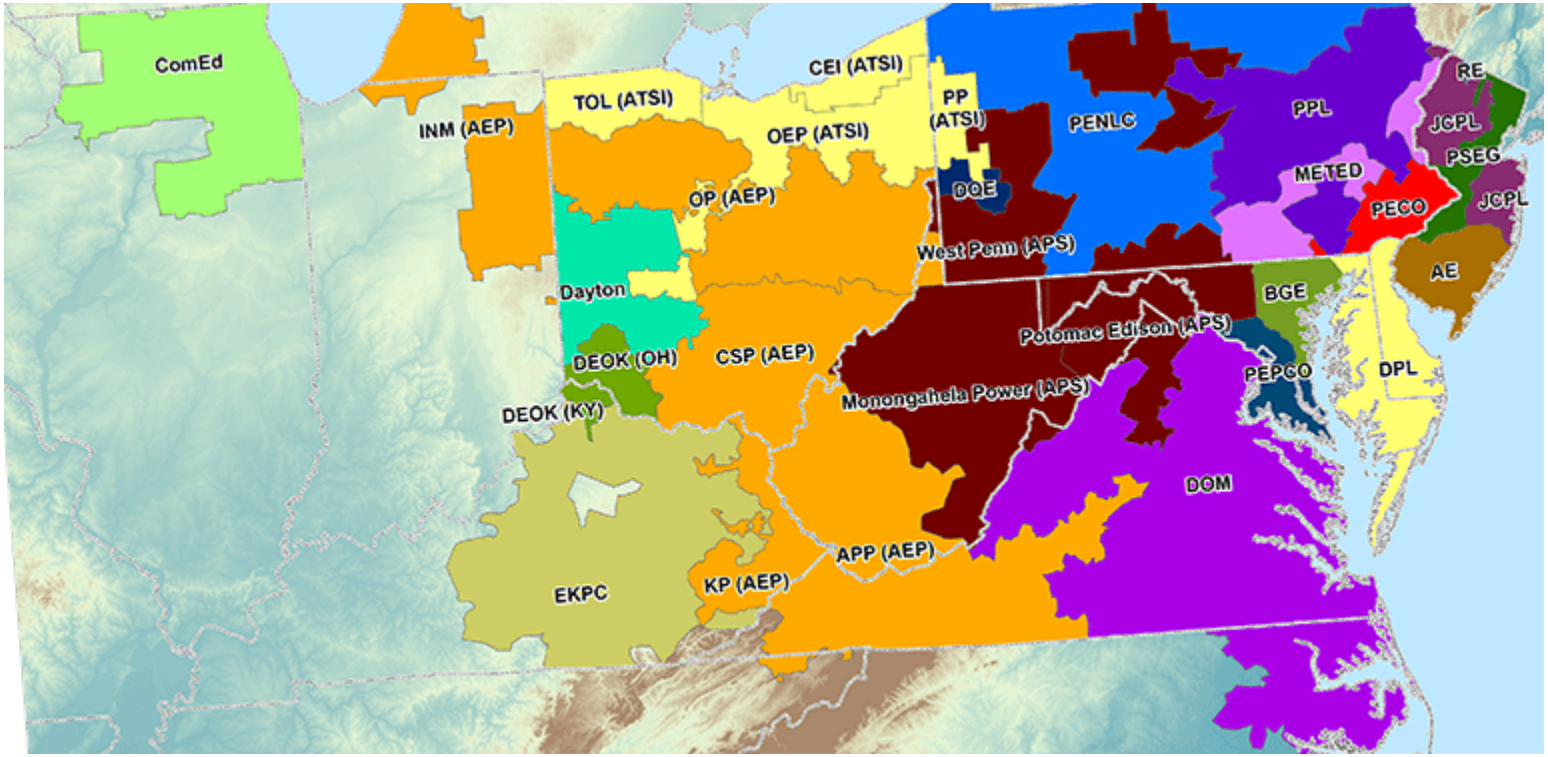
PJM'S ROLE WITH GRID OPERATIONS

PJM

- Who is PJM?
  - The largest Regional Transmission Organization (RTO) in the world. 13 states and over 65 million people in the footprint.
- What is their purpose?
  - Serves as the region's Balancing Authority
  - Operates a competitive wholesale electricity market
  - Manages the high-voltage electricity grid
    - ***Does not own the transmission or generation assets***

PJM's Footprint

(breakout by transmission zones)



How PJM "balances" their footprint

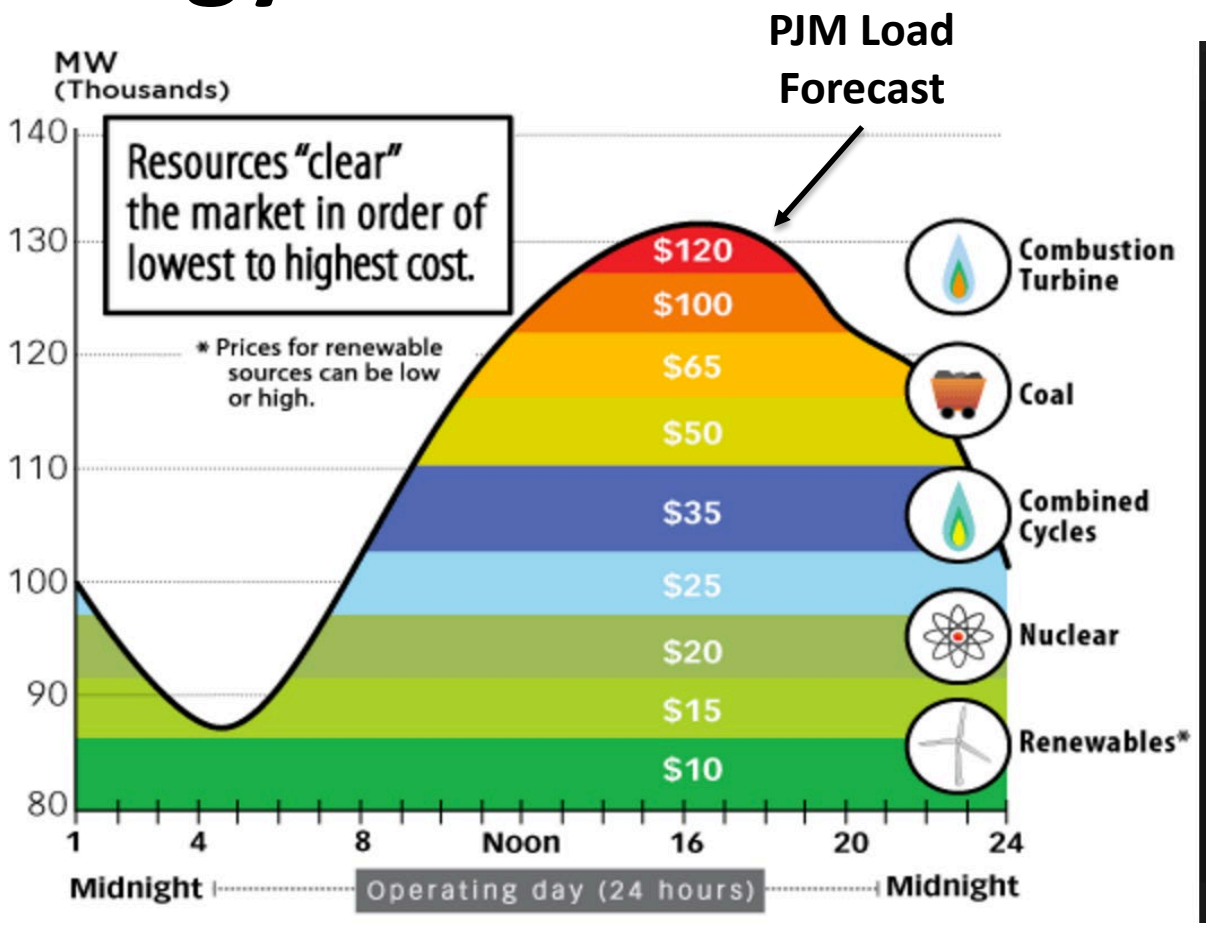
- Coordinates generators and transmission
- 24/7 monitoring of system conditions
  - Have 3 fully redundant control centers
- "What if" scenarios – contingency analysis
- Maintain generation reserves
- Implement and enforce rules for market participation
  - PJM has roughly 1,000 members

PJM Control Center

PJM Operates Multiple Markets

- Energy Markets (day-ahead and real-time)
  - Short-term time period
- Capacity Market
  - Longer-term product (up to 3-years forward)
- Ancillary Services Market
  - Other necessary products to maintain grid reliability

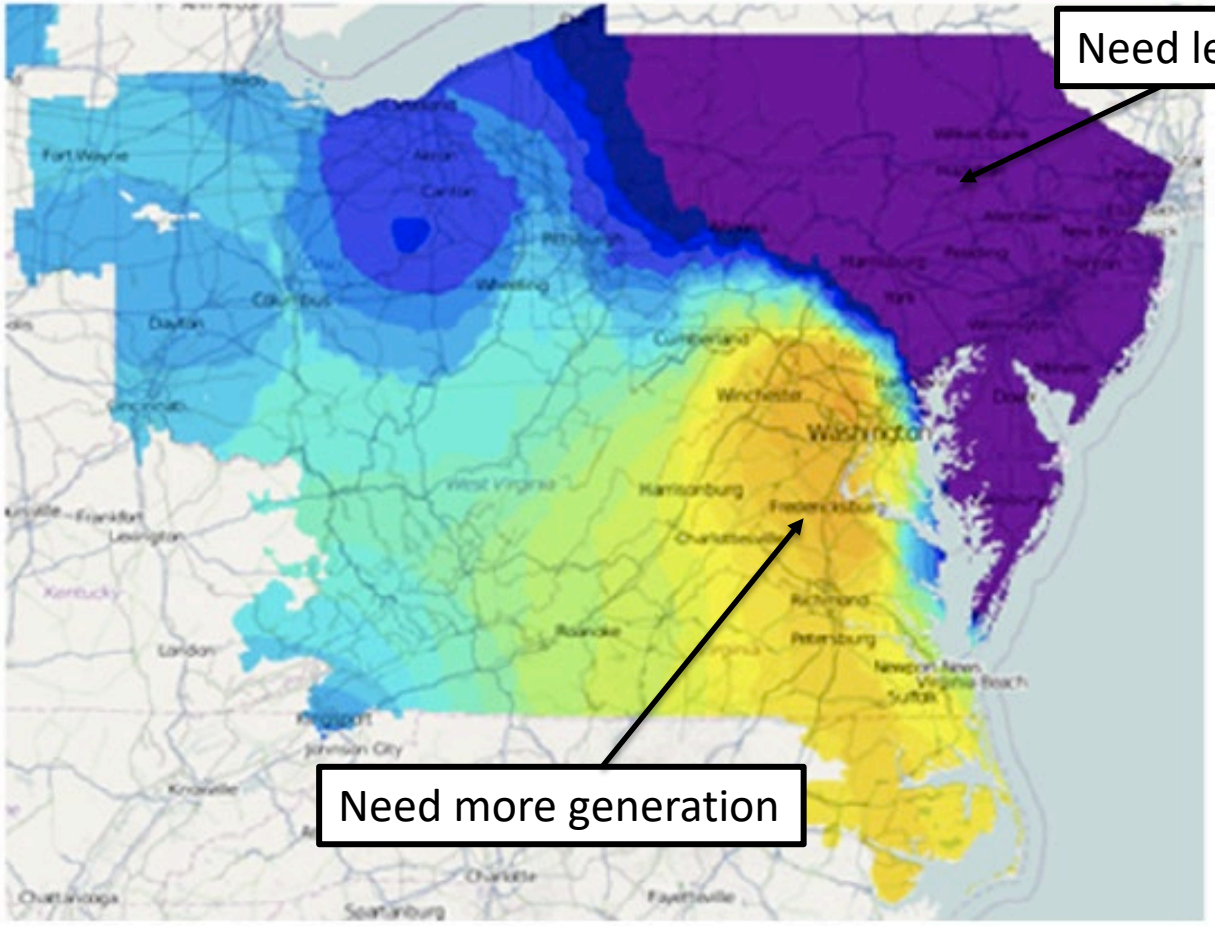
PJM Energy Market



Locational Marginal Price (LMP)

- Pricing method PJM uses that reflects necessary actions
  - Higher LMPs to indicate they need more generation
  - Lower LMPs to indicate they need less generation
- Different by location (over 8,000 locations)
- Calculated for both Day-Ahead and Real-Time markets

PJM setting LMPs to different levels based on system conditions



Day-Ahead (DA) Market

- Market participants are required to submit parameters to PJM by 11 AM for the next day
  - Generation and load parameters
- PJM uses the submitted information to clear the market for the next day. They ensure enough generation will be online to cover forecasted load.
  - This is called the DA Market

Real-Time (RT) Market

- Based on the **actual** conditions of the system
- LMPs calculated for every 5-minute interval
- RT Market can be extremely volatile
  - PJM uses RT LMP to send price signals to make sure the system stays in balance (generation = load)
  - PJM does not own generation, so they provide a price signal / incentive (LMP) for generators to respond to system conditions

PJM Capacity Market

- Ensure enough generation is available 3 years in the future
- Procures enough to meet demand plus a reserve margin
  - PJM's 2022 Peak Load: ~150,000 MW
  - PJM's 2022/23 Capacity Procured ~180,000 MW
- Supply resources are paid to be available when needed
- Load pays for capacity based on their contribution to PJM's highest load hours in the summer (i.e. PJM 5 CP)
    - If we can lower our consumption, we can lower our cost (Load Control)

Requirements for Capacity Resources

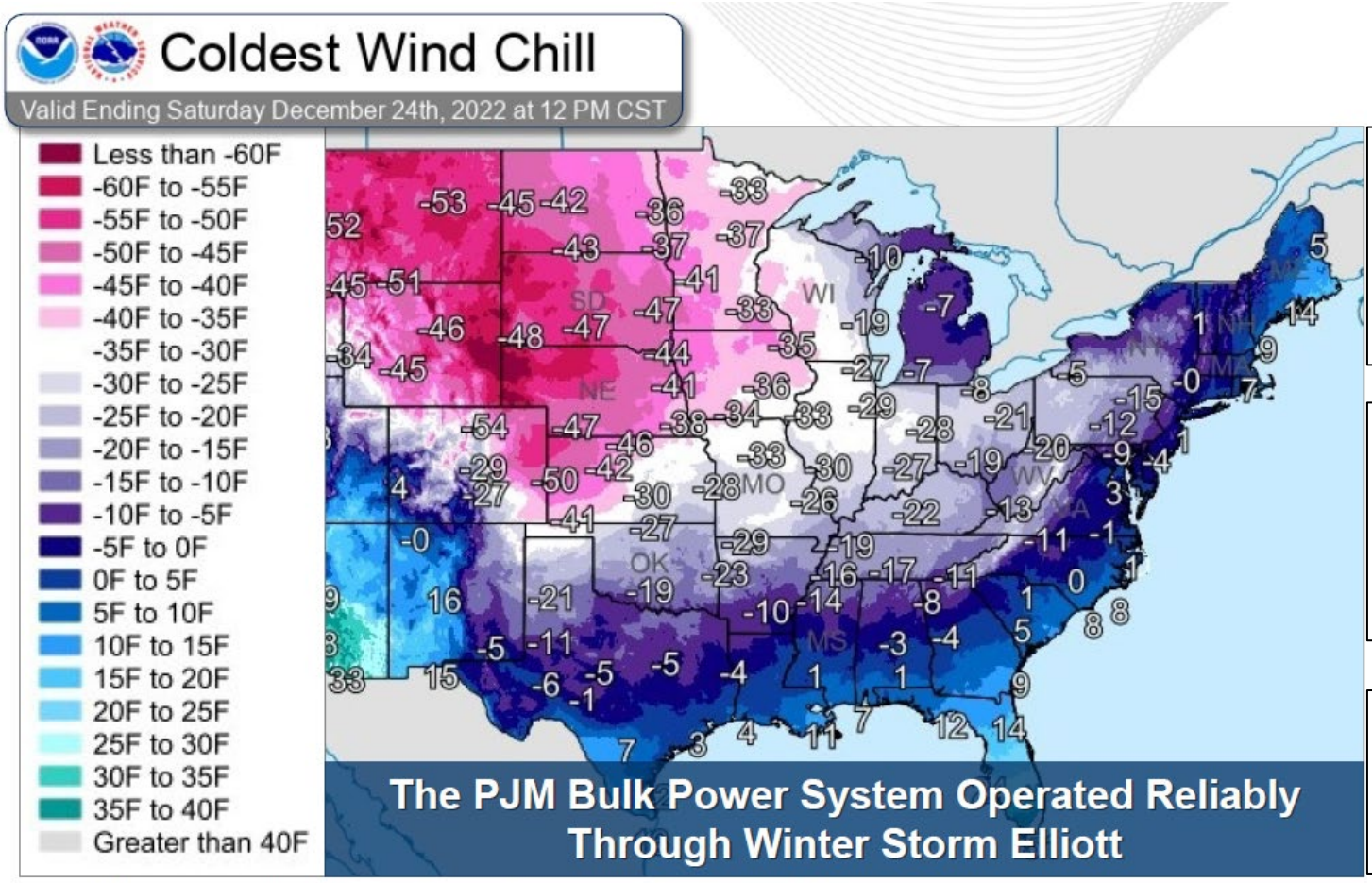
- Must-offer requirement in the energy market
  - Only for traditional resources like Buckeye's
- Requirement to be on during PJM Emergencies
  - Strict rules and large penalties for being unavailable
    - **No excuses**
  - 2022/23 penalty: ~$3,000/MWh
    - Example: 1 hour penalty if a Cardinal unit is offline = ~$2M

What happens in PJM when the grid isn't balanced?

PJM Emergency Operations

- PJM has a series of escalating Alerts, Warnings, and Actions they can issue depending on severity of imbalance
- Informs everyone of the level of available reserves and the potential need for PJM and/or member actions

PJM Winter Storm



Top 3 Issues:

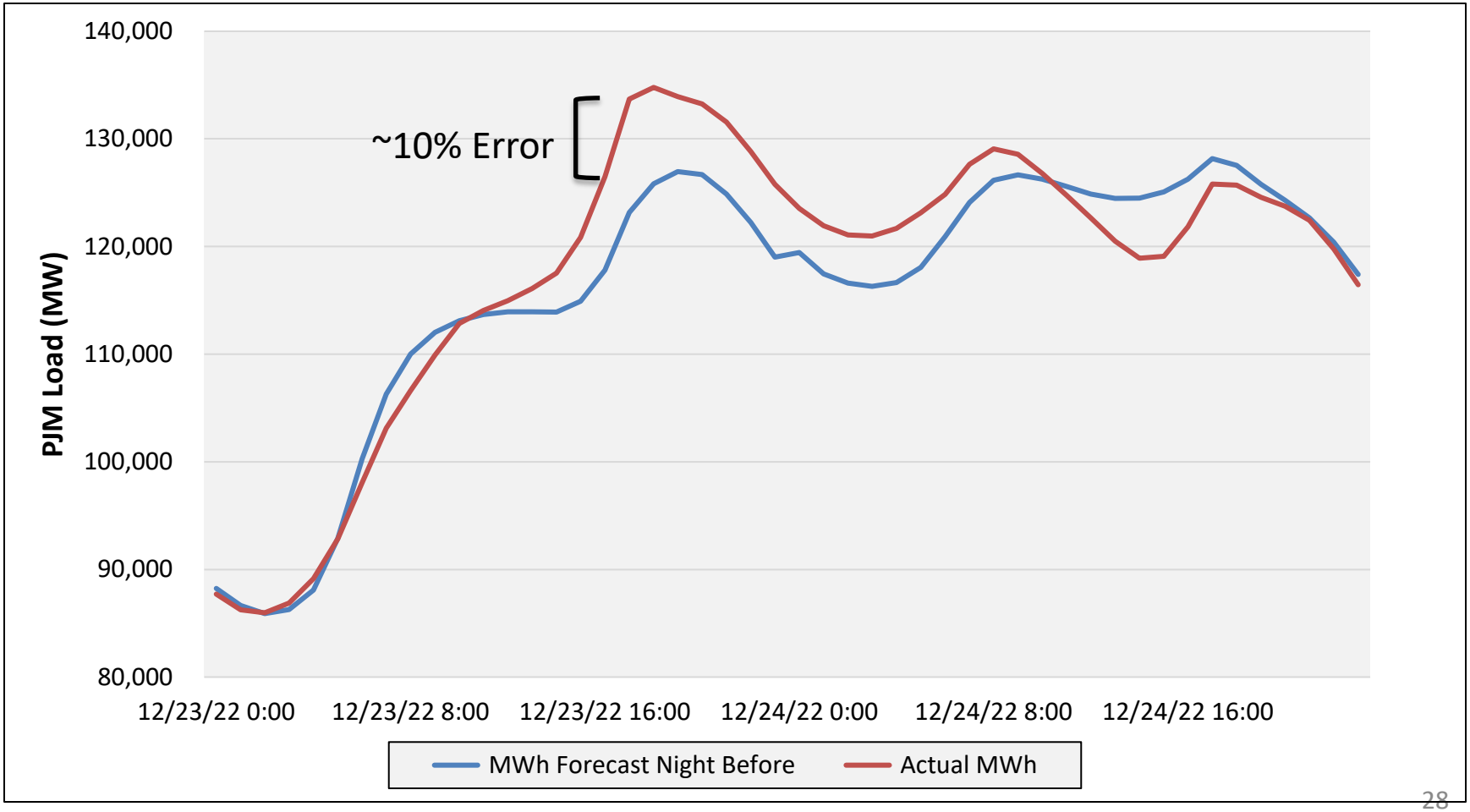
Drastic temperature drop of 29 degrees over a 12-hour period on 12/23.

PJM load forecast off by 10% which is equal to 14,000MW.

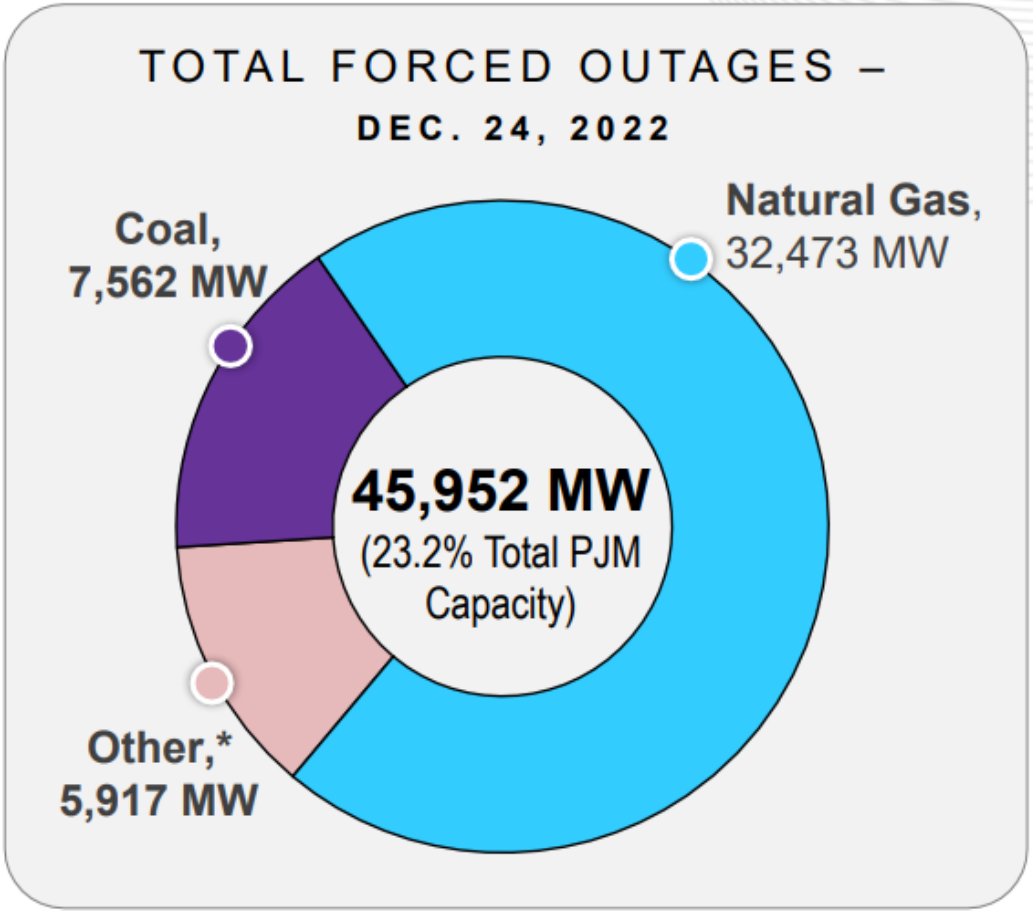
Outage rate > 20% due to fuel and cold weather.

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

PJM's Load Forecast



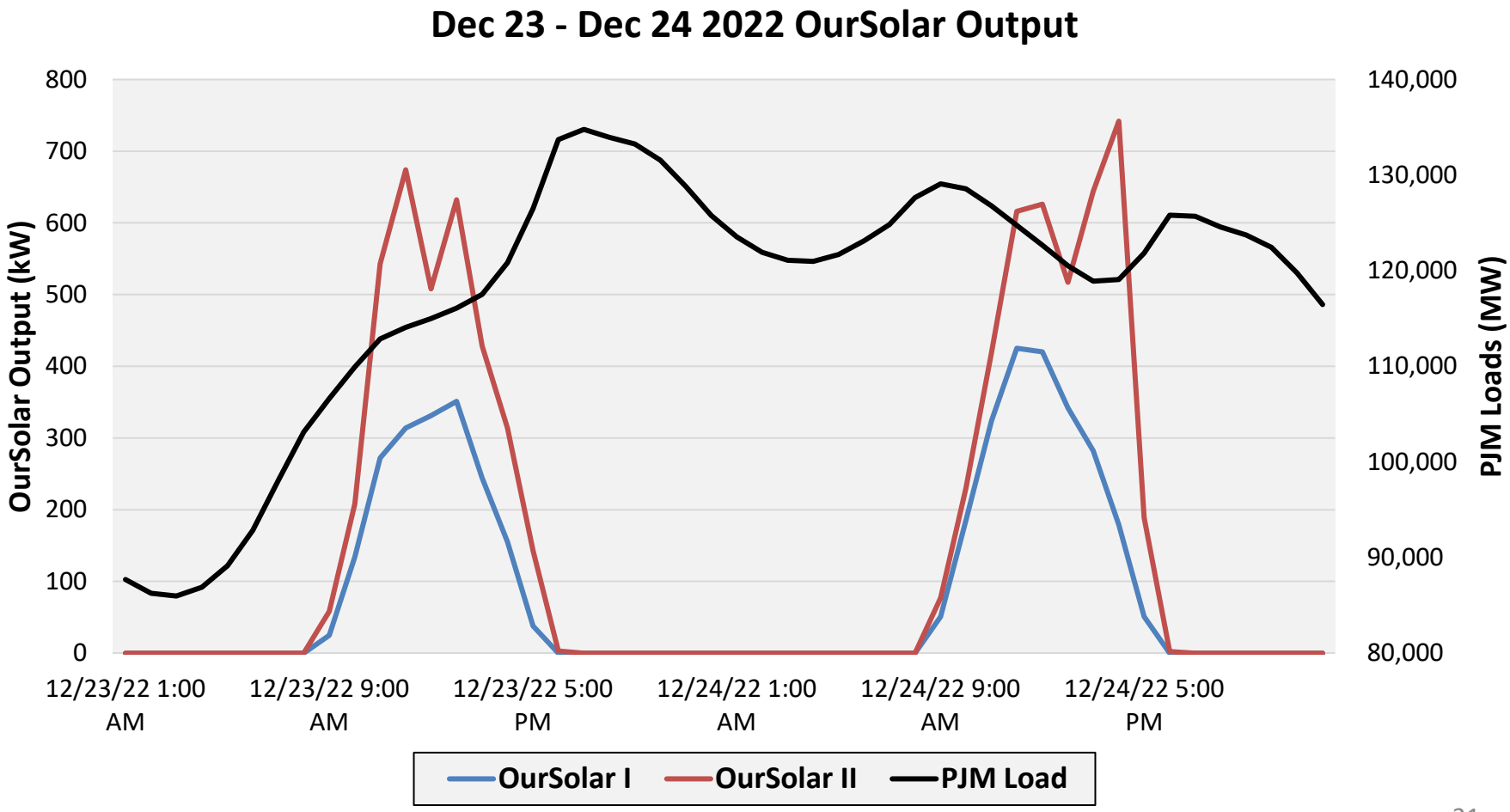
Generation Outages – 23.2%



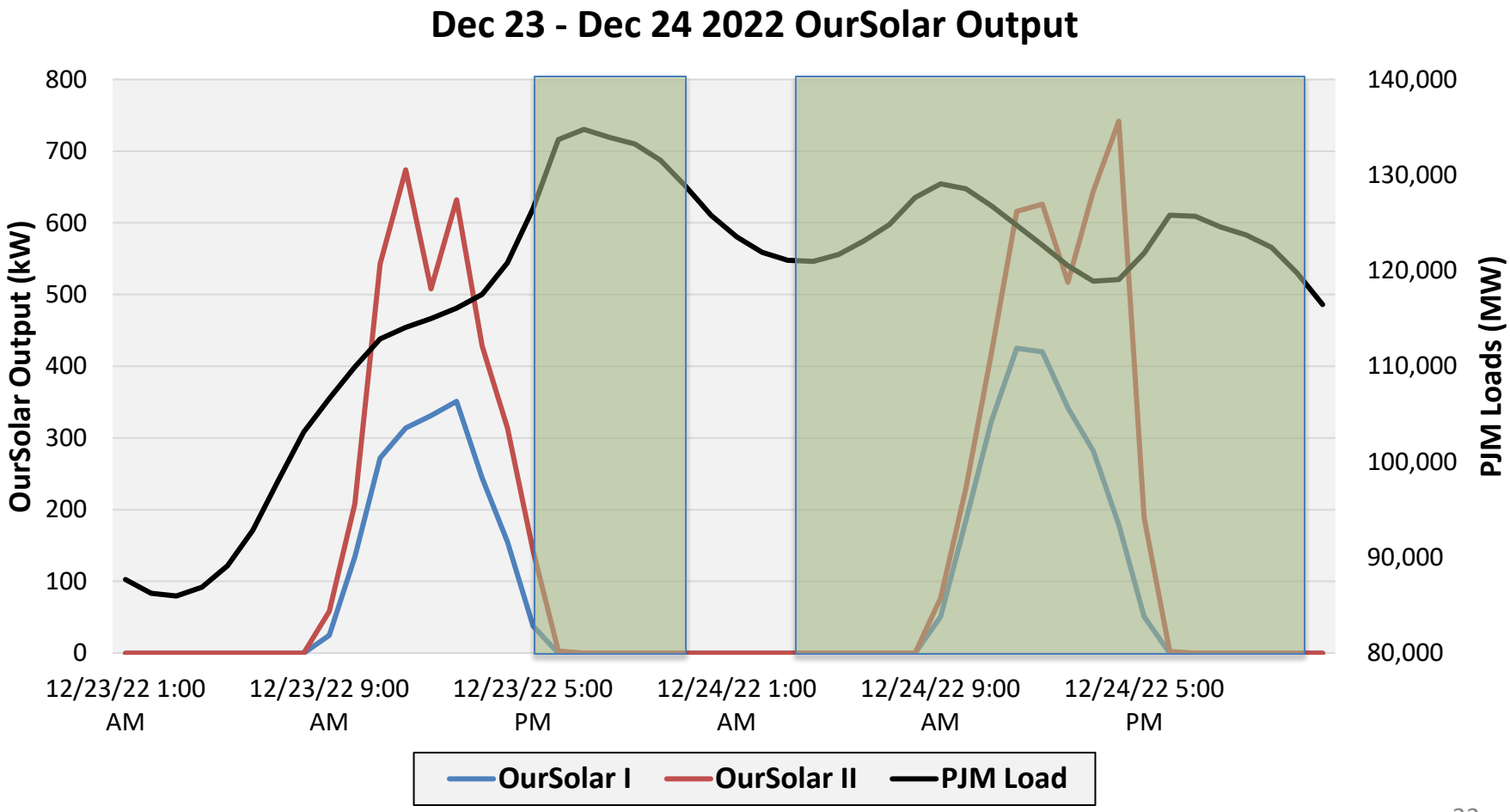
Energy Dependent Resources

- **Pumped Hydro:** ~4,900 MW. Limited ability to replenish pond levels for pumped storage hydro prior to the morning peak on Dec. 24. Limited run hours
- **Battery Storage:** Could not recharge overnight for morning peak on Dec. 24. Limited run hours

Solar Output During Emergencies

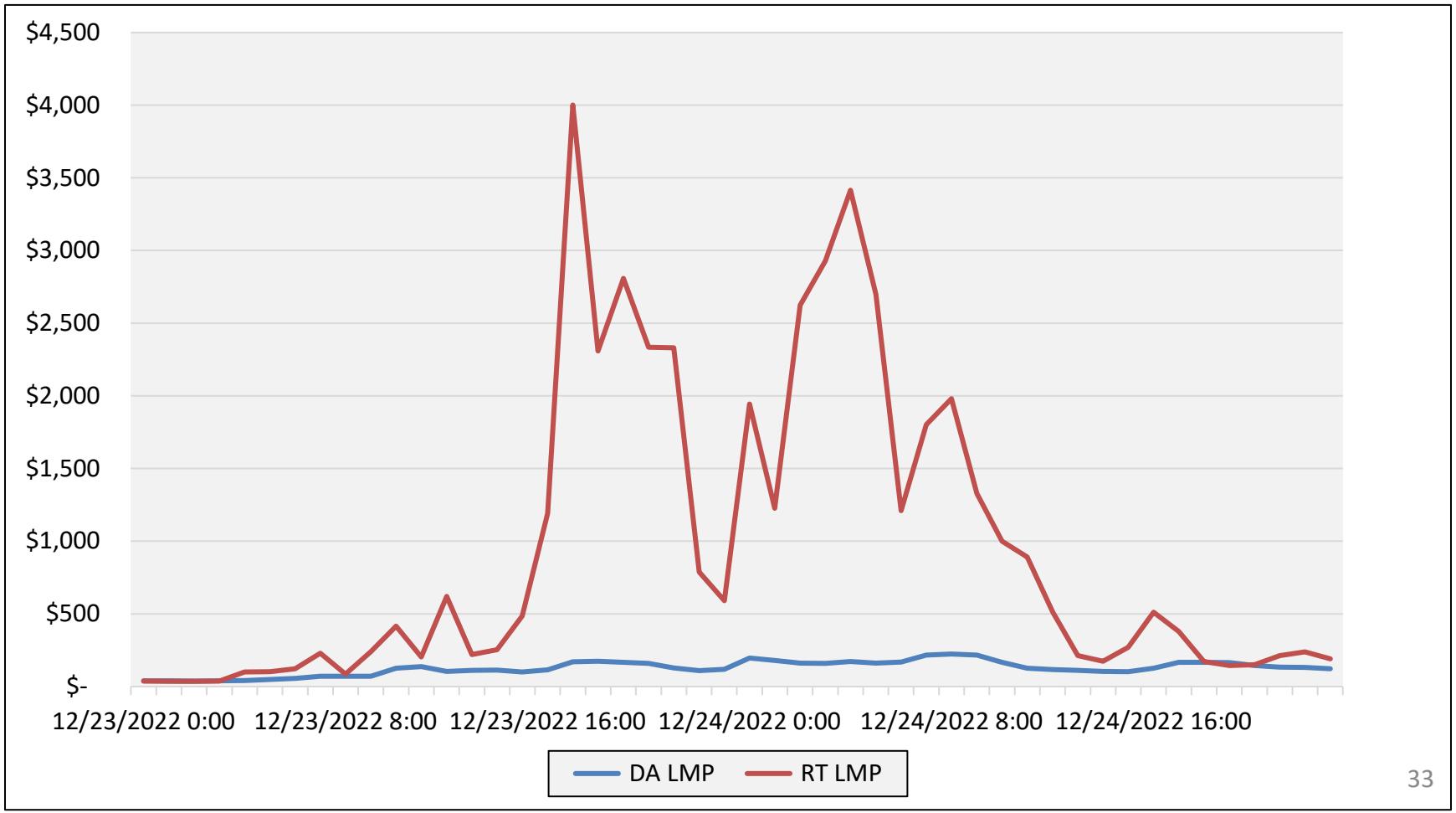


Solar Output During Emergencies



Demand > Supply

PJM Sends High Real-Time Price Signal



Wrap-up

- Supply must equal demand at all times
- Everyone is interconnected to each other
- Reliability needed for the entire area
- PJM has numerous tools to help maintain reliability, but got really close to failing in December
  - TVA, Duke, LG&E KU did have rolling blackouts

QUESTIONS?