Introduction to PJM Markets and Operational Reliability

PJM Initial Training Program

Student Guide

Prepared by:
State & Member Training

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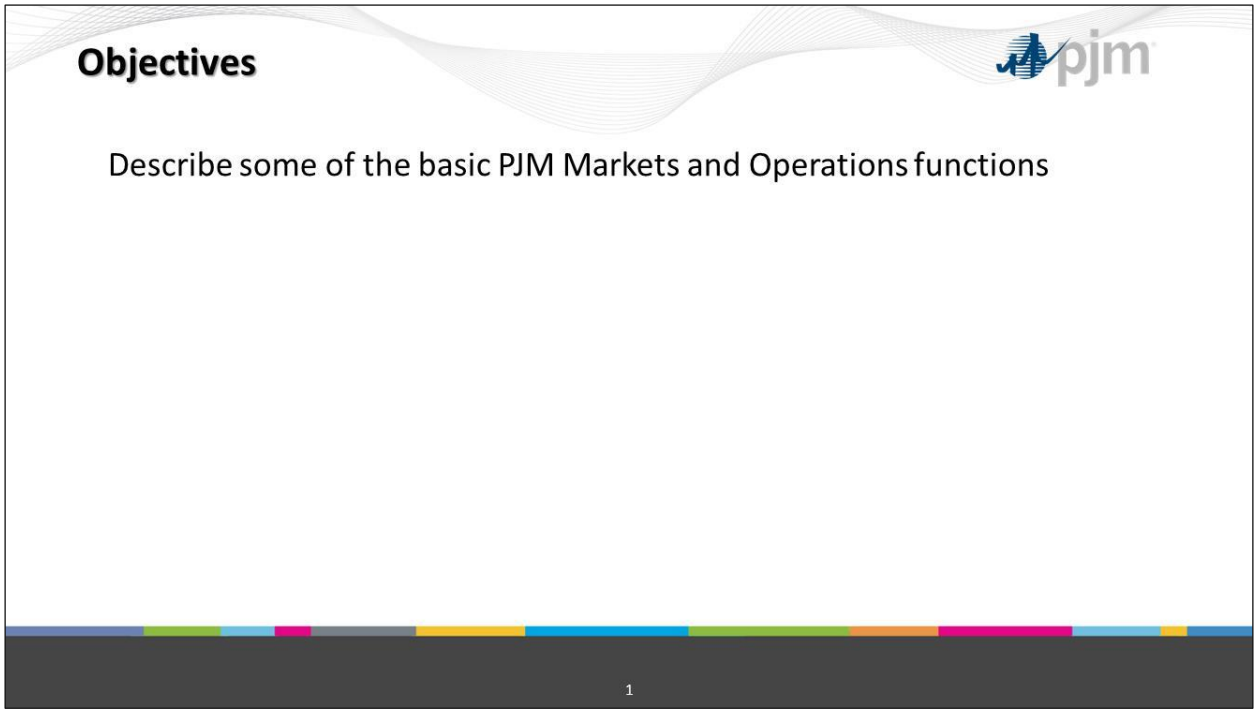
Objectives


Objectives
Describe some of the basic PJM Markets and Operations functions
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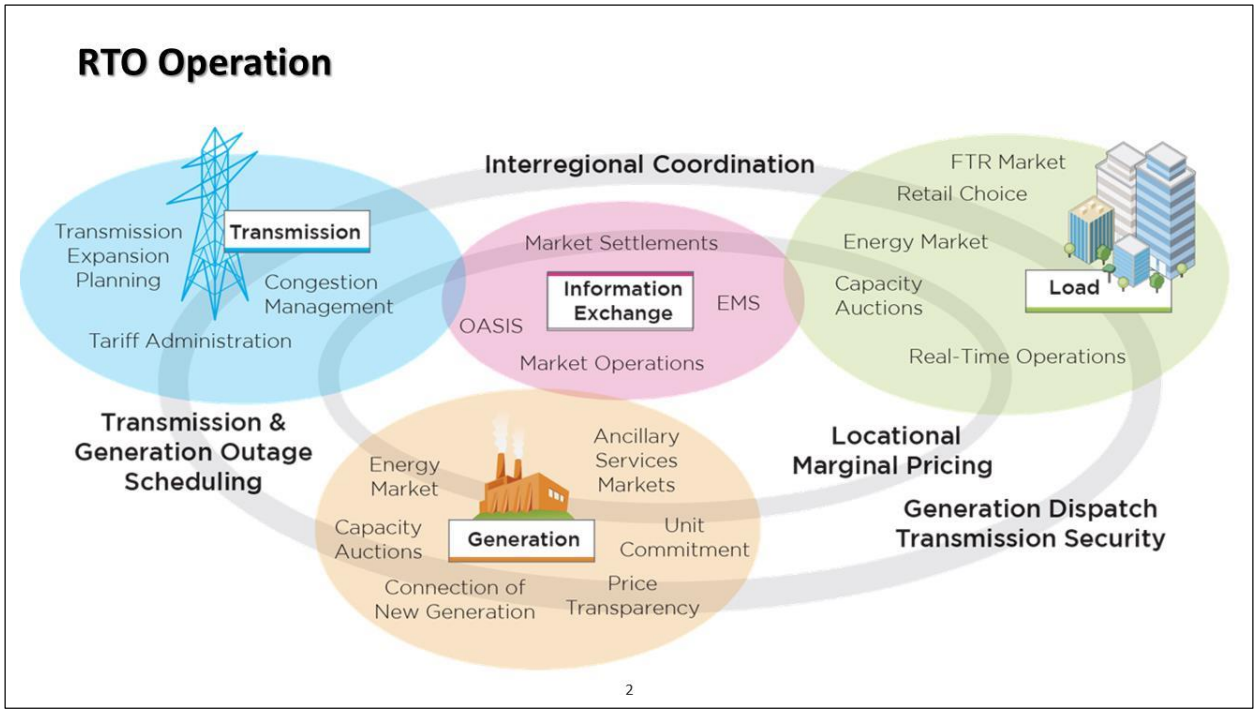
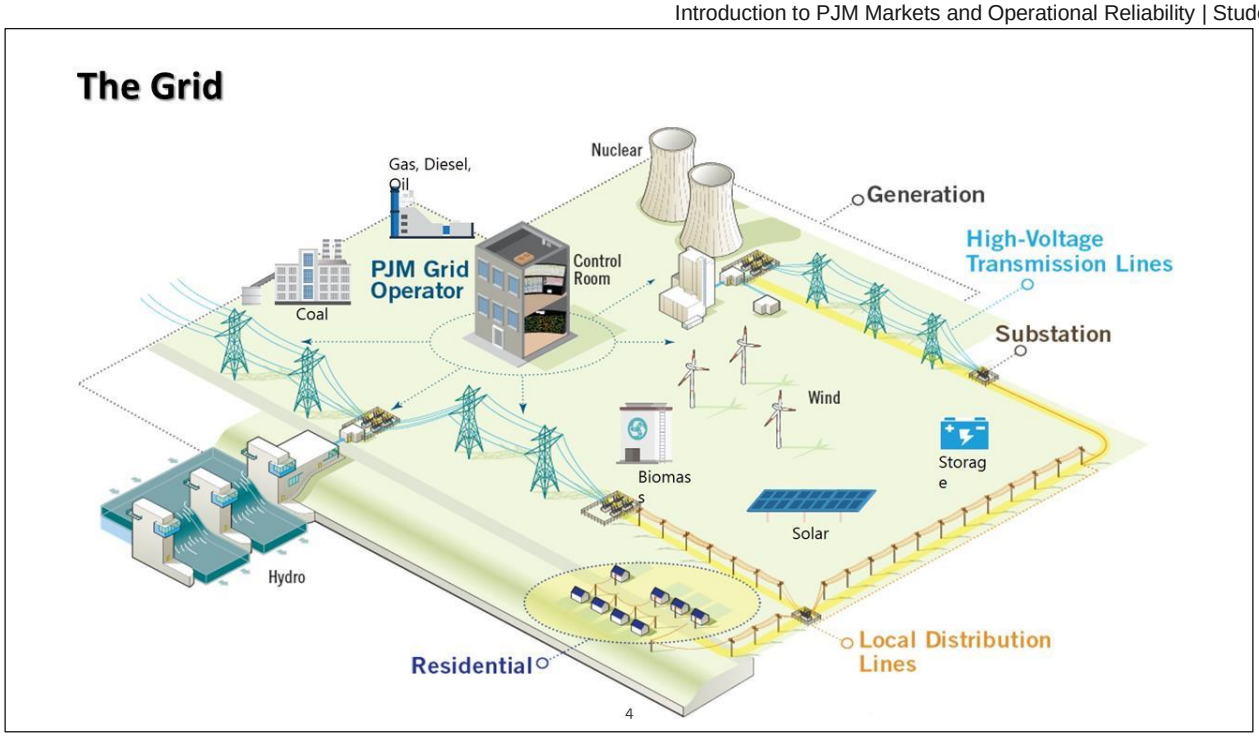
PJM's Responsibilities




The Grid
Gas, Diesel, Oil
Nuclear
Generation
High-Voltage Transmission Lines
PJM Grid Operator
Control Room
Coal
Substation
Wind
Biomass
Storage
Solar
Hydro
Residential
Local Distribution Lines
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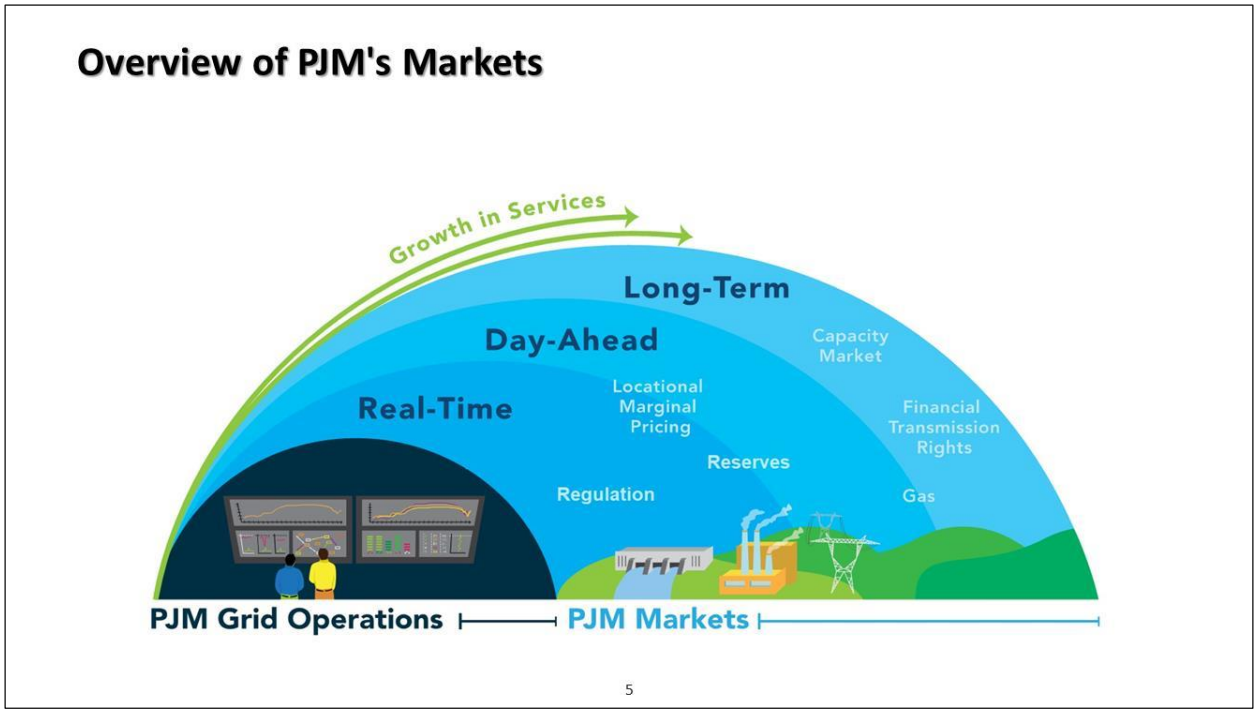
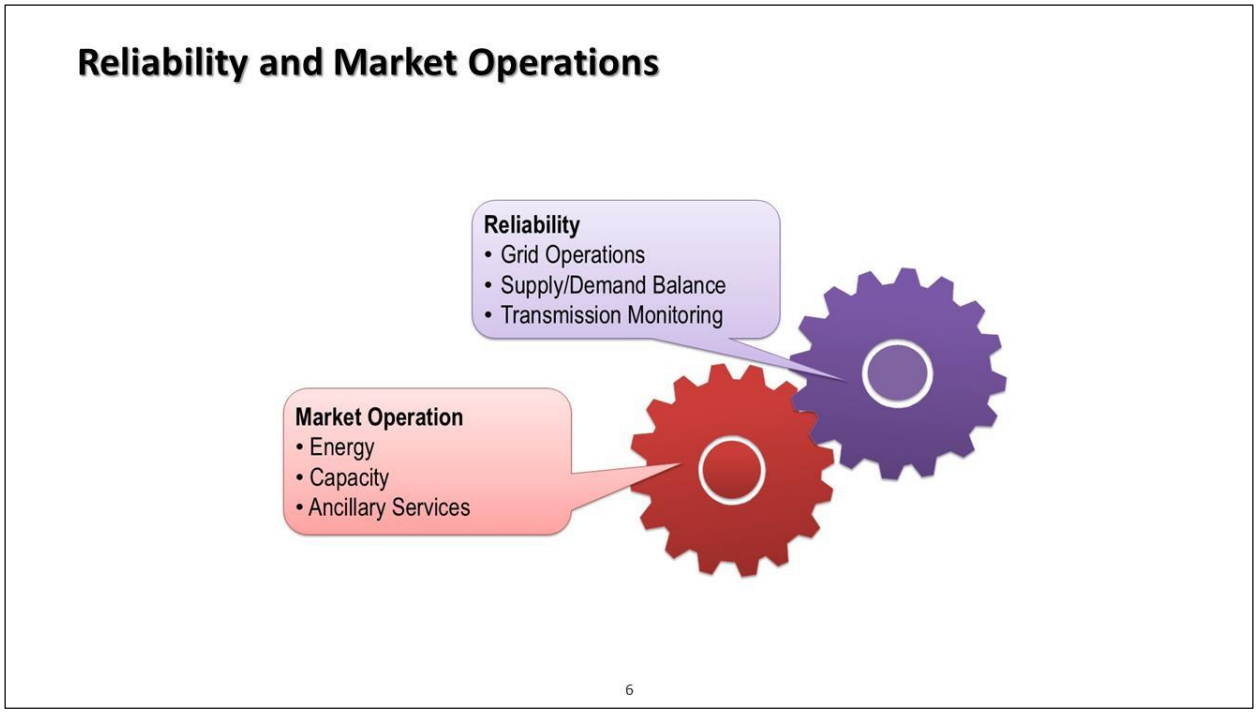
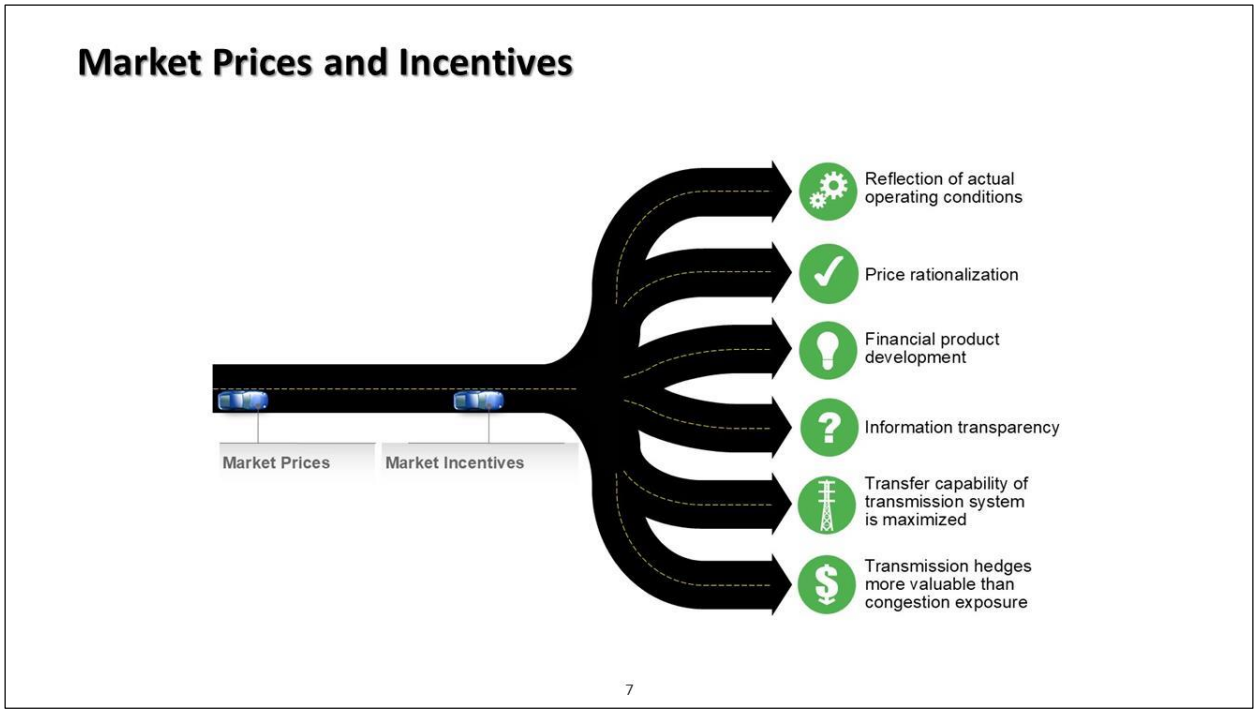
Overview of PJM's Markets



Reliability and Market Operations



Market Prices and Incentives



Transparency Leads to Trust

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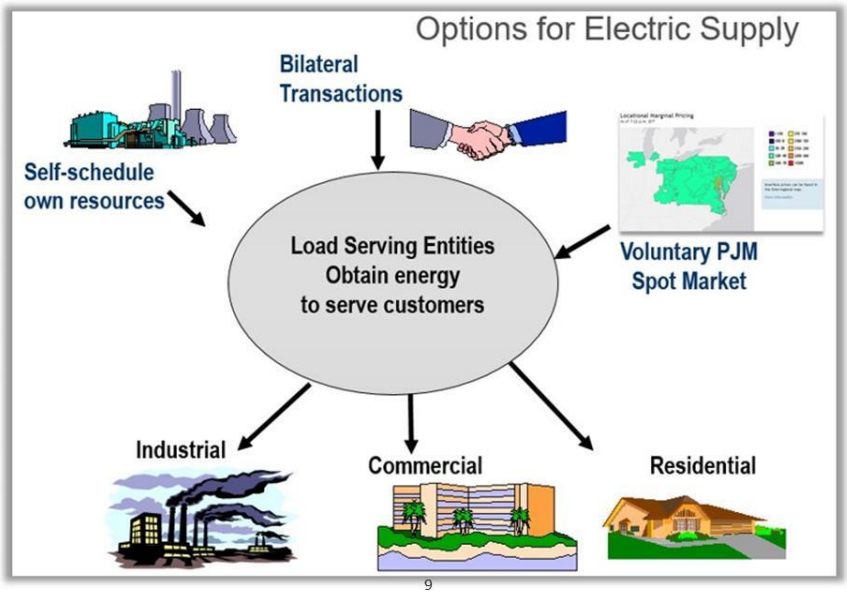
Load Serving Entities

Load Serving Entities - Overview



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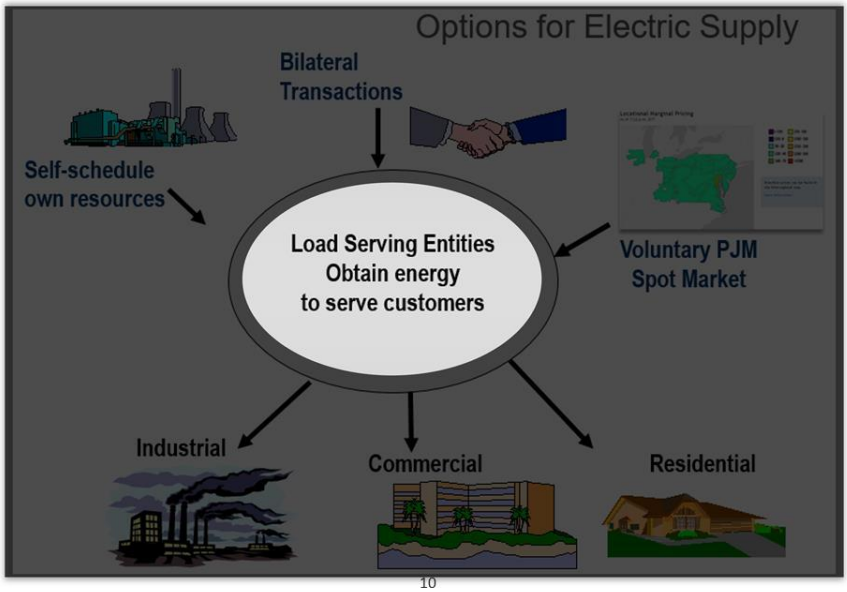
Load Serving Entities - LSEs



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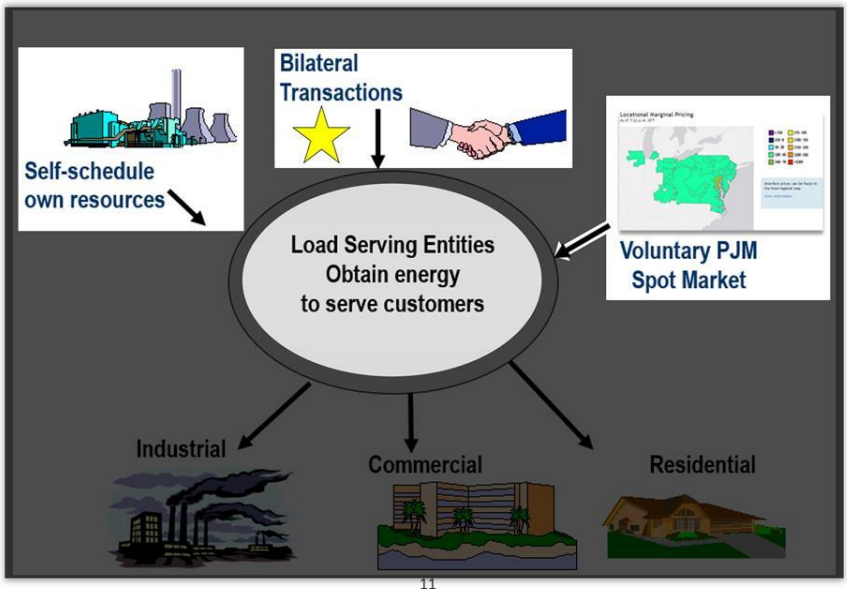
LSE Energy Purchases



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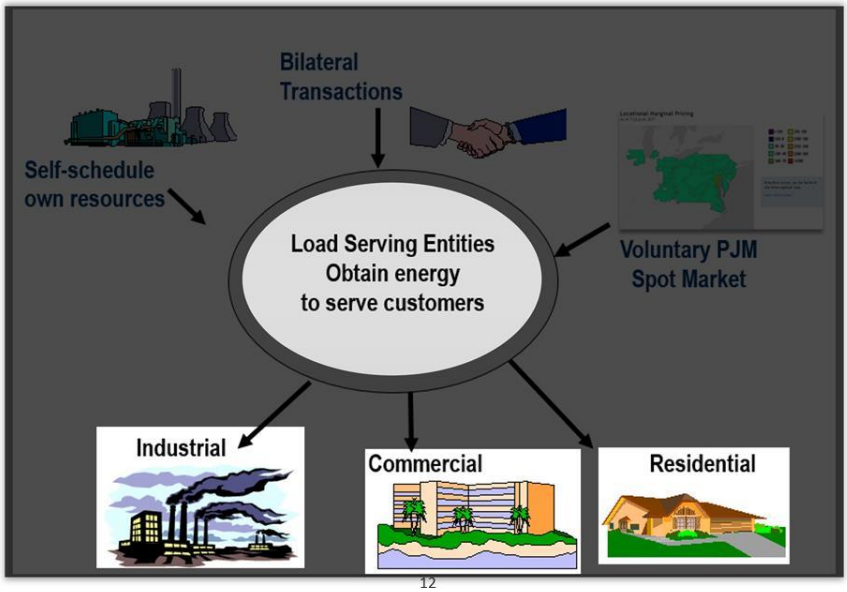
LSE Energy Customers



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PJM Has a Variety of Markets

Energy Market

PJM coordinates the continuous buying, selling and delivery of wholesale electricity through the Energy Market

PJM balances the needs of suppliers, wholesale customers and other market participants and monitors market activities to ensure open, fair and equitable access

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Reliability Pricing Model (RPM)

PJM's Reliability Pricing Model (RPM) provides a long-term price signal, consistent with the PJM Regional Transmission Expansion Planning process, for capacity resources and load serving entities' (LSEs) unforced capacity obligations

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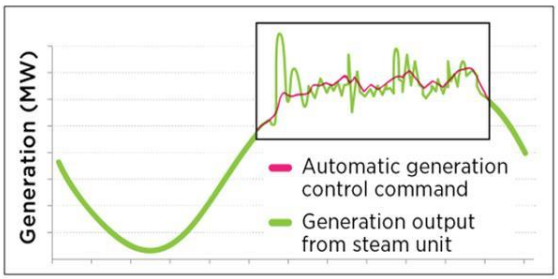
Regulation Market

Regulation helps match generation and demand to keep grid functioning normally by

- Maintaining system frequency of 60 Hertz
- Tracking moment-to-moment fluctuations in customer electricity use
- Correcting for unintended fluctuations in generation (such as a large generating unit disconnecting from the system)
- Managing differences between forecasted or scheduled power flow and actual power flow on system



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Synchronized Reserves

Reserve capability that can be converted fully into energy or load that can be removed from the system within 10 minutes of the request from the PJM dispatcher and must be provided by equipment electrically synchronized to the system

This includes

- Increase in the output of a synchronized generator
- Reduction in load from a synchronized resource such as the load of a pumped hydro resource currently synchronized in the pumping mode and capable of being shut down
- The maximum output energy level that could be attained on a resource operating as a synchronous condenser

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Financial Transmission Rights (FTRs)

PJM auctions Financial Transmission Rights (FTRs) to assist market participants in hedging price risk when delivering energy on the grid

FTRs are financial instruments that entitle the holder to a stream of revenues (or charges) based on the hourly energy-price differences across the transmission path in the Day-Ahead Market

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Dispatch Functions

Dispatch Functions

Ensure sufficient generation is available or running to satisfy the demand at any hour of the day including maintaining adequate reserves

- This is called ***Generation Control***

Monitor, operate and control the high voltage transmission system in a reliable manner

- This is called ***Transmission Control***

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Generation Dispatch

Generation Dispatch

Generation is economically dispatch to meet the demand across the entire RTO at the lowest cost

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Generation Dispatch Operations

Generation Dispatch Operations

Maintain System Control

- Generation/Demand balance

Maintain Adequate Reserves

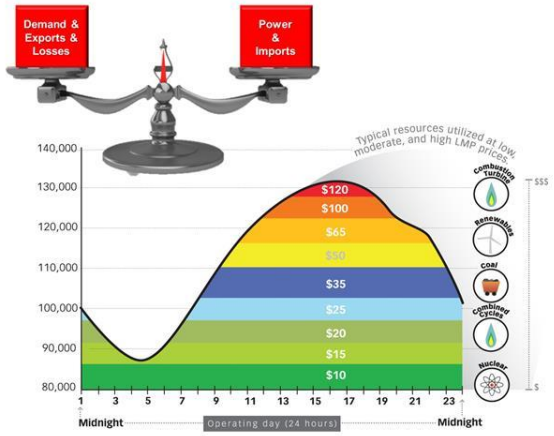
- Operate on contingency basis

Implement Emergency Procedures

- To keep the lights on!

Synchronized Reserve/Regulation Market

- Clear Market
- Administer real-time optimization



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Economic Generation Control

Economic Generation Control

- Purpose is to ensure that the least cost generation is used to satisfy demand
- Enables power system to follow load as it moves from valley, to peak, to valley over a 24-hour period
- Adjustments are allocated to generating units to optimize economy

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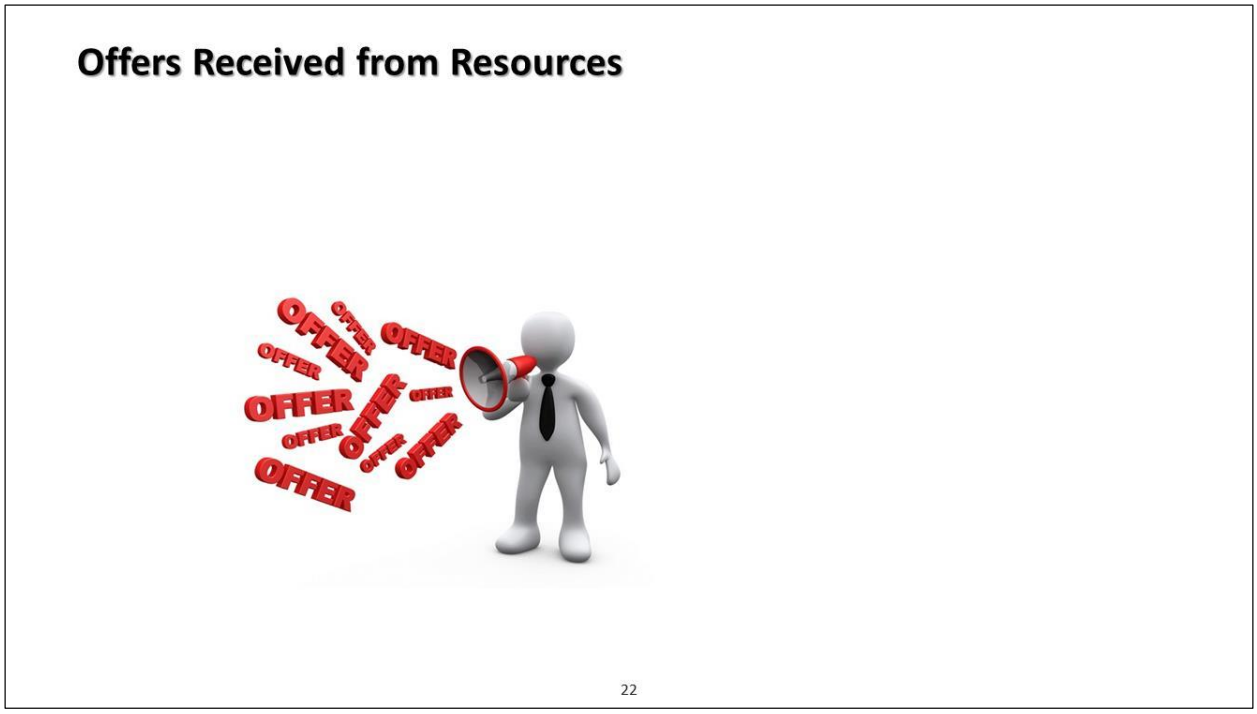
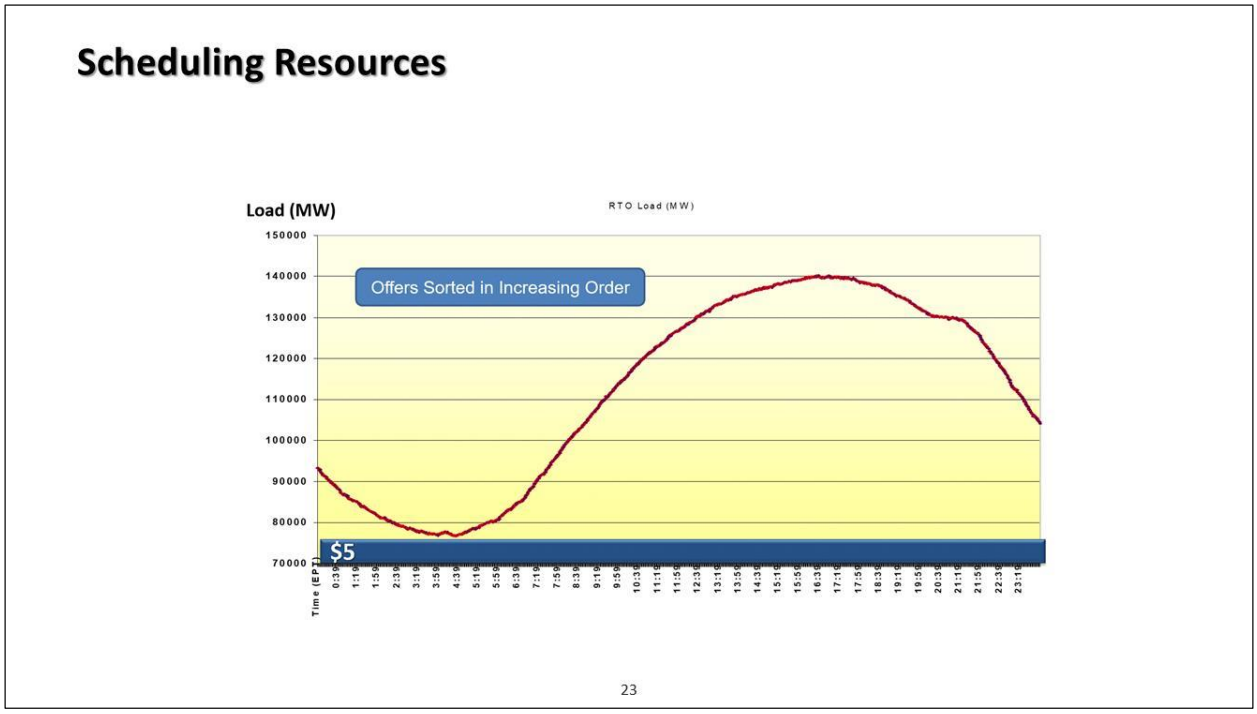
Offers Received from Resources



Scheduling Resources



Unexpected Events

Unexpected Events

Events That May Take Place

- Units trip - unexpected loss
- Units are delayed
- Contract curtailments
- Weather
- Emergency Procedures

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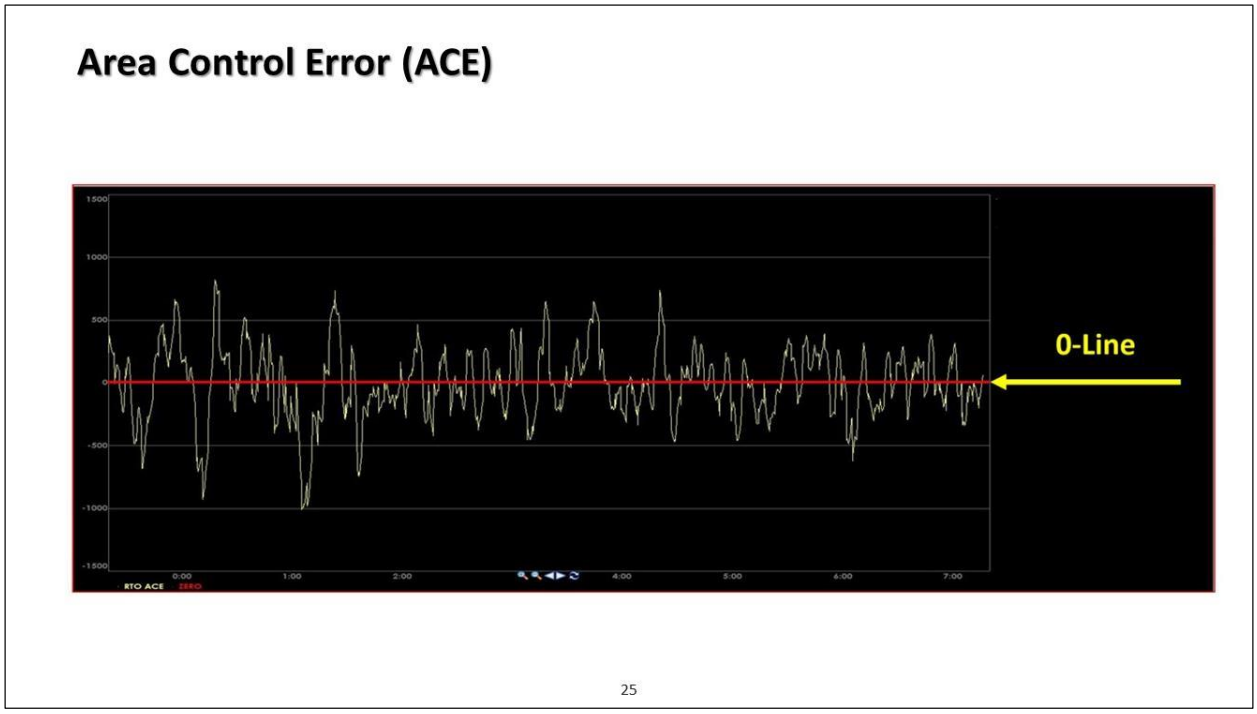
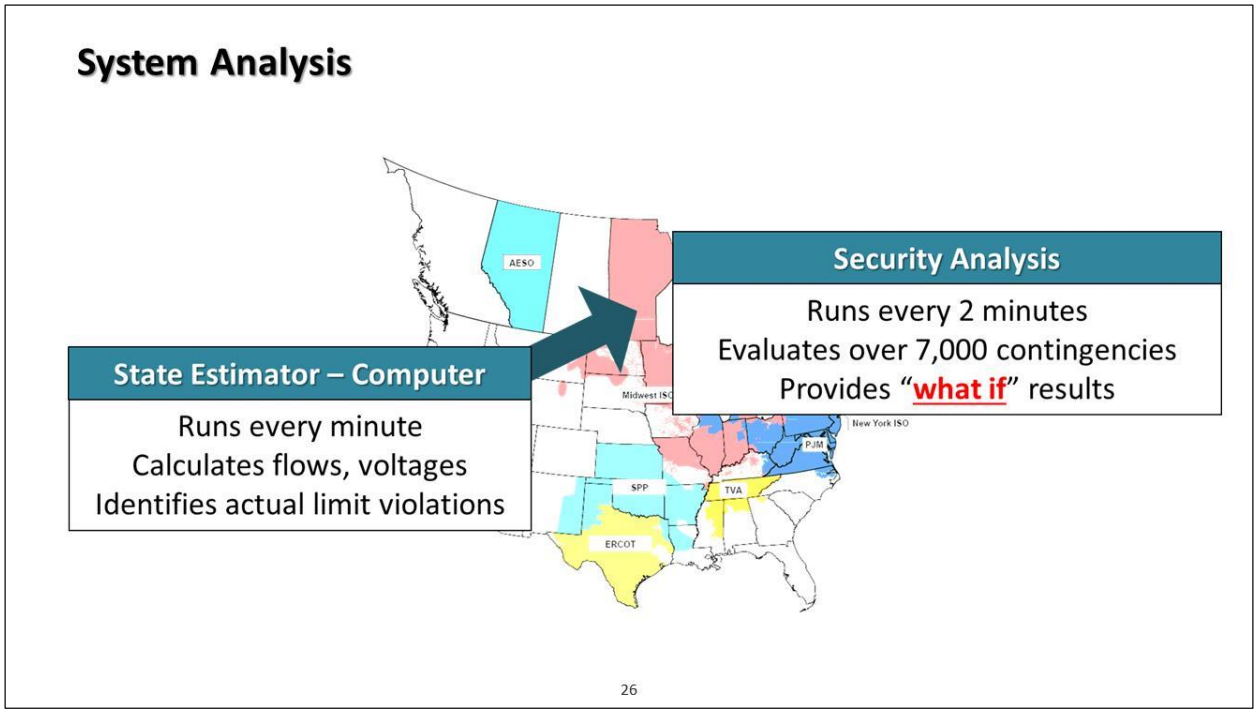
Area Control Error (ACE)



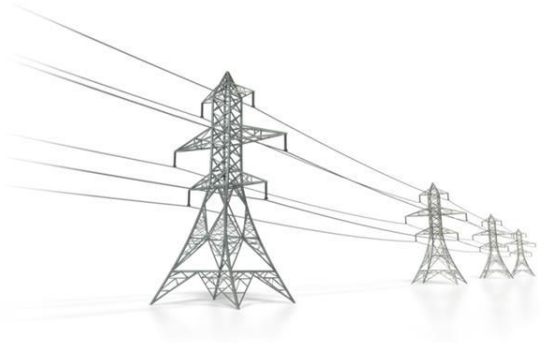
System Analysis



Power Transfer Limits

Power Transfer Limits

- Thermal Limits
- Voltage Limits
- Stability Limits



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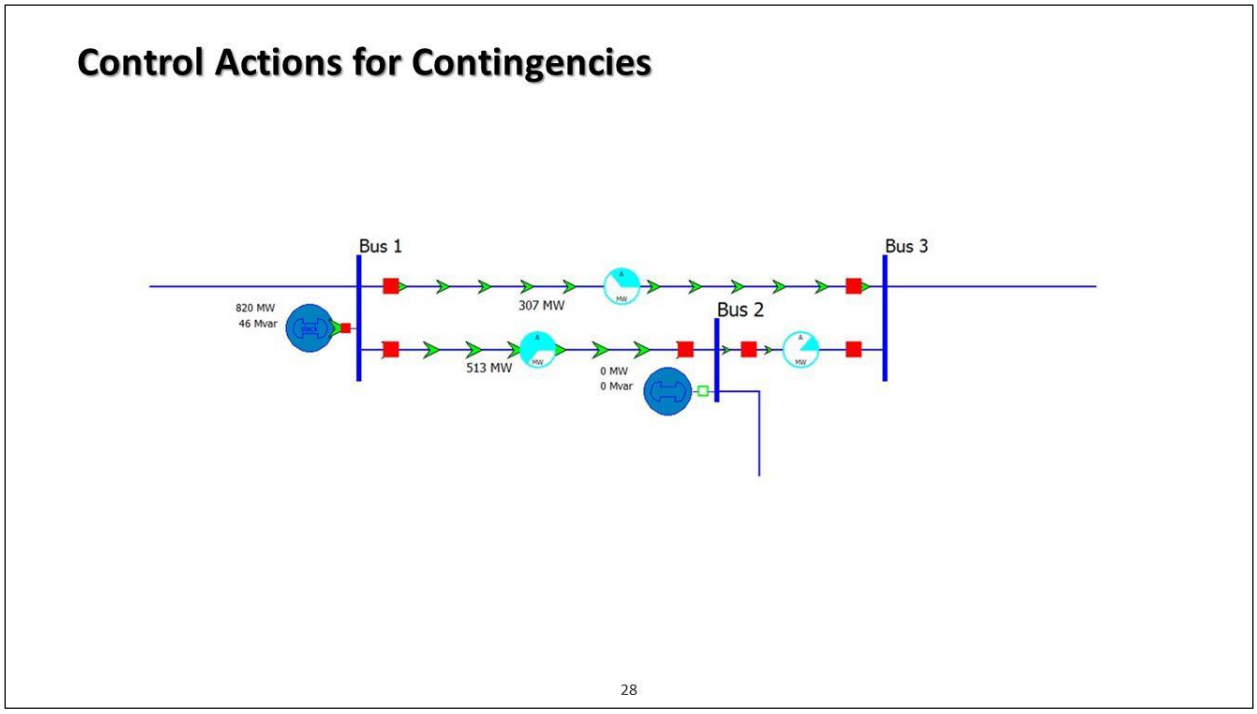
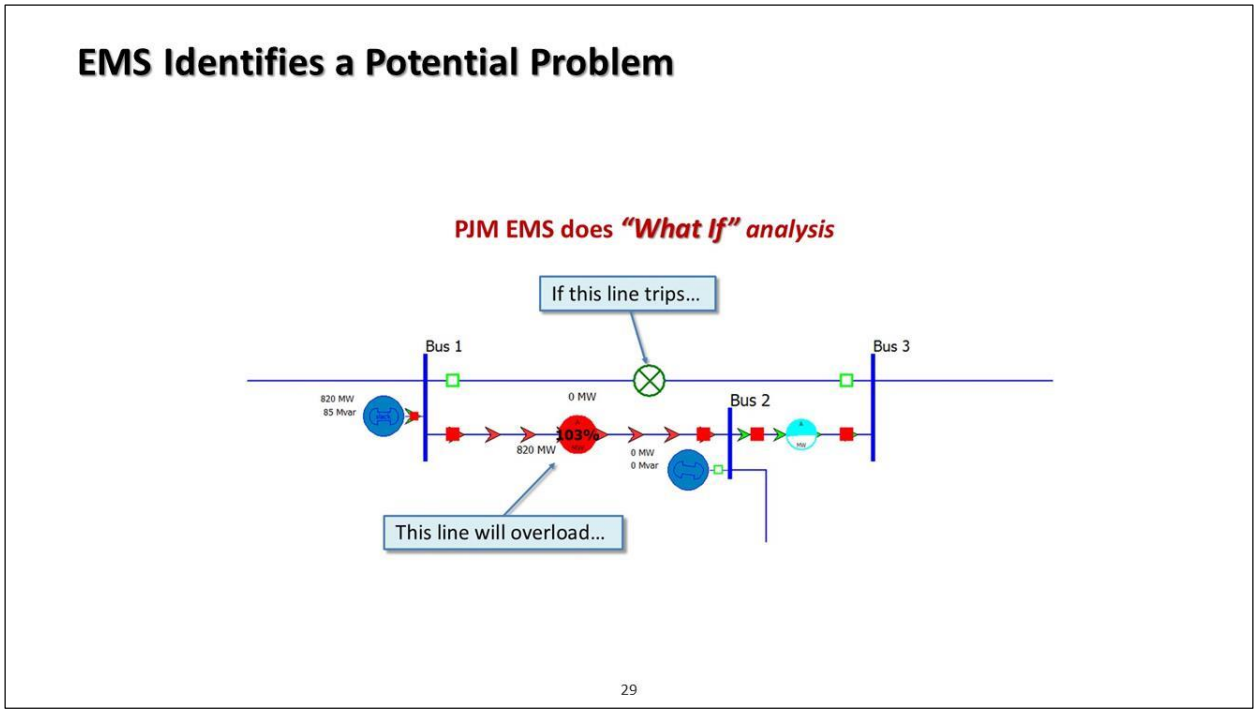
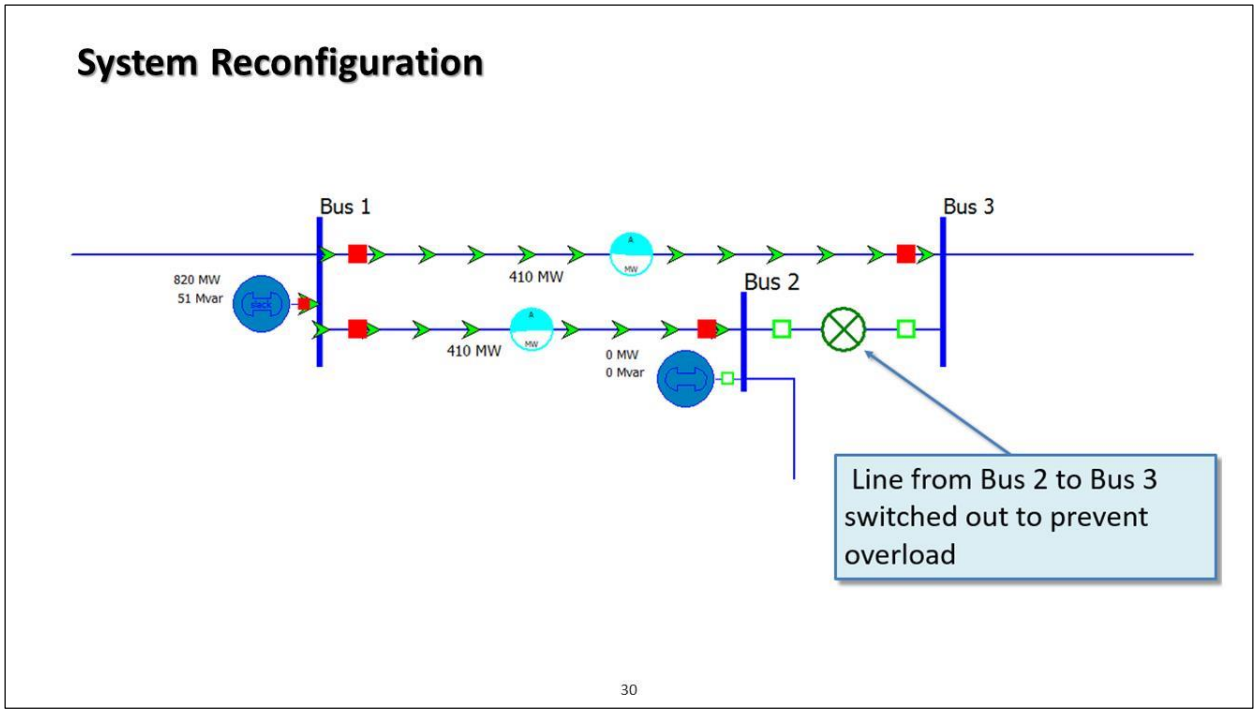
Control Actions for Contingencies



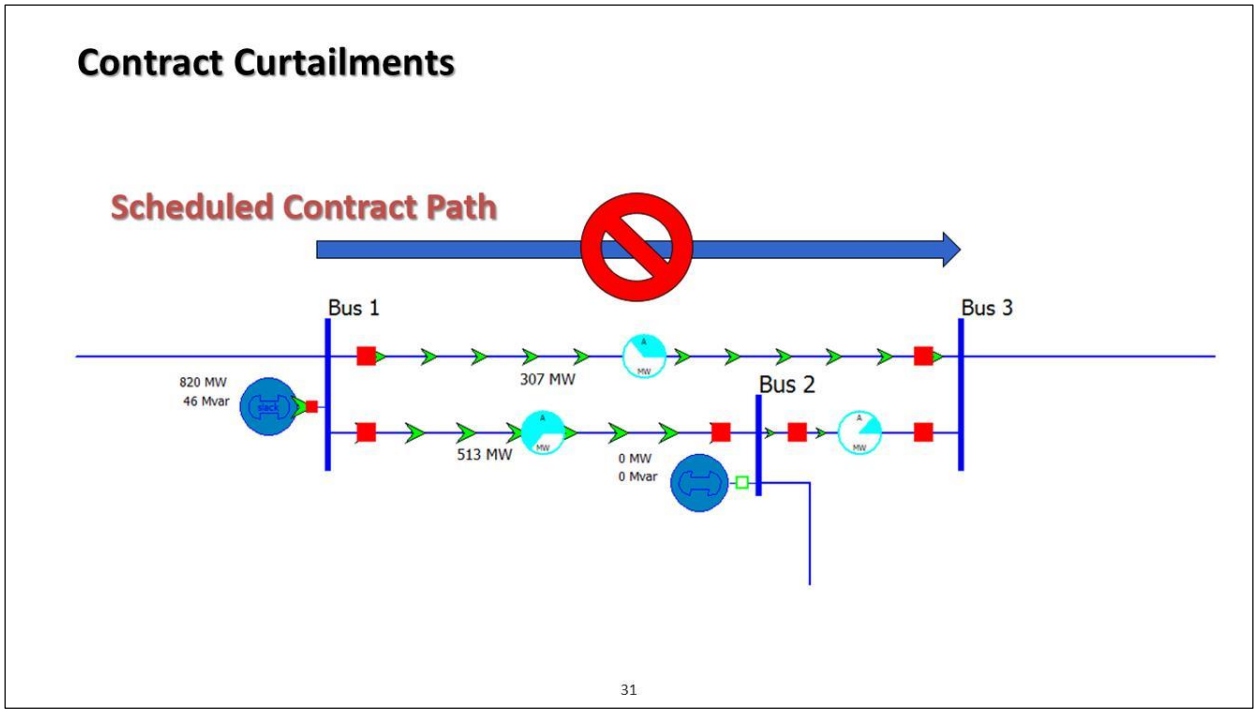
EMS Identifies a Potential Problem



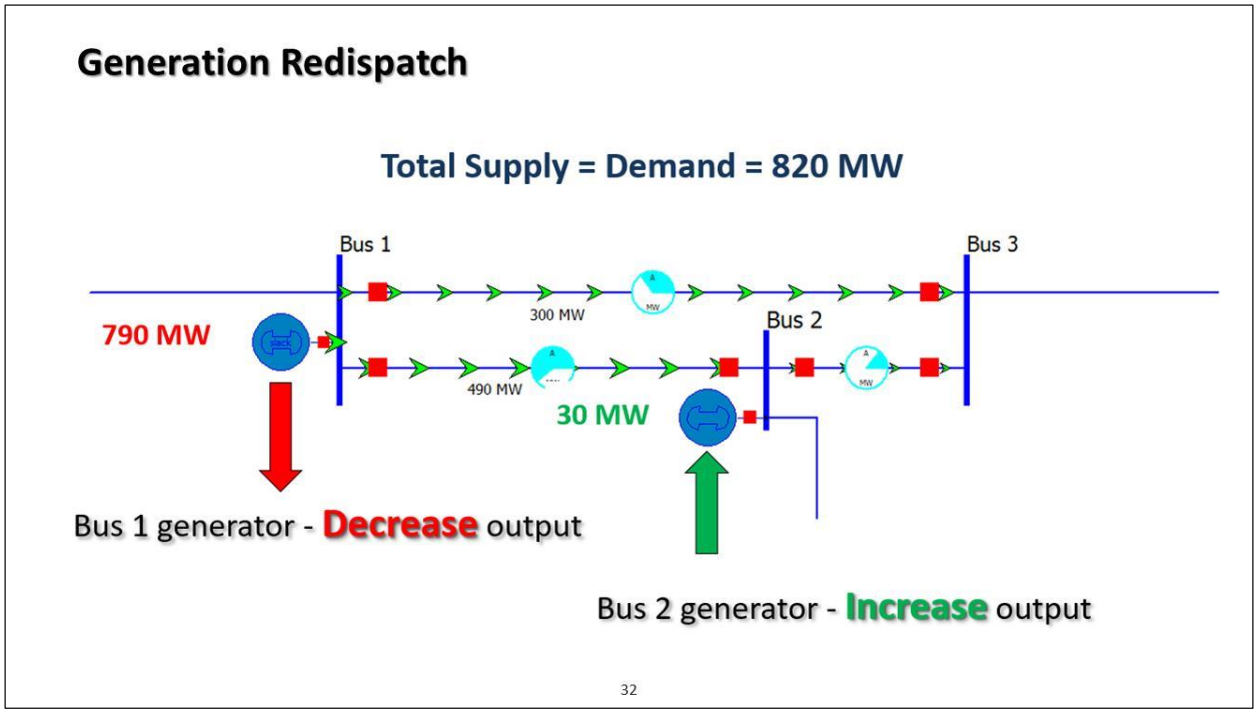
System Reconfiguration



Contract Curtailments

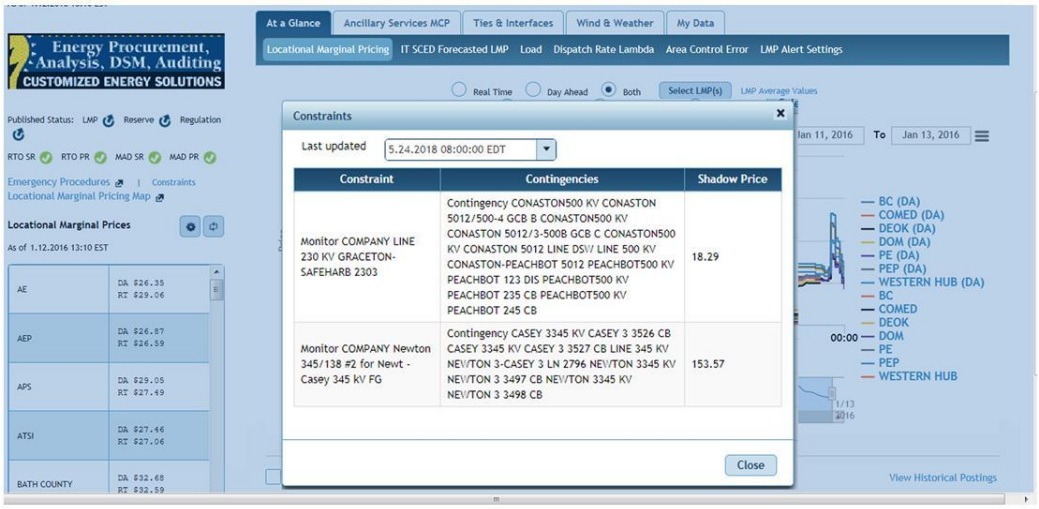


Generation Redispatch



Viewing Constraints

Viewing Constraints



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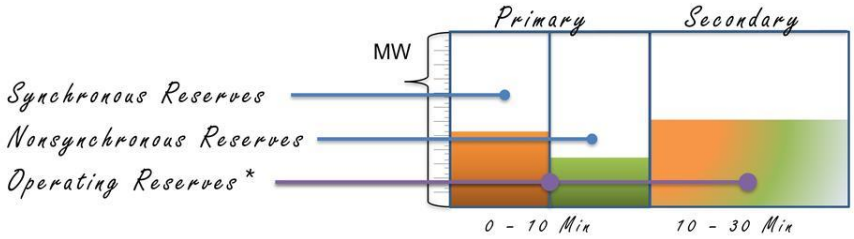
Reserve Monitoring

Reserve Monitoring

- Reserves are additional capacity above the expected load
- Used to protect the system against uncertain occurrences
  - Loss of capacity
  - Load forecasting errors
- Compliance with NERC, SERC and RF BAL standards



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Operating Reserve

Operating Reserve

Generating capability and/or equivalent generating capability scheduled to operate in excess of the forecast hourly integrated PJM RTO load that can be converted fully into energy within 30 minutes from the request of the PJM dispatcher

Load that can be removed from the system in 30 minutes from the request of the PJM dispatcher

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Primary Reserve

Primary Reserve

NERC defines this type of reserve as "Contingency Reserves"

- Per NERC, these are considered to be any on or off-line resource that can be available within 15 minutes

PJM defines this type of Reserve as "Primary Reserves"

- Per PJM, these are considered to be either reserves which can be full converted into energy within 10 minutes of the request from the PJM dispatcher
- **OR**, load that can be removed from the system within 10 minutes of the request from the PJM dispatcher

The NERC and PJM terms are interchangeable

Primary (Contingency) Reserves are subdivided into two categories:

- Synchronized Reserves
- Non-Synchronized (Quick Start) Reserves

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Synchronized Reserves

Synchronized Reserves

- Synchronized Reserves are considered to be reserve capability that can be converted fully into energy or load that can be removed from the system within 10 minutes of the request from the PJM dispatcher and must be provided by equipment electrically synchronized to they system
- These include...
  - An increase in the output of a synchronized generator
  - A reduction in load from a synchronized resource such as the load of a pumped hydro resources currently synchronized in the pumping mode and capable of being shut down
  - The maximum output energy level that could be attained on a resource operating as a synchronous condenser

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Quick Start Reserves

Quick Start Reserves

Quick Start, or non-synchronized, reserves are considered to be reserve capability that can be fully converted into energy or load that can be removed from the system within 10 minutes of the request from the PJM dispatcher and is provided by equipment not electrically synchronized to the system

Examples include:

- Run-of-River Hydro
- Pumped Hydro
- Industrial Combustion Turbines, Jet Engine/Expander Turbines
- Diesel Units
- Interruptible Demand Resources

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Secondary Reserves

Secondary Reserves

Secondary Reserves are considered to be reserve capability that can be fully converted to energy or load that can be removed from the system within a 10-to-30 minute interval following the request of the PJM dispatcher

These resources do not need to be electrically synchronized to the system

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Knowledge Check!

1. **What is the primary purpose of PJM's RPM (Capacity) Market?**

   a. *Controlling real-time electricity prices*

   b. *Purchasing fuel for generation*

   c. *Ensuring future resource adequacy*

   d. *Balancing transmission flows*

2. **What is the response time requirement for Primary Reserves?**

   a. *30 minutes*

   b. *15 minutes*

   c. *60 minutes*

   d. *10 minutes*

3. **Which of the following tools simulates potential failures like line outages?**

   a. *Energy Management System*

   b. *State Estimator*

   c. *Security Analysis*

   d. *Auction Revenue Rights*

Questions

Questions?

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