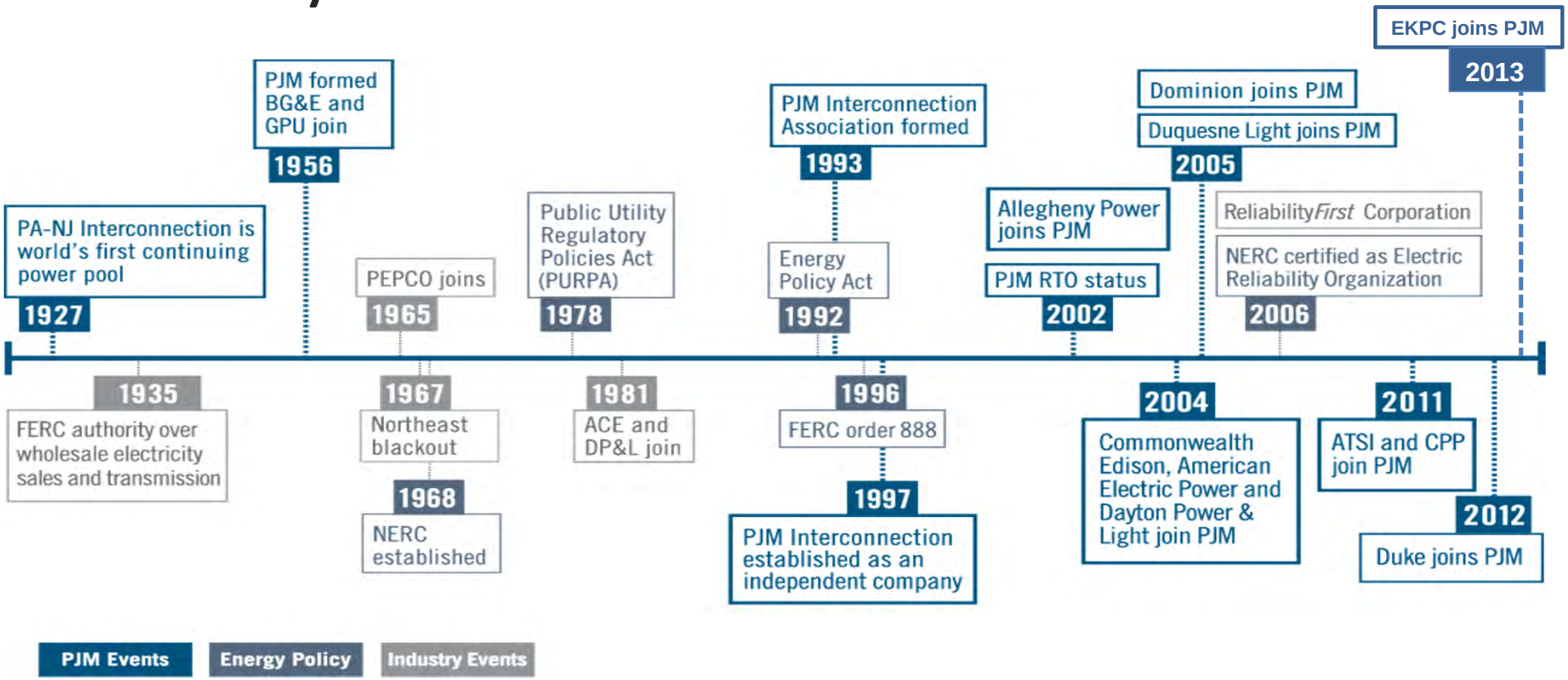
Introduction to the PJM Markets

Objectives

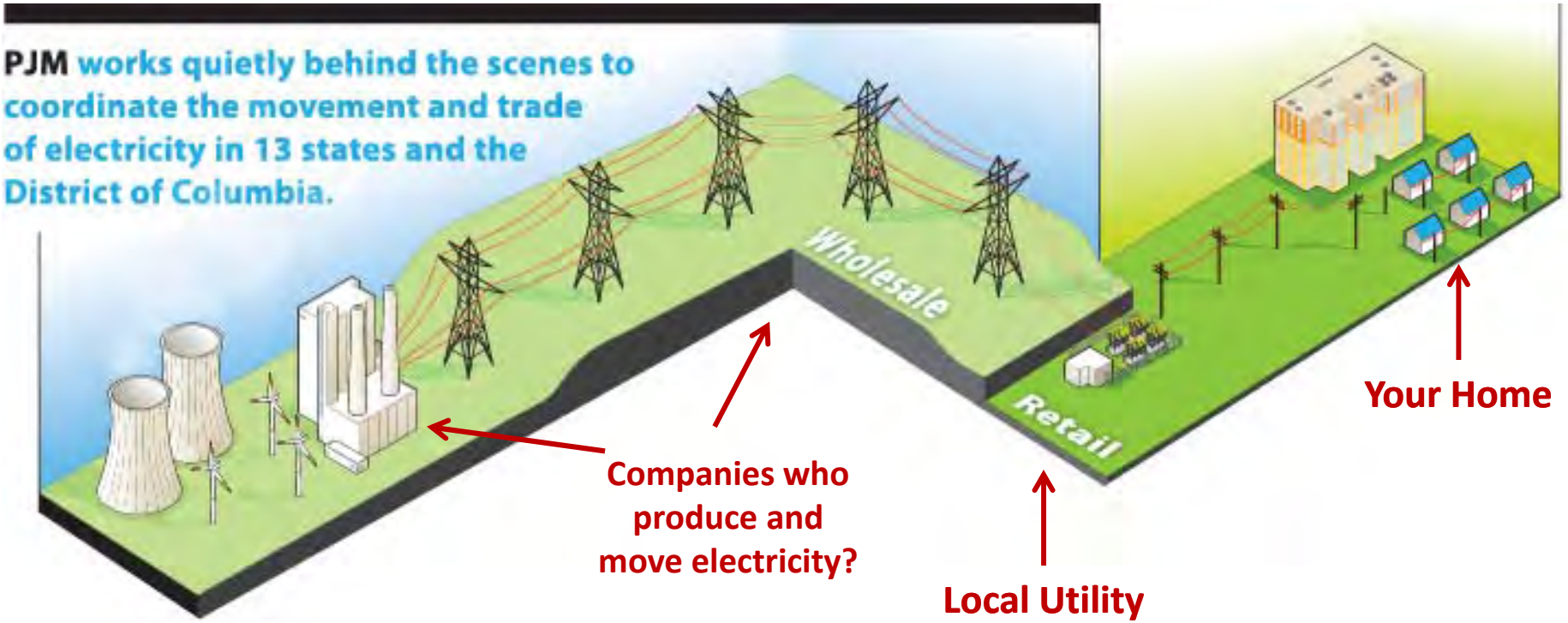
Students will be able to:

- Describe some of the basic functions of PJM

The History of PJM



Our Responsibility – Managing the Bulk Power System



PJM Markets Today

- Day-Ahead Energy Market
- Real-Time Energy Market
- Reliability Pricing Model (RPM)
- Reserve Market
- Regulation Market
- Financial Transmission Rights/Auction Revenue Rights (FTR/ARR)

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

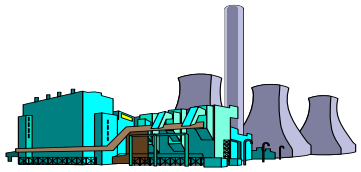
RPM

- 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

Regulation

Regulation is:

- A variable amount of generation energy under automatic control
- Independent of economic cost signal
- Obtainable within five minutes
- Responds to frequency deviations



- These generating units or demand response resources provide fine tuning that is necessary for effective system control
- Regulating units correct for small load changes that cause the power system to operate out of balance (measured as “ACE”)

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
- 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

FTR

- 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

Questions ?

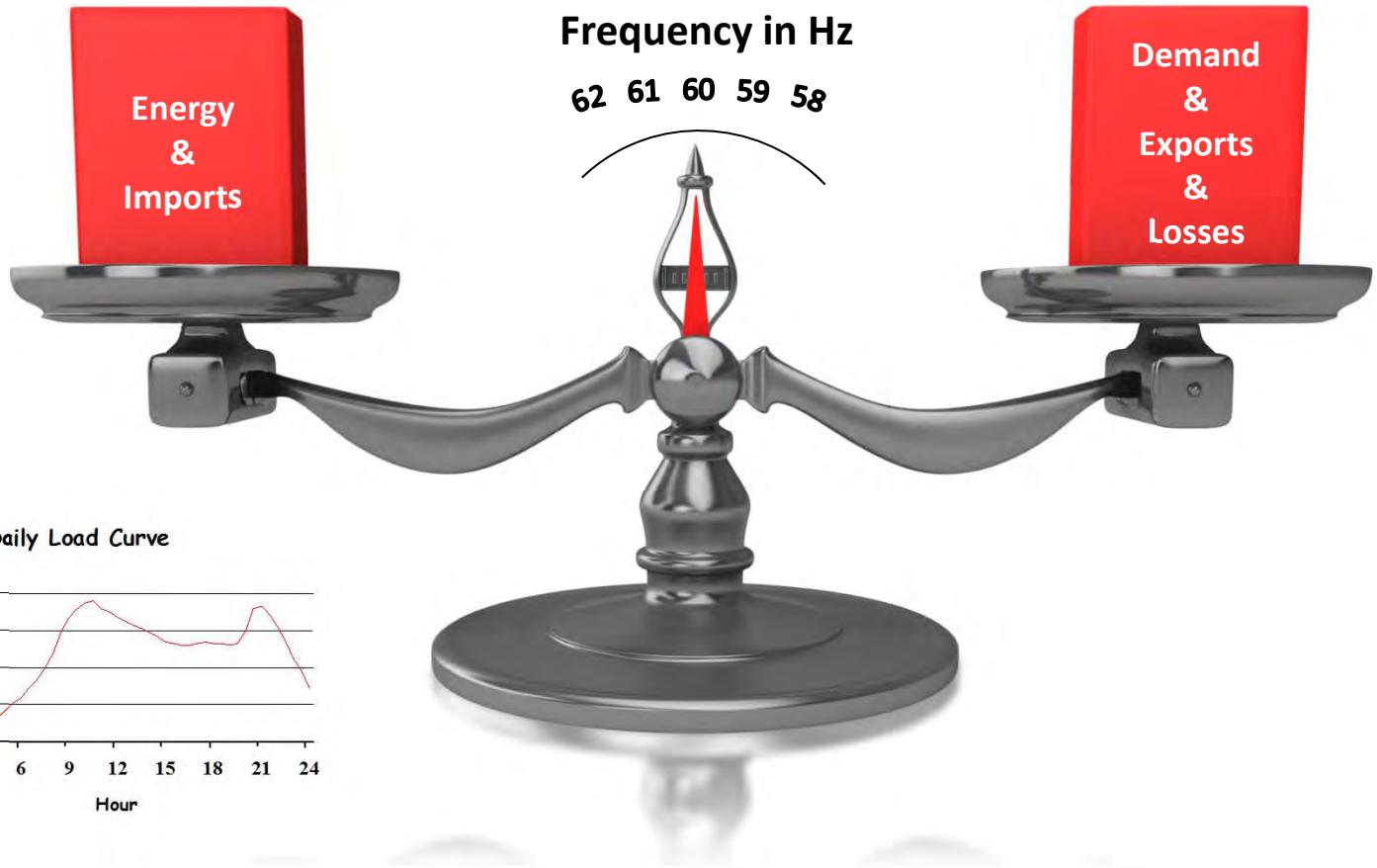
Operational Reliability

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***

Achieving Energy Balance



ACE Graph


1500
1000
500
0
-500
-1000
-1500
0:00
1:00
2:00
4:00
5:00
6:00
7:00
RTO ACE
ZERO
\\pi01awp\ca_rt_pc/rto_ltu:ar-rto ace:mw
61
MW
ZERO.Value
0
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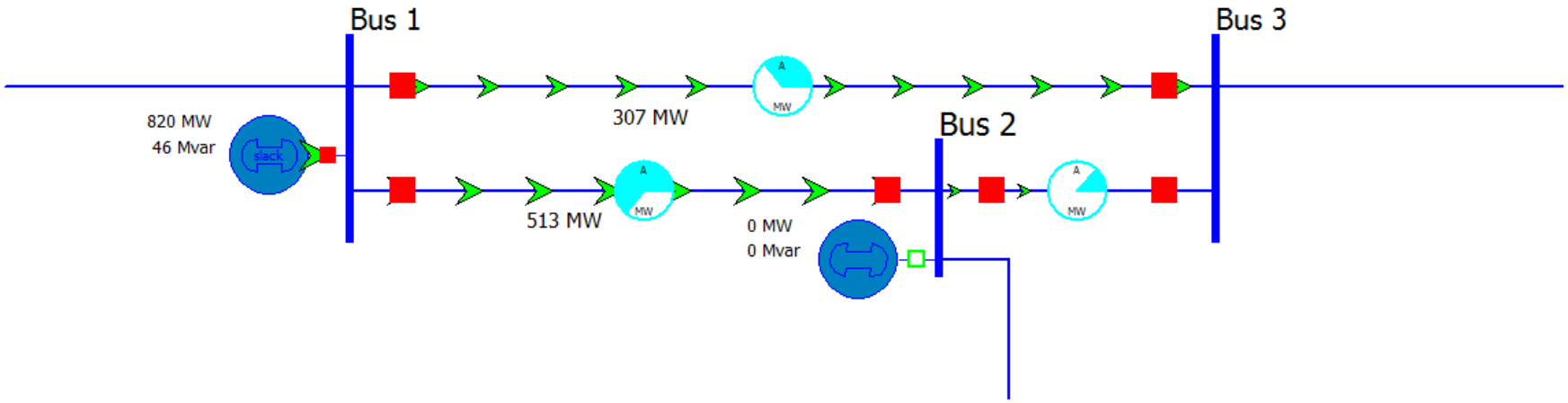
Events That Take Place

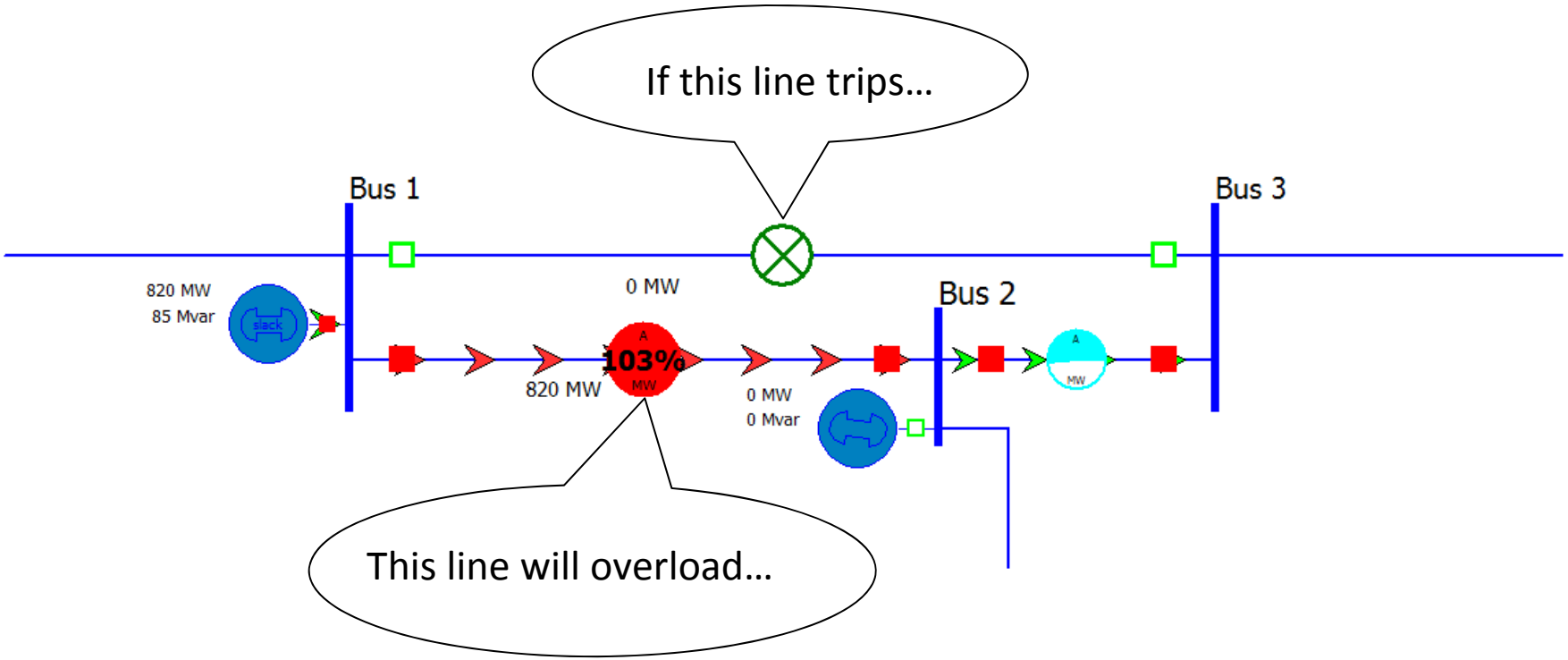
- Units trip
- Units are delayed
- System Constraints
- Contract Curtailments
- Weather
- Emergency Procedures

Operations



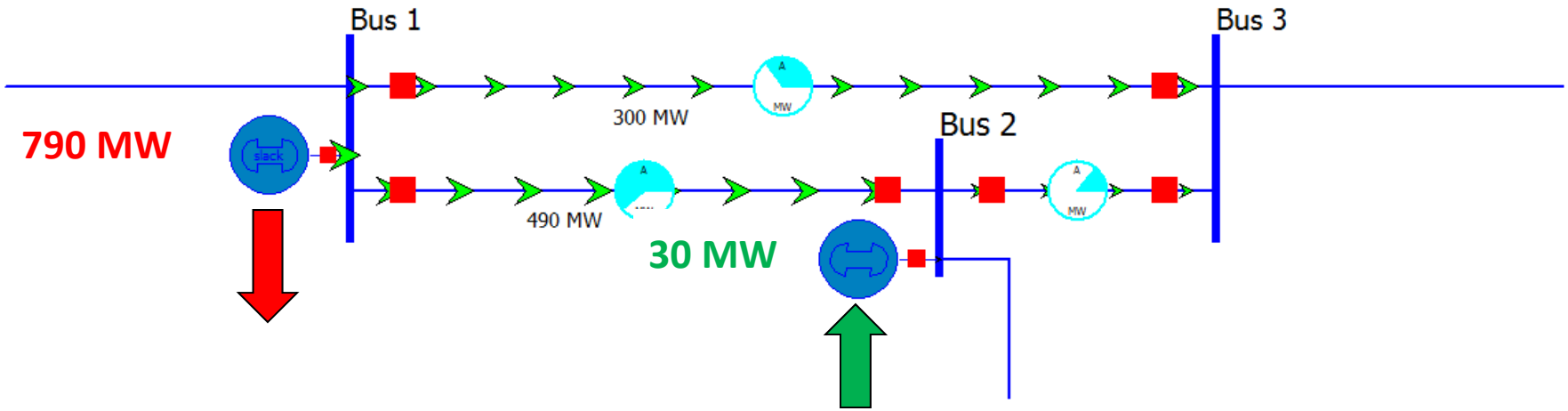
Operations

PJM EMS says “What If”?



Operations

Total supply = Demand = 820 MW



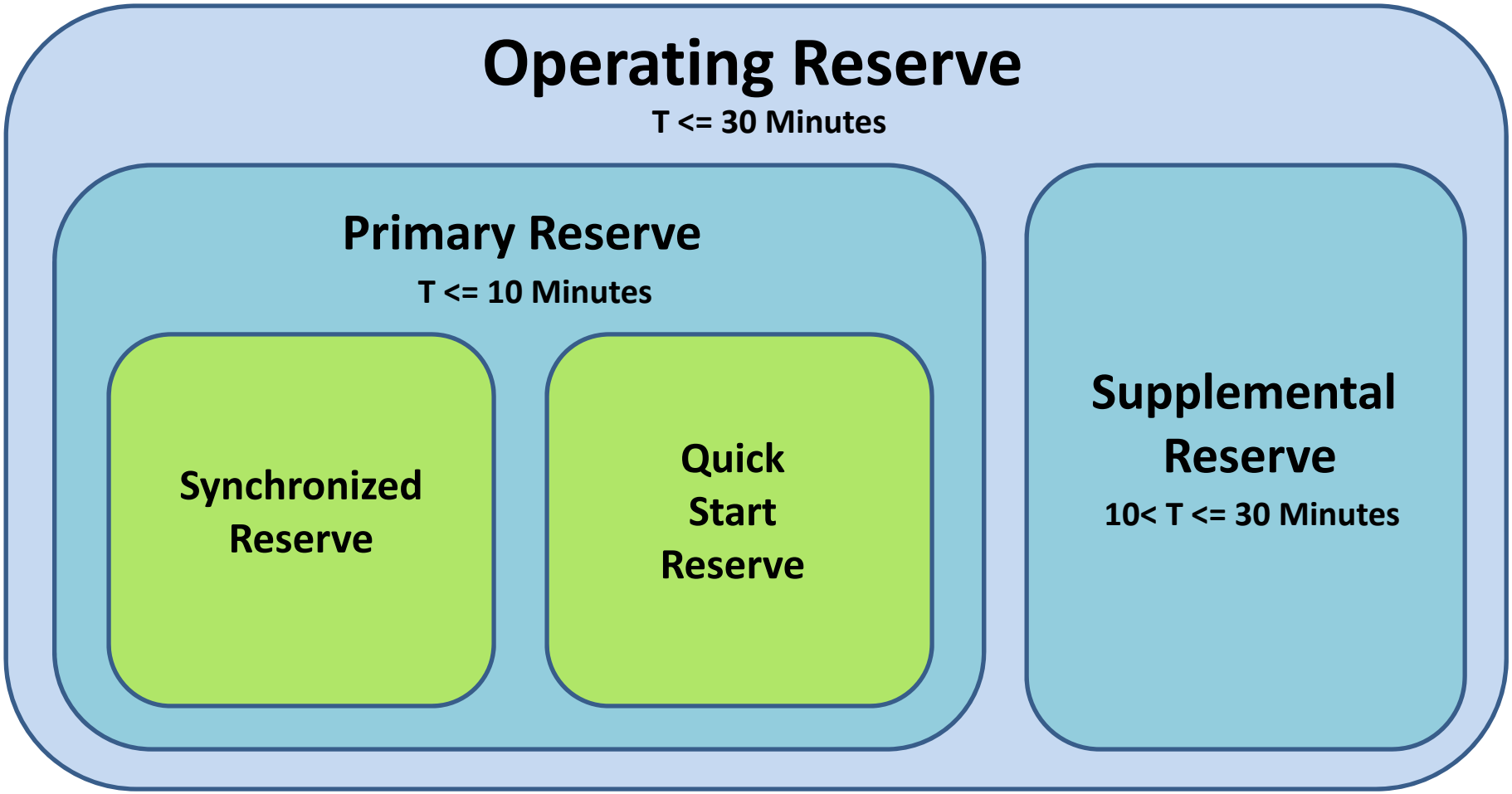
Bus 2 generator - Increase output

Bus 1 generator - Decrease output

PJM Reserves - Introduction

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 RFC BAL standards


Operating Reserve
T <= 30 Minutes
Primary Reserve
T <= 10 Minutes
Synchronized Reserve
Quick Start Reserve
Supplemental Reserve
10< T <= 30 Minutes

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

Primary Reserve

- NERC term is Contingency Reserves
  - On or off-line reserves available within 15 minutes
- PJM Primary Reserves
  - Reserves which 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
- NERC and PJM terms are interchangeable
- Primary (Contingency) Reserves are subdivided two categories:
  - Synchronized Reserves
  - Non- Synchronized (Quick Start) Reserves

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
- 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

Quick Start (non-synchronized) Reserves

- 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
- Includes:
  - the reduction in load from a non-synchronized resource which can be attained in 10 minutes
  - Examples:
    - run-of-river hydro
    - pumped hydro
    - industrial combustion turbines, jet engine/expander turbines
    - combined cycle units
    - Diesels
    - interruptible demand resources

Supplemental Reserve

- Reserve capability that can be fully converted into 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 have to be electrically synchronized to the system

Questions?