Reserve Market

PJM Initial Training Program

Student Guide

Prepared by:
State & Member Training

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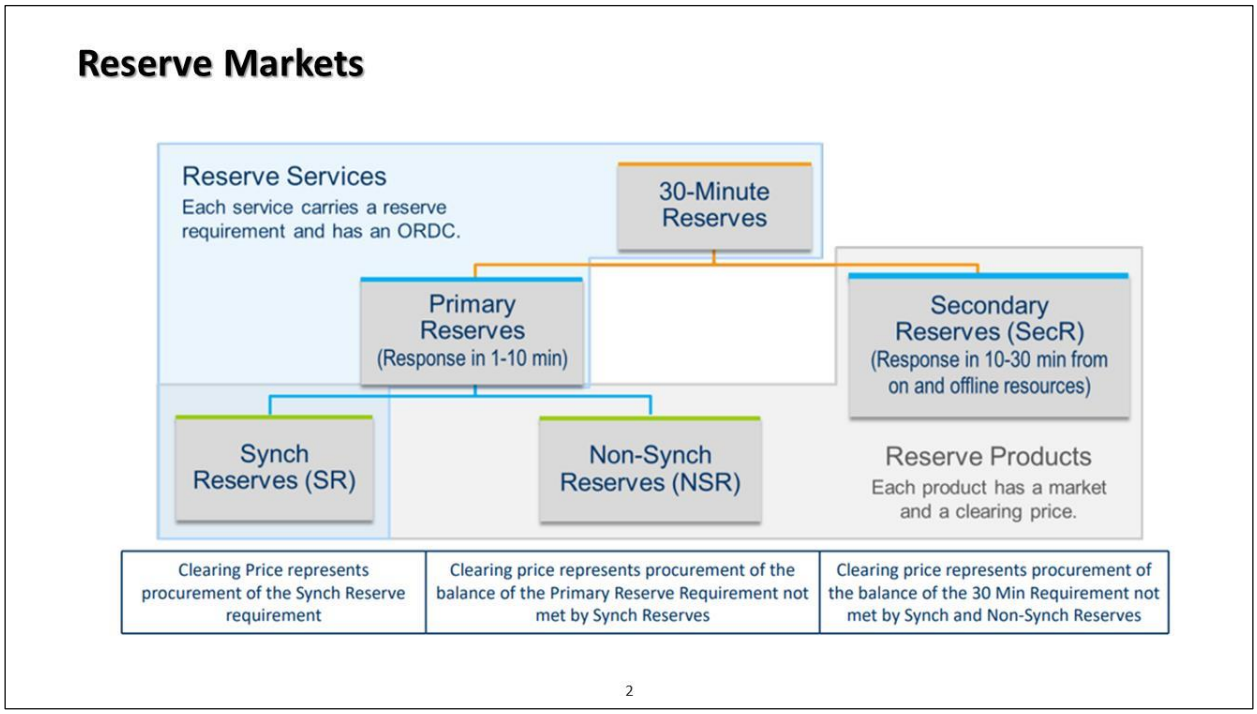
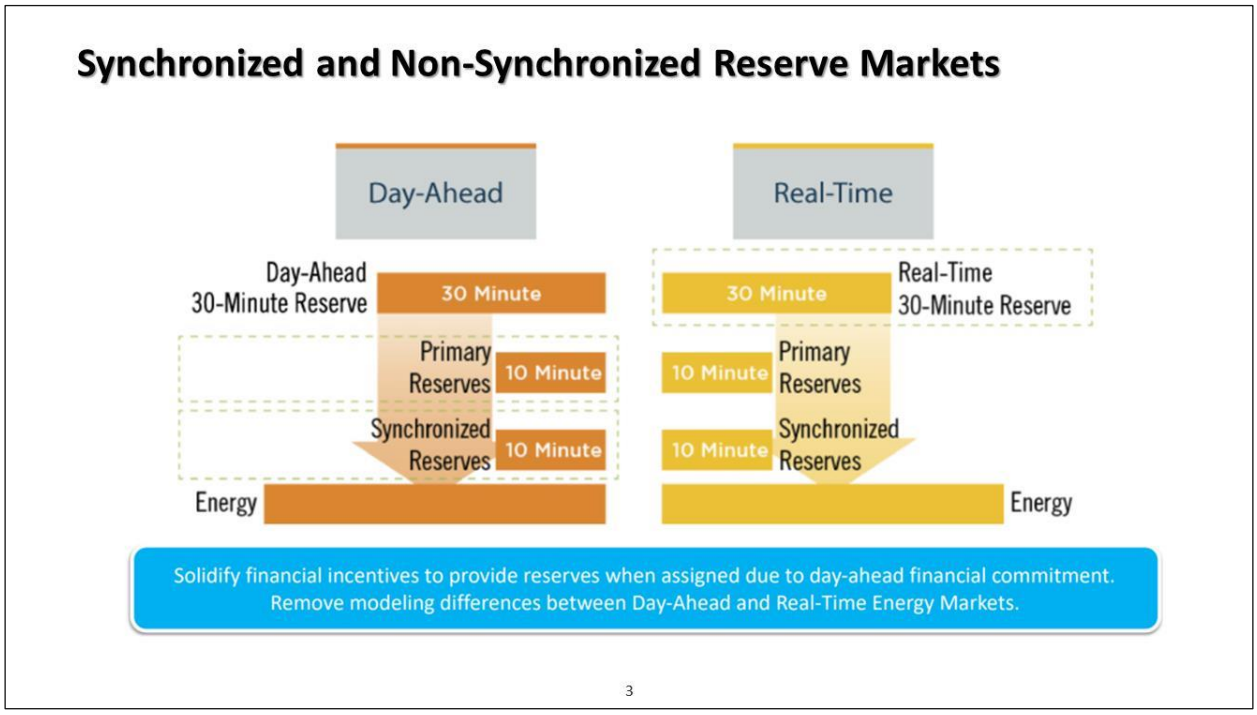
Objectives

- Describe the types of reserves
- Identify PJM reserve requirements
- Explain the PJM Reserve Markets
- Describe the Reserve participation response verification process

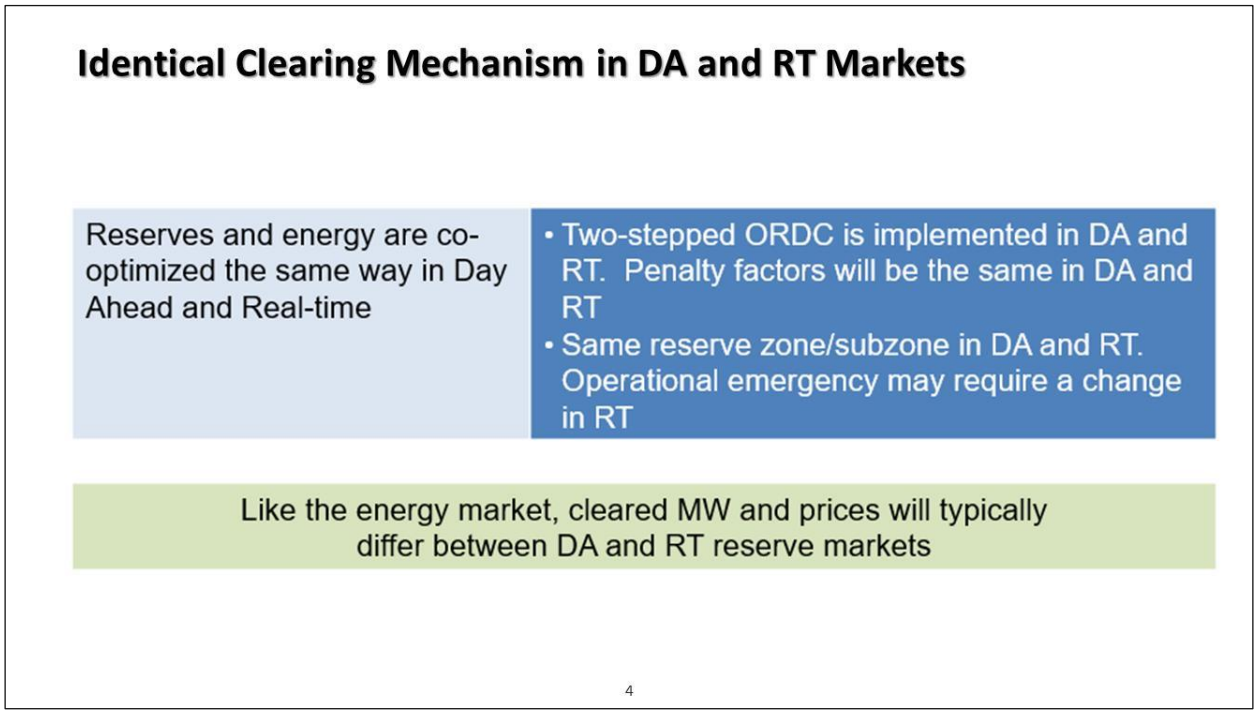
Reserve Markets



Synchronized and Non-Synchronized Reserve Markets

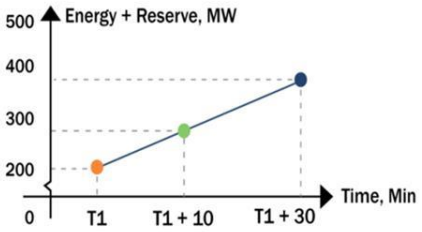


Identical Clearing Mechanism in DA and RT Markets



Reserve MW Calculation Example from an Online Unit

Reserve MW Calculation Example from an Online Unit



Unit A

STATUS: **Online** **200 MW**		STARTUP TIME: **5 Min**	NOTIFICATION TIME: **0 Min**
ECOMIN: **100 MW**	ECOMAX: **600 MW**	RAMP RATE (RR): **5 MW/Min**	

SR = min[EcoMax – MW, RR*10]
= min[600 – 200, 5*10]
= min[400,50]
= **50 MW**

SecR = min[EcoMax – MW, RR*30]-SR
= min[600 – 200, 5*30]-50
= min[400,150]-50
= 150-50
= **100 MW**

*Note: For Day Ahead, EcoMin is used instead of the current MW output (e.g. min[EcoMax - *EcoMin*, RR*10]

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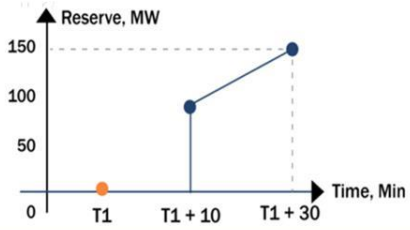
Reserve MW Calculation Example from an Offline Unit

Reserve MW Calculation Example from an Offline Unit



Unit A

STATUS: **Offline** **0 MW**		STARTUP TIME: **5 Min**	NOTIFICATION TIME: **2 Min**
ECOMIN: **50 MW**	ECOMAX: **150 MW**	RAMP RATE (RR): **10 MW/Min**	

NSR = min[EcoMax, EcoMin + (10 – StartTime – NotifTime)*RR]

= min[150, 50 +(10 – 5 - 2)*10]

= min[150,50 + 3*10]

= min[150,80]

= **80 MW**

SecR = min[EcoMax, EcoMin + (30 – StartTime – NotifTime)*RR]-NSR

= min[150, 50 + (30 – 5 – 2)*10]-80

= min[150,280]-80

= 150-80

= **70 MW**

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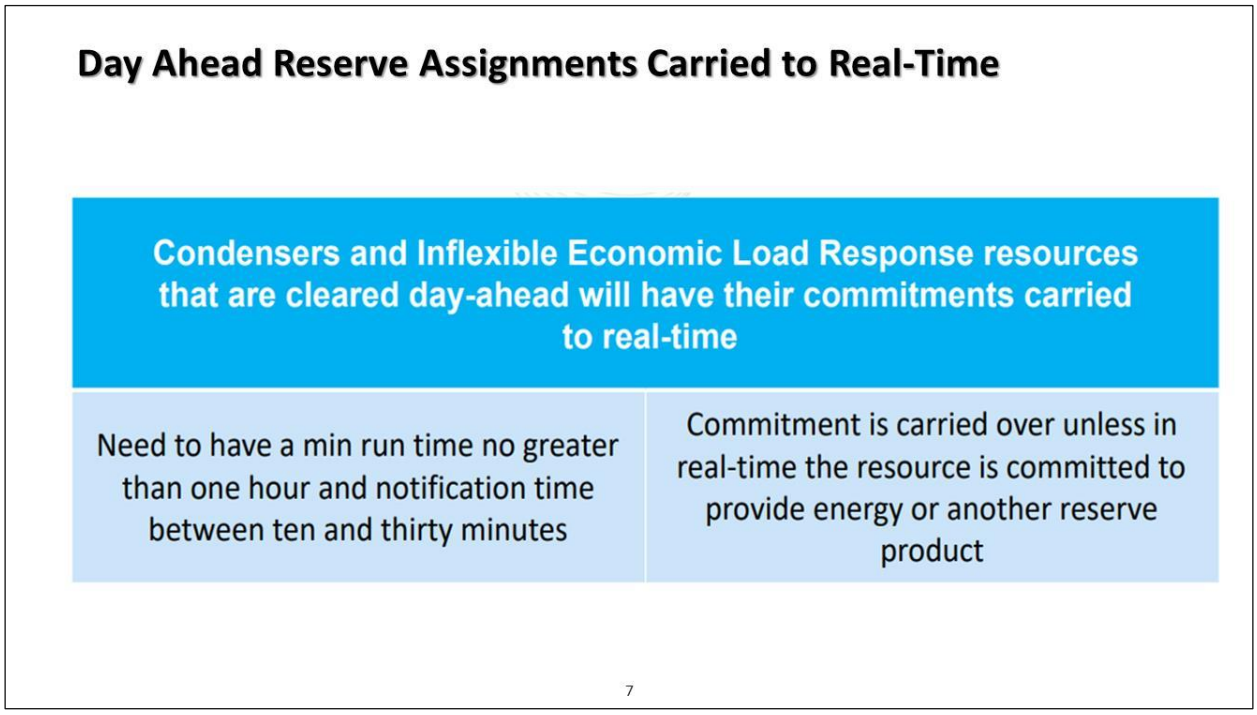
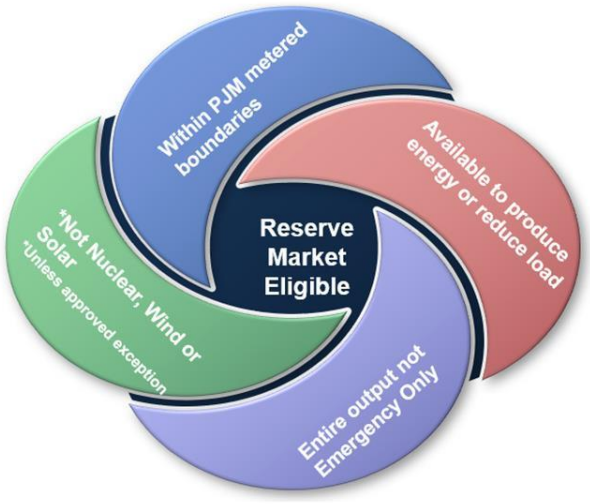
Day Ahead Reserve Assignments Carried to Real-Time



Reserve Market Resource Eligibility

Reserve Market Requirements and Obligations

Reserve Market Resource Eligibility



Not Eligible for Non-Synchronized Reserves:

- Economic Load Response
- Energy Storage Resources enrolled participation model

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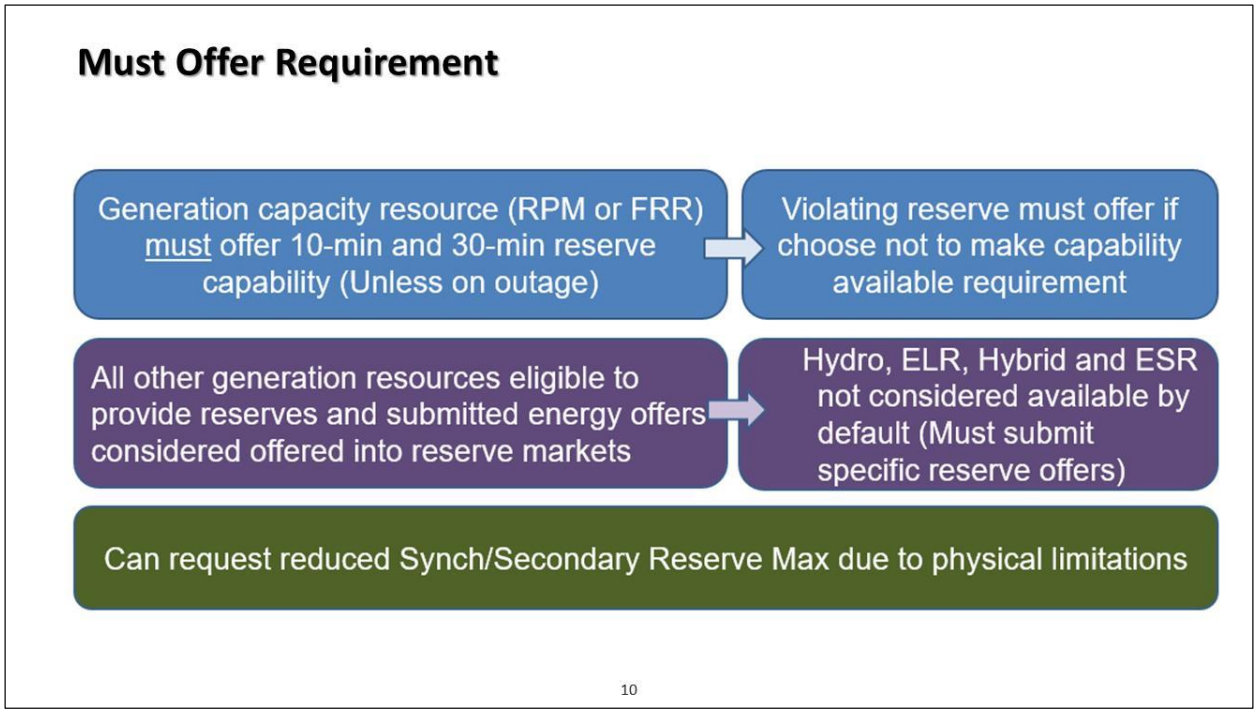
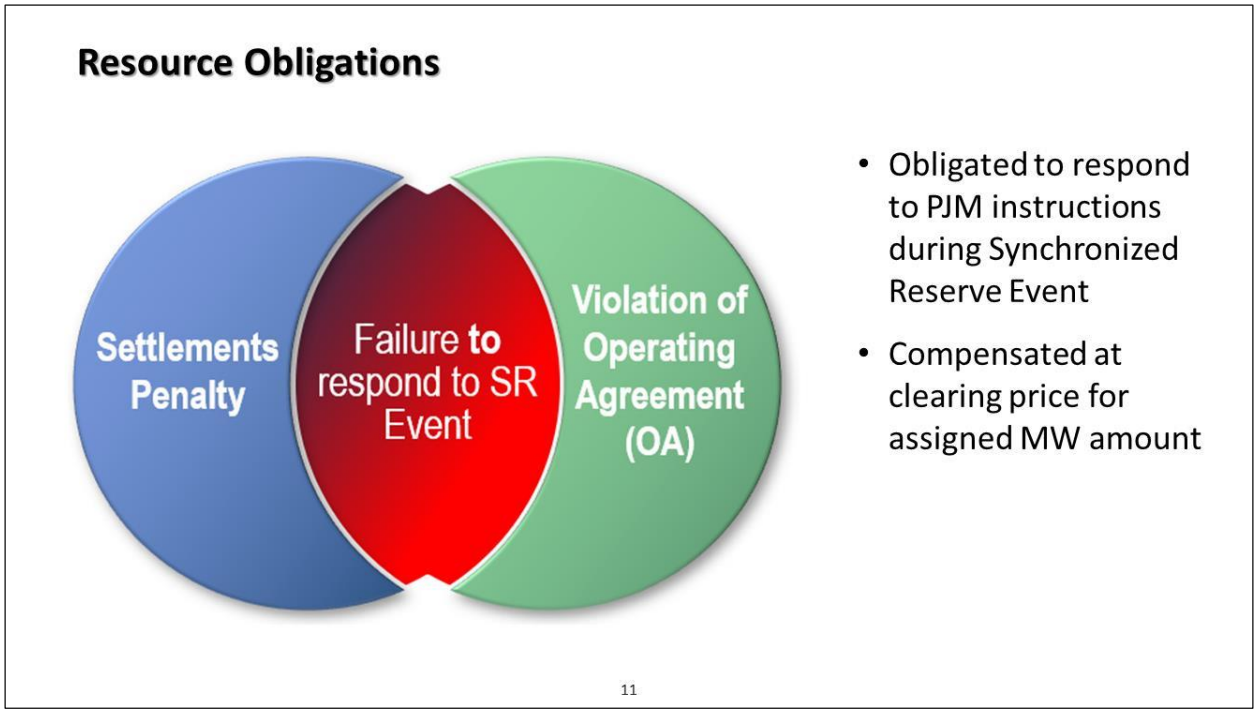
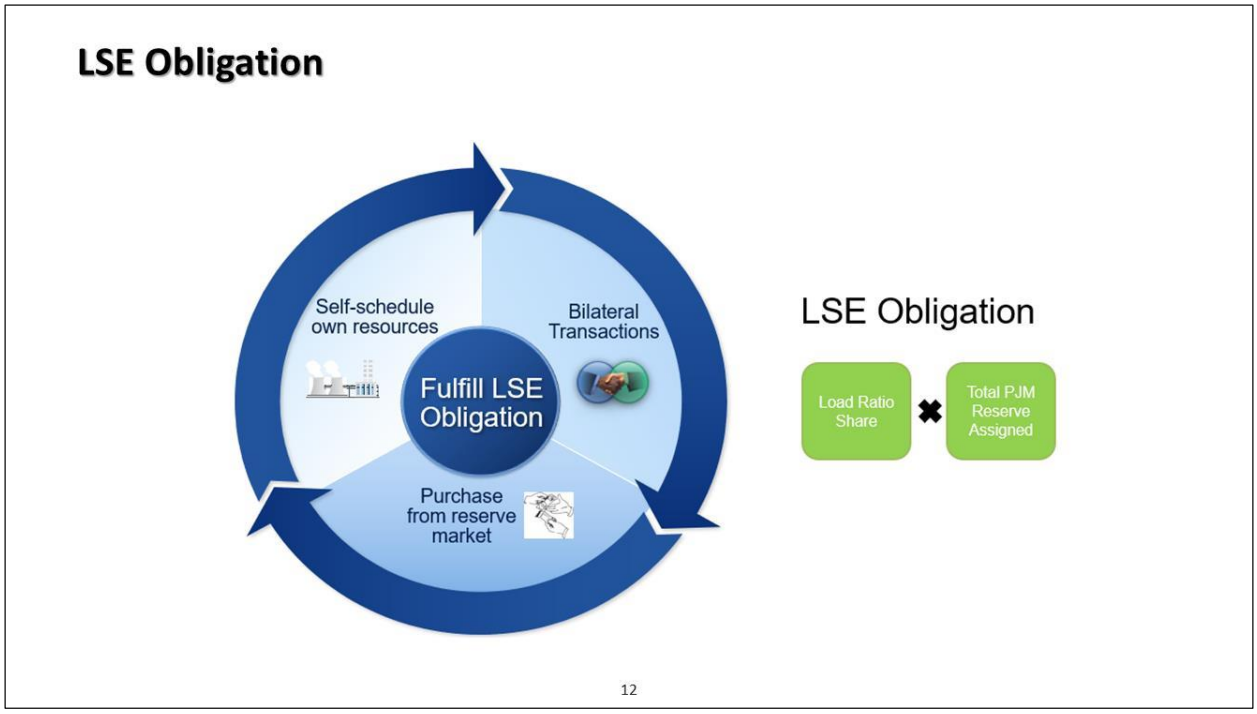
Must Offer Requirement



Resource Obligations



LSE Obligation



Reserve Offers

Reserve Offers and Data

Reserve Offers

- Consist of three elements:
  - Availability
  - Offer MW
  - Offer price
- If Hydro, ESR, Hybrid and ELR unable to participate in any given hour during Operating Day:
  - Set Offer MW = 0
  - Set to "Not Available"
  - Done in Markets Gateway sixty-five (65) minutes prior to the operating hour

Reserve Market	Resource Type				
	Condensers	Other Gen	Wind/Solar/ Nuclear	ESR/Hydro/Hybrid Resource	Load Response
SR	Set through energy offer			Specify availability separately	
NSR				N/A for ESR and Hybrid Resource; Specify availability separately for hydro	N/A for NSR
SecR				Specify availability separately	

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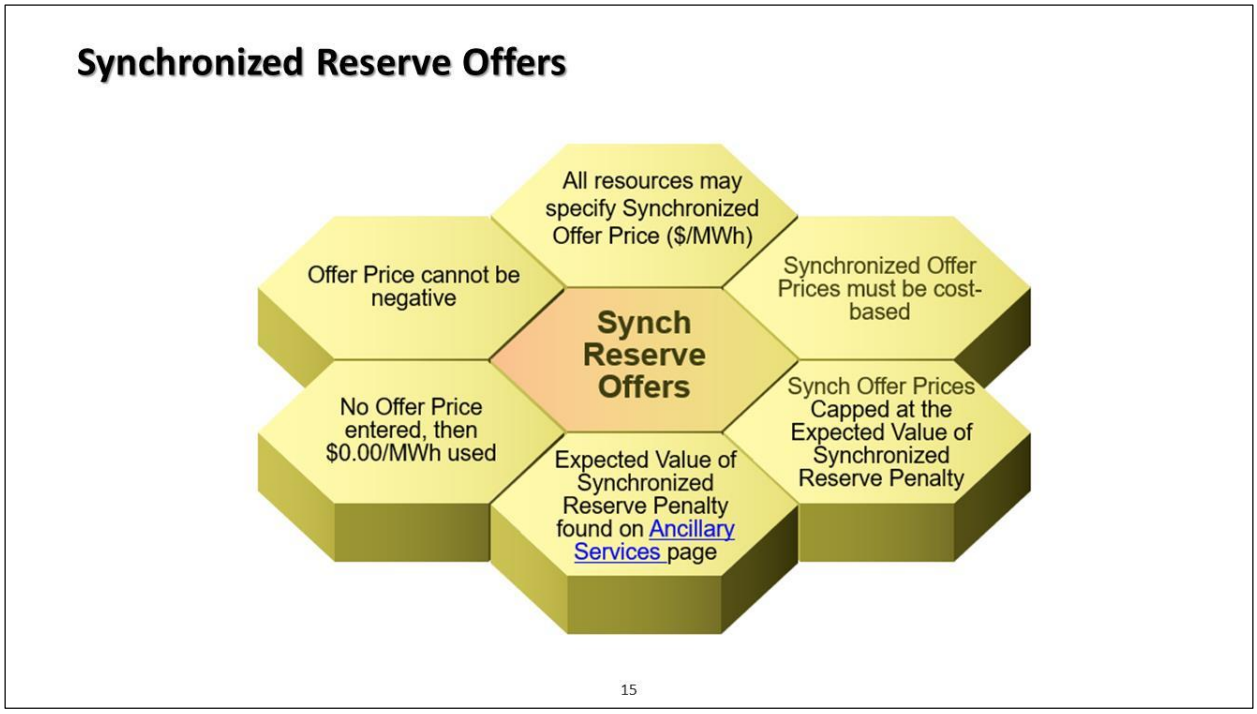
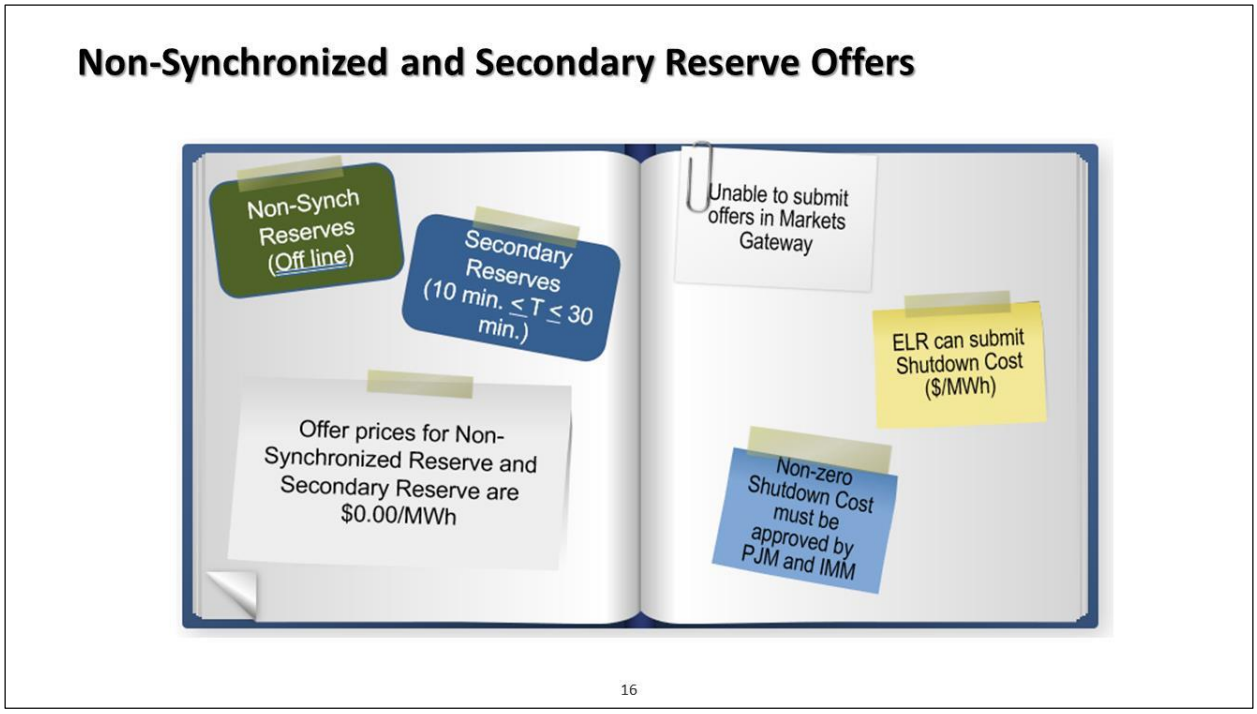
Synchronized Reserve Offers



Non-Synchronized and Secondary Reserve Offers



Reserve Parameters

Reserve Parameters

Parameter	Update Available	Markets Gateway Update Location
EcoMax & EcoMin	Must be entered prior to 11 a.m. the day before the operating day Can be updated anytime to reflect real-time changes	• Generator > Unit > Detail • Demand Response > Hourly Updates • Generator > Hourly Updates
Initial Energy Output	No updates available. Based on actual resource output	N/A
Ramp Rates	Default and Daily Ramp Rates must be entered prior to 11 a.m. the day before the operating day. Ramp Rate updates can be made during the operating day 65-minutes prior to the operating hour.	• Default: Generator > Unit > Detail • Daily Ramp Rate: Generator > Unit > Ramp Rates • Updates: Generator > Unit > Ramp Rates Updates
Startup Time	Must be entered prior to 11 a.m. the day before the operating day	Generator > Unit > Detail
Notification Time	Must be entered prior to 11 a.m. the day before the operating day Notification Time updates can be made during the operating day 65-minutes prior to the operating hour.	• Demand Response > Parameters • Generator > Unit > Detail • Updates: Generator > Schedules > Detail Updates
Condense to Generation Time	Must be entered prior to 11 a.m. the day before the operating day	Generator > Unit > Detail

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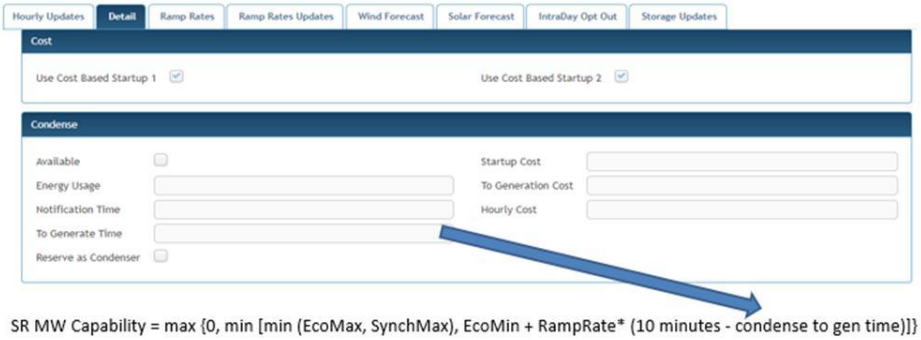
Managing Synchronized and Secondary Reserve Data

Managing Synchronized and Secondary Reserve Data

- Condense to Gen Cost
- Condense Startup Cost
- Condense Hourly Cost
- Heat Rate
- Condense To Notification Time
- Condense To Generate Time



SR MW Capability = max {0, min [min (EcoMax, SynchMax), EcoMin + RampRate* (10 minutes - condense to gen time)]}

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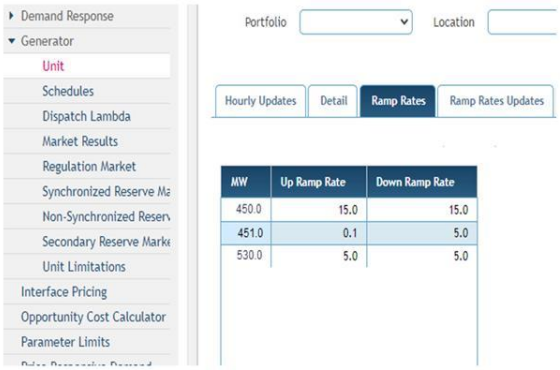
Segmented Ramp Rates

Segmented Ramp Rates



- Ensure ramp rates are accurate
- Utilize Ramp Rates in Markets Gateway
  - Allows use of segmented ramp rates
  - Model situations where ramp rates can change
    - Mill Points
    - Transition Points
- Can be updated hourly
  - Ramp Rates Updates tab

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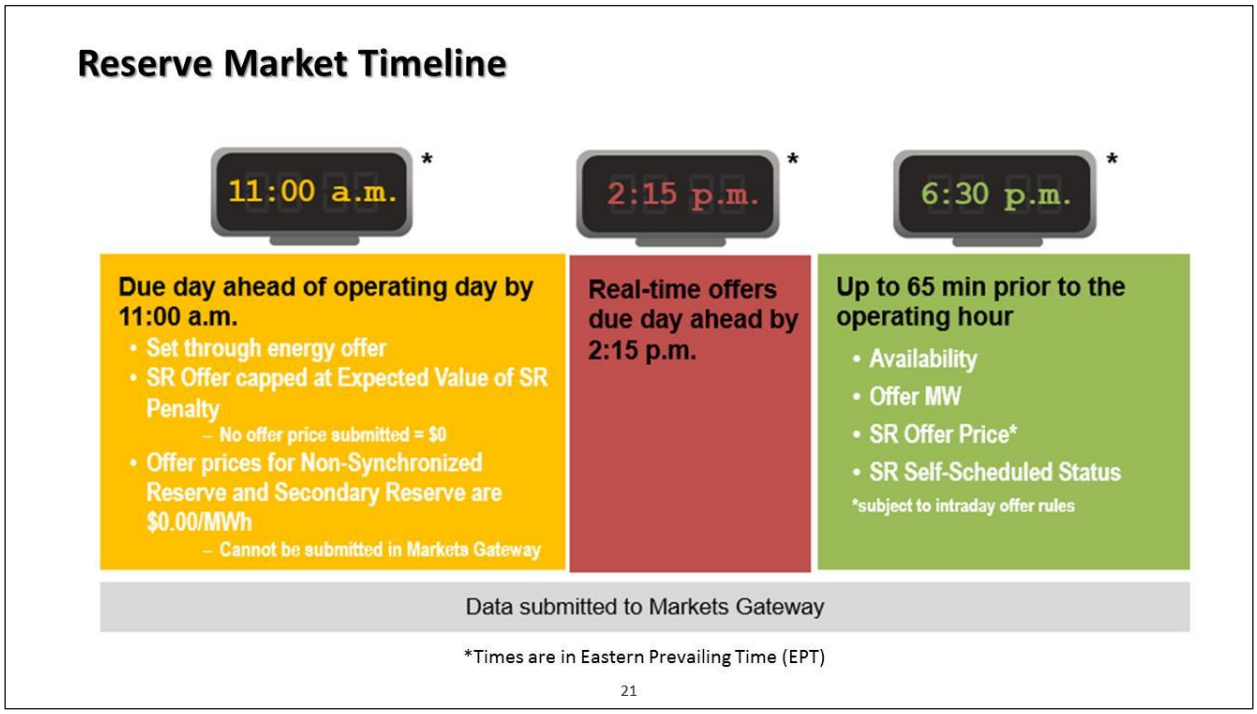
Reserve Market Timeline



Synchronized Reserve Timing

Synchronized Reserve Timing

- Forward commitment for reserve resources and all regulation resources will be posted 30 minutes prior to the operating hour
  - Synchronous Condensers and Economic Load Response resources will be considered “inflexible” units and committed on a forward basis

*Ancillary Service Optimizer

Incremental commitments may be made for inflexible units

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Reserve Results Posting

Reserve Results Posting

	What	Frequency	Location	When
Day Ahead	Synch Reserve	Hourly	Market Results in Markets Gateway	A day ahead of the operating day
	Non-synch Reserve	Hourly	Market Results in Markets Gateway	A day ahead of the operating day
	Secondary Reserve	Hourly	Market Results in Markets Gateway	A day ahead of the operating day
Real-Time	Inflexible Synch Reserve	Hourly	Market Results in Markets Gateway	30 min prior to top of hour
	Inflexible Secondary Reserve	Hourly	Market Results in Markets Gateway	30 min prior to top of hour
	Flexible Reserves	Every 5 minutes	ICCP link and Dispatch Lambda in MG	Every 5 min
	Clearing Price	Every 5 minutes	Data Miner and PJM Now	Every 5 min

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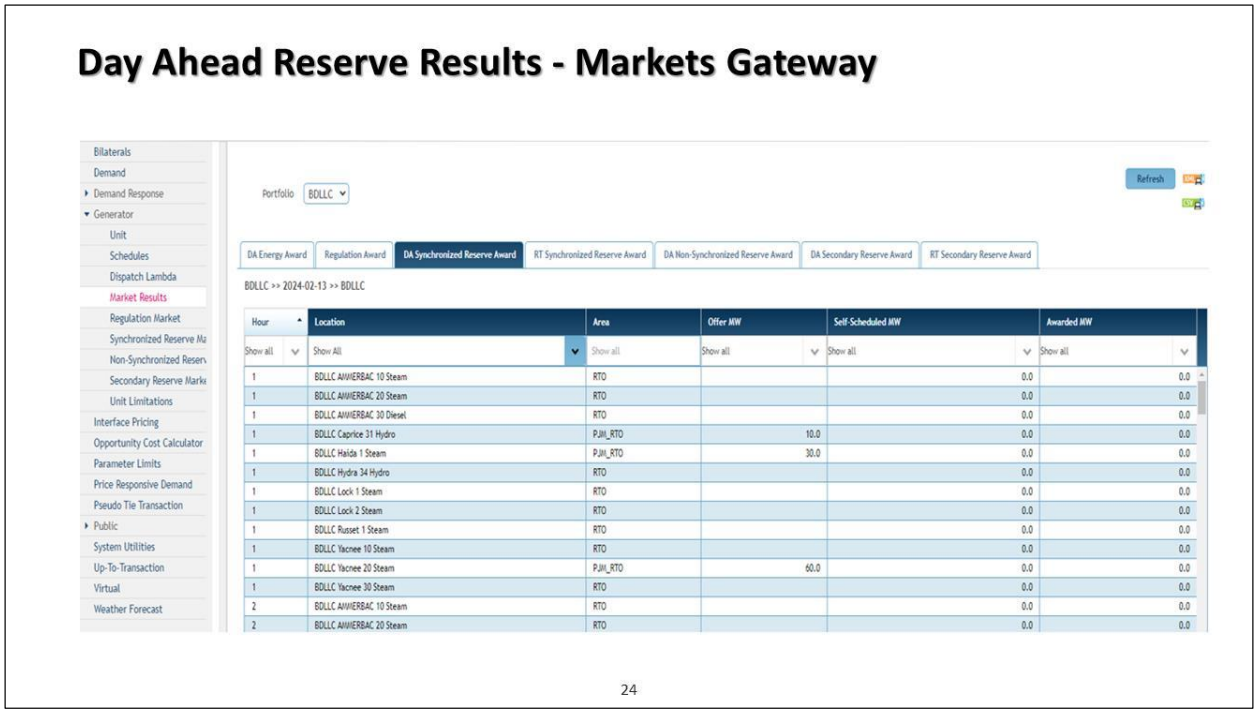
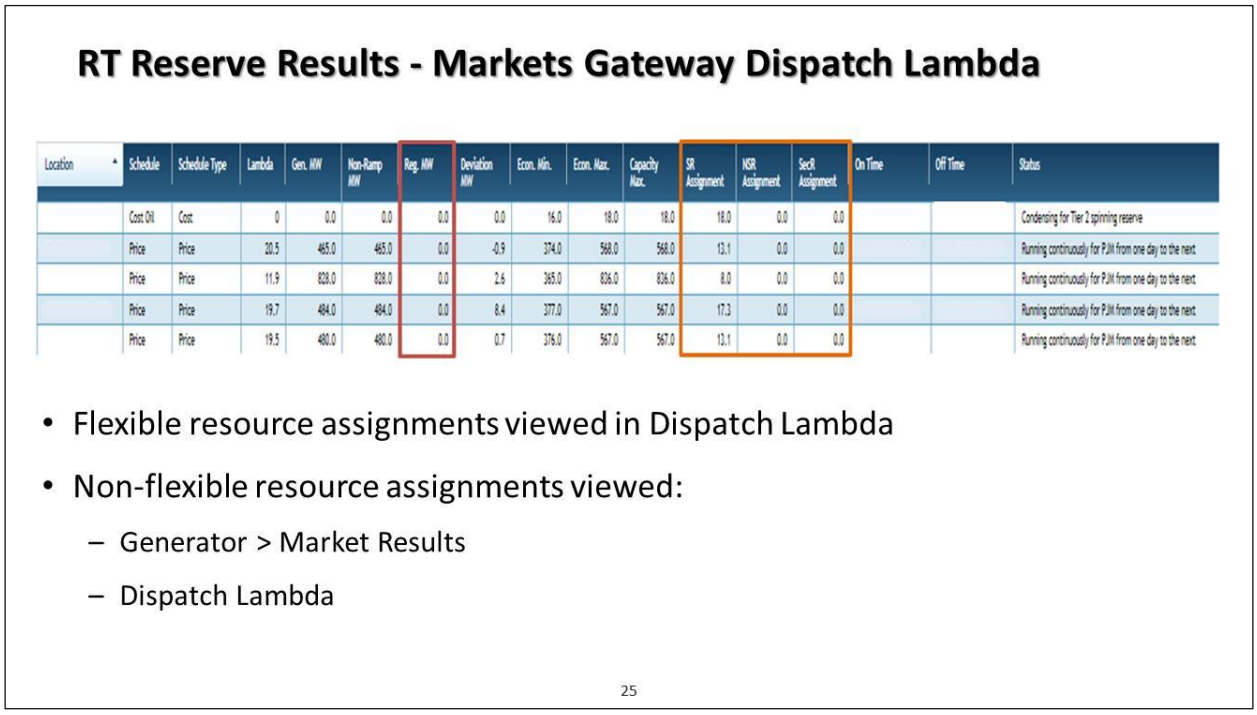
Day Ahead Reserve Results - Markets Gateway



RT Reserve Results - Markets Gateway Dispatch Lambda



RT Reserve Results - Markets Gateway Dispatch Lambda

Location	Schedule	Schedule Type	Lambda	Gen. MW	Non-Ramp MW	Reg. MW	Deviation MW	Econ. Min.	Econ. Max.	Capacity Max.	SR Assignment	NSR Assignment	SecR Assignment	On Time	Off Time	Status
	Cost Oil	Cost	0	0.0	0.0	0.0	0.0	16.0	18.0	18.0	18.0	0.0	0.0			Condensing for Tier 2 spinning reserve
	Price	Price	20.5	465.0	465.0	0.0	-0.9	374.0	568.0	568.0	13.1	0.0	0.0			Running continuously for PJM from one day to the next
	Price	Price	11.9	828.0	828.0	0.0	2.6	365.0	836.0	836.0	8.0	0.0	0.0			Running continuously for PJM from one day to the next
	Price	Price	19.7	494.0	494.0	0.0	8.4	377.0	567.0	567.0	17.3	0.0	0.0			Running continuously for PJM from one day to the next
	Price	Price	19.5	480.0	480.0	0.0	0.7	376.0	567.0	567.0	13.1	0.0	0.0			Running continuously for PJM from one day to the next

- Flexible resource assignments viewed in Dispatch Lambda
- Non-flexible resource assignments viewed:
  - Generator > Market Results
  - Dispatch Lambda

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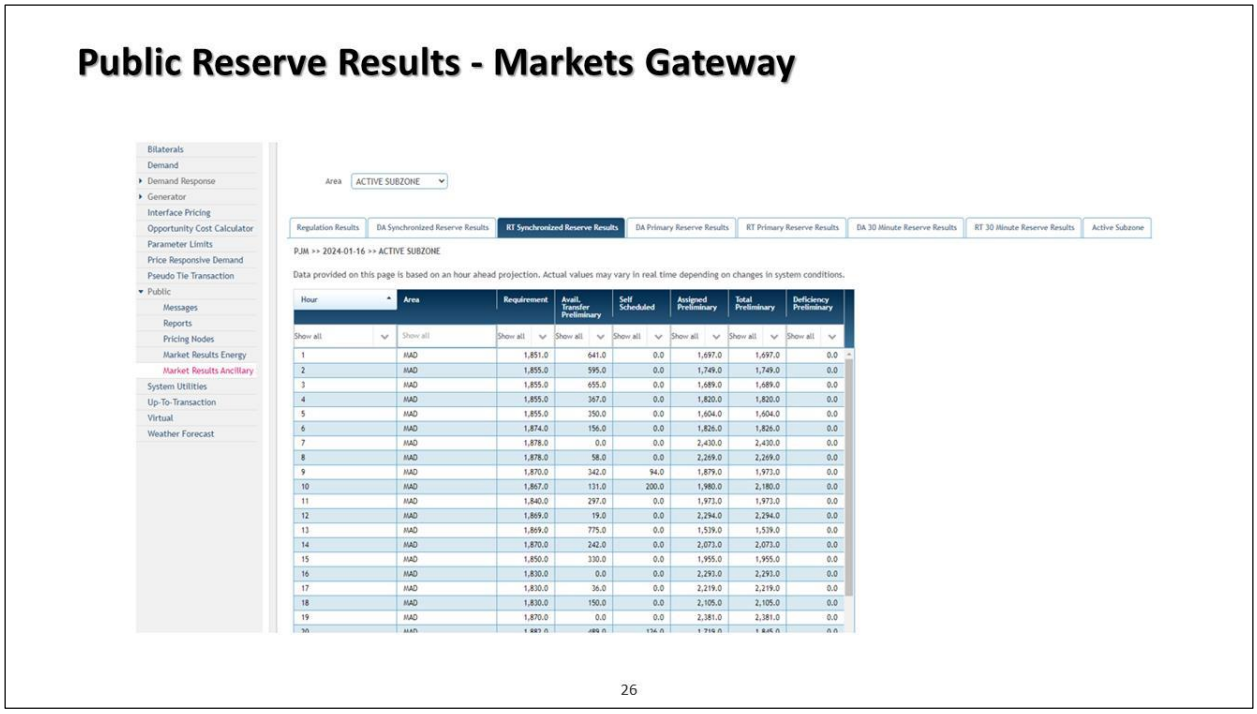
Public Reserve Results - Markets Gateway



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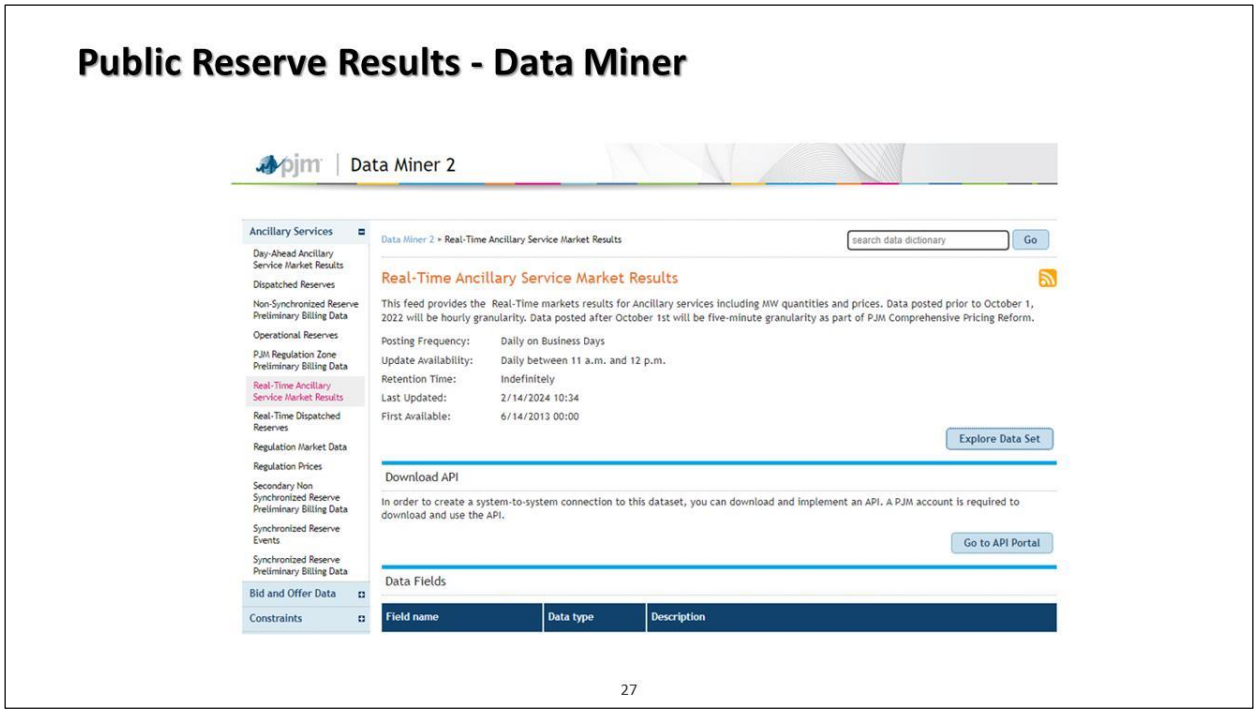
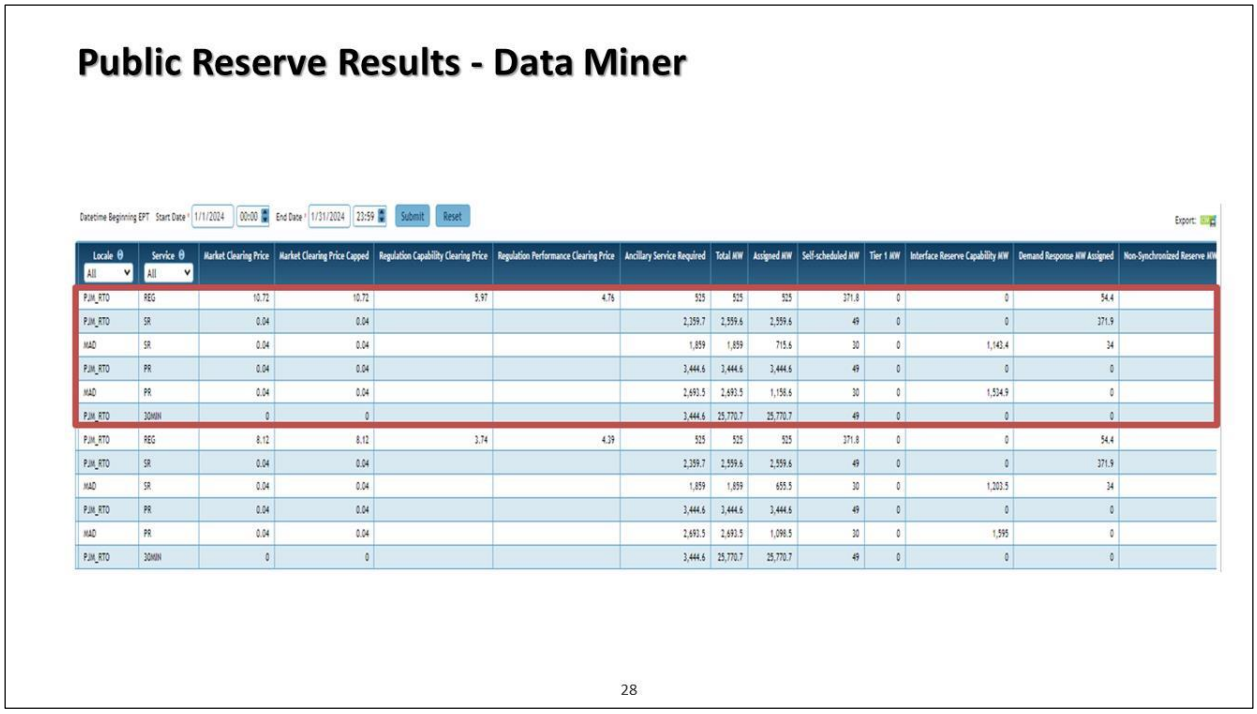
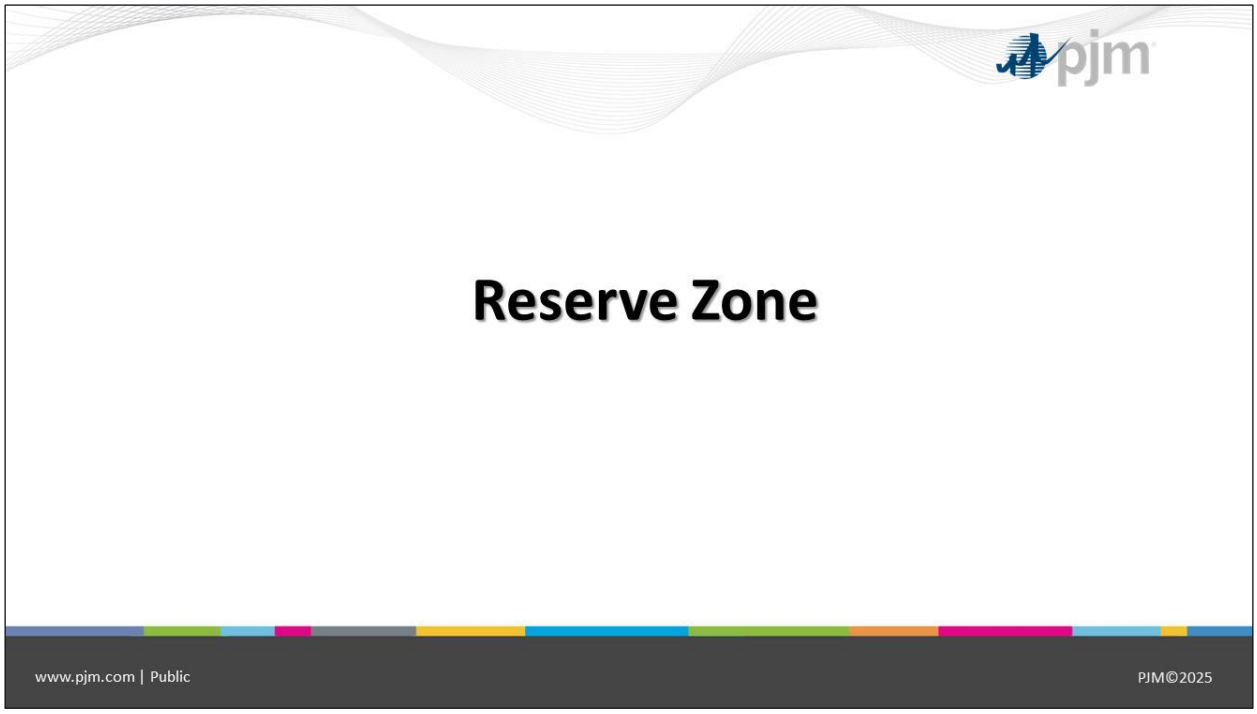
Public Reserve Results - Data Miner



Public Reserve Results - Data Miner



Reserve Zone Structure



Reserve Zone Structure

One Reserve Zone: RTO Reserve Zone

- Currently, one subzone due to potential deliverability issues
  - Mid-Atlantic Dominion (MAD)

Creation of New Reserve Subzones

- New reserve subzones defined as far in advance as possible
- Cannot be created on a same-day basis
- Defined for constraints in these three categories:
  - Reactive transfer interfaces (AP South, BEDBLA, etc.)
  - >= 230 KV actual overload constraint (i.e. Conastone-Peach Bottom 500kV actual overload)
  - Contingency overload exceeding load dump limit on 230kV or above facility

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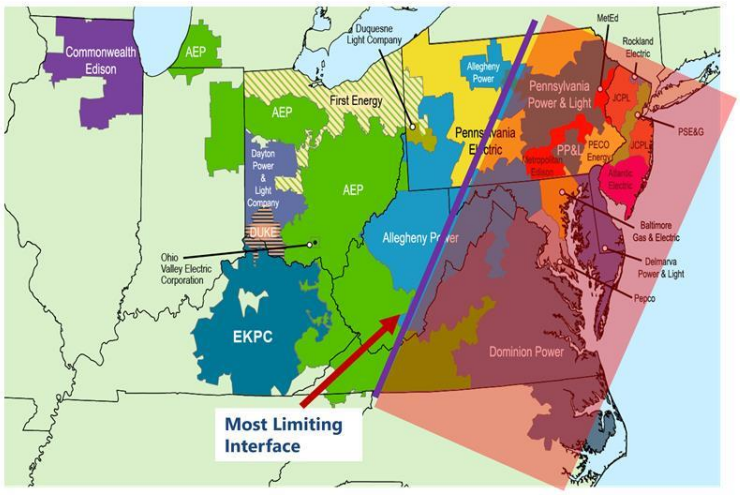
Mid-Atlantic Dominion (MAD) Reserve Subzone

Mid-Atlantic Dominion (MAD) Reserve Subzone

- Default subzone
- Defined by the most-limiting reactive transfer interface
  - Procure reserves that will not overload critical constraints when reserves are deployed



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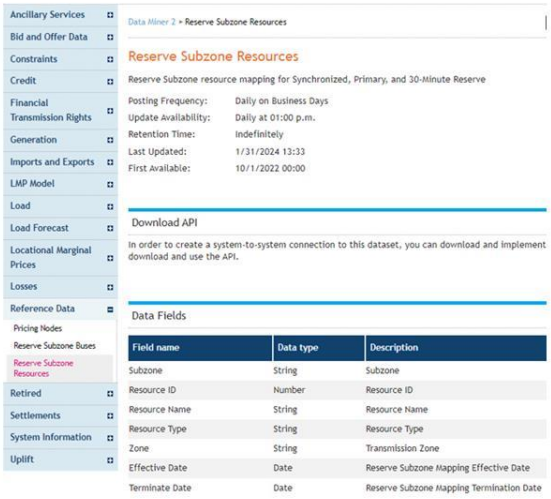
Reserve Subzone Composition

Reserve Subzone Composition

- Reserve subzones defined as all buses with 3% or greater (raise-help) distribution factor on associated transmission constraint
- Definitions typically published every business day
- Definitions posted on Data Miner



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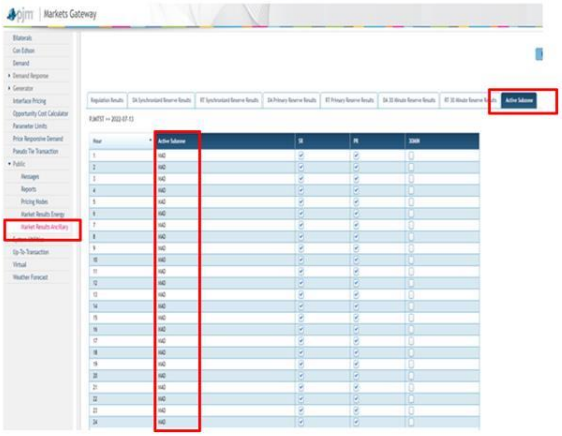
Flexible Reserve Subzones

Flexible Reserve Subzones

- Dynamically adjust reserve subzone to reflect system conditions
- Better enable reliable operations and result in market results more consistent with system operations
- Only one subzone active at any given time
  - Communicated in Markets Gateway

Note: Changes to the active reserve subzone can be made in real-time intraday on an exception basis



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Loading Synchronized Reserves

Loading Synchronized Reserves

Loading Synchronized Reserves

- After SR initiation, Economic Basepoints raised for resources with assignments
- ELR follow instructions in DR Hub
- Self-scheduled, not following dispatch generation and Synchronous Condensers take manual action to respond

★ During SR event, AGC will only change basepoint for units with SR assignment if SCED call for increase in output

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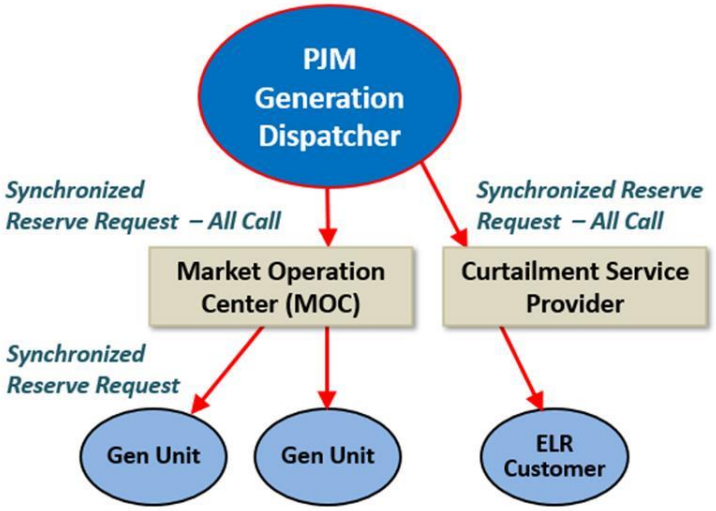
Call for Synchronized Reserve

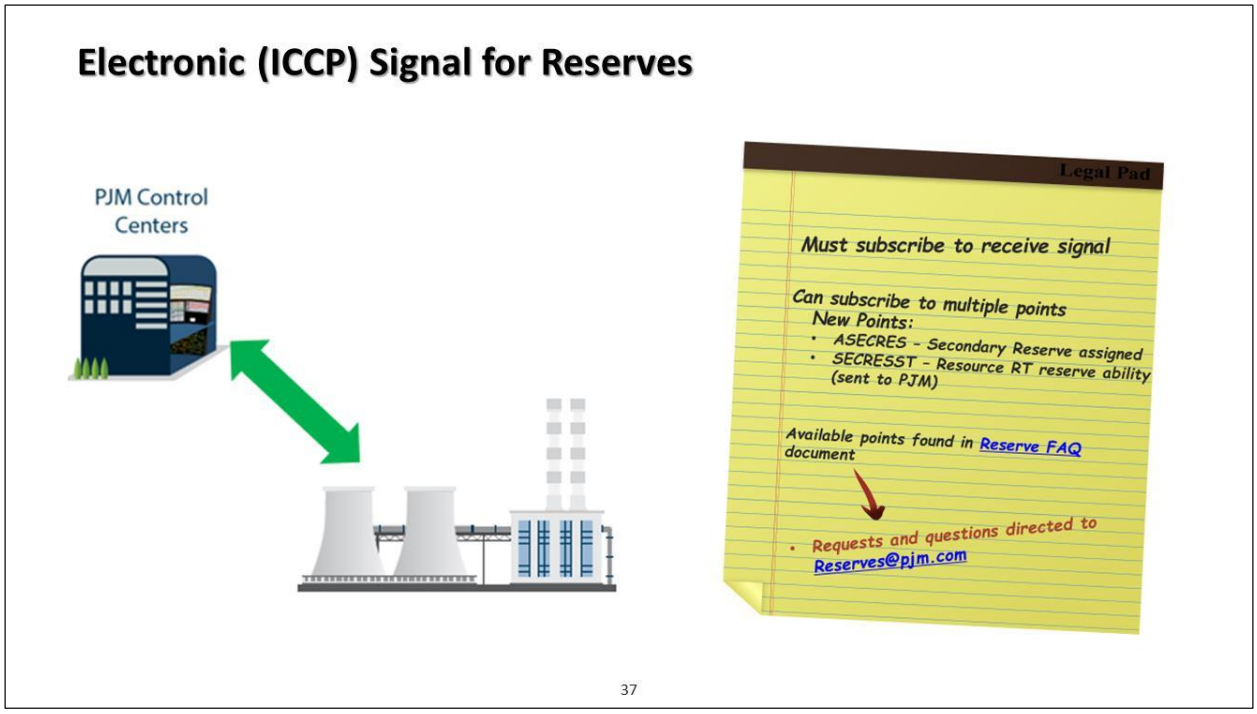
Call for Synchronized Reserve

Loading of Synchronized Reserve is a Reliability Service!

- ELR resources implement requested percentage of Synchronized Reserve as quickly as possible without regard to price
- Continue to implement Synchronized Reserve until directed by PJM to discontinue
  - **At most, one level of operator intervention between PJM and entity taking action**



Electronic (ICCP) Signal for Reserves



https://www.pjm.com/-/media/DotCom/etools/markets-gateway/synchronized-reserve-deployment-and-reserve-price-formation-faq.pdf

Response Calculation / Verification

Response Calculation

Response Calculation / Verification

- Resource responses verified by PJM Performance Compliance Dept. following each event
- Actual responses compared to assignments used to determine penalties

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Resource Response Measurement

Resource Response Measurement

- Resource response to a synchronized reserve event is
  - Difference between resource's output at start of event, **and**
  - Output ten minutes after start of event, allowing for small fluctuations and possible telemetry delays
- Resource output at start of event
  - Lowest telemetered output between 1 minute prior to and 1 minute following start of event
- Resource output ten minutes after event
  - Greatest output achieved between 9 and 11 minutes after start of event

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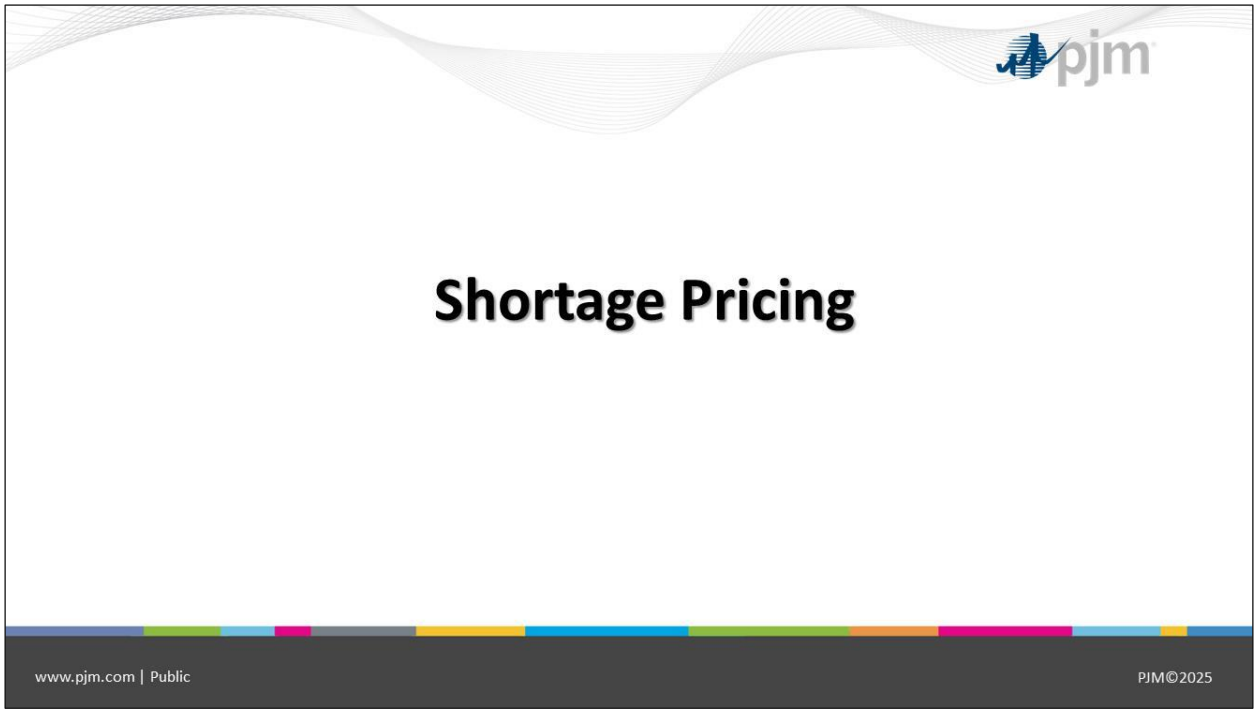
Shortage Conditions



Shortage Conditions

- Reserve Requirements (RTO & Sub Zone) exist for:
  - 30-minute Reserves
  - Primary Reserves
  - Synchronized Reserves
- Reserve shortage when not enough non-emergency resources available to maintain requirements in event of unforeseen incident including, but not limited to:

- Extreme Weather	- Higher peak load growth
- Higher than average generator outages	- Unexpected transmission outage

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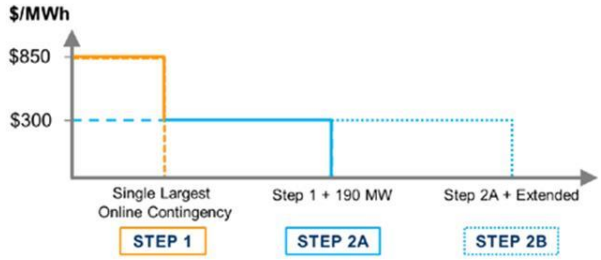
Shortage Pricing

Shortage Pricing

- Max Energy LMP Component = Energy Offer Cap + 2 * Reserve Penalty Factor



- Max Energy Offer
  - $2000/MWh
- Max Penalty Factor
  - $850/MWh
- Max Energy Component
  - $3700/MWh**

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Knowledge Check

Let's Review

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1. **Which service has an Operating Reserve Demand Curve (ORDC)?**

   a. *Synchronized Reserves*

   b. *Non-Synchronized Reserves*

c. *Secondary Reserves*

d. *Regulation Reserves*

2. What is the PJM Primary Reserve Reliability Requirement?

a. *Largest single contingency*

b. *Largest single contingency + 190 MW*

c. *150% of the Synchronized Reserve requirement*

d. *150% of the Synchronized Reserve requirement + 190 MW*

Summary

Questions

Questions

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