Reserve Nesting, Reserve Offers & Cost Allocation

Emily Barrett

Market Design

Reserve Certainty Senior Task Force

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- Nesting of 30-Min and Day-Ahead Reserve Products
- Reserve Offers
- Cost Allocation

Nesting of 30-Min and Day-Ahead Reserve Products

New and Existing Reserve Products Cleared in the Real-Time Market

30-Min Reserves – Updated

Addresses net-load ramping, net-load forecast uncertainty and the need for replacement reserves for system recovery.

30-Min Ramp/Uncertainty Reserves (Online)

Addresses net-load ramping and net-load forecast uncertainty

10-Min Ramp/Uncertainty Reserves – Up and Down Reserves

Addresses net-load ramping and net-load forecast uncertainty

Synchronized Reserves (SR) (10-minute reserves) – 100% MSSC*

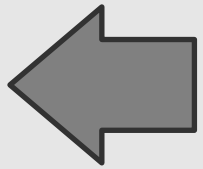
Contingency reserves and ACE recovery

New and Existing Reserve Products Cleared in the Day-Ahead Market

Day-Ahead Scheduling Reserves (60-Min reserves)
Addresses net-load forecast uncertainty and generator performance risk in DA. Reserve quantities depend on risk assessment.

Energy Gap (Online) 60-Min reserves
Cleared on medium- and high-risk winter days.

30-Min Reserves and 10-Min RUR can meet the DASR and Energy Gap Requirements through product nesting.



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Why is PJM Proposing to Nest the 30-Min Reserve Products?

- One of the primary drivers for unnesting PJM's reserve products is the difference in the duration requirements needed for different reserves. Historically, PJM had a reserve hierarchy based solely on flexibility or speed of response. A faster moving resource was always considered more valuable than a slower moving resource.
- In the future, PJM's fastest moving resources may not have the energy endurance or duration that PJM needs to meet all its reliability obligations. Batteries can ramp very quickly, but if they are state-of-charge limited, they may not be able to sustain that output.
- This introduces a second value dimension to PJM's reserve products: duration. PJM proposed unnesting its fast-moving reserve products (i.e., SR and 10-Min RUR) from its slower-moving reserve products (i.e., 30-Min Reserves), to reflect these different reserve value dimensions.
- Given that the proposed 30-Min Ramp and Uncertainty Reserve and 30-Min Secondary Reserve products both have a duration requirement of 4 hours, these products can be nested, which could simplify certain aspects of the design.

Nesting Real-Time Reserve Products with Day-Ahead Reserve Products

- At the December 10th RCSTF, PJM presented some settlement examples, which demonstrated that resources might not be indifferent to receiving a Day-Ahead-Only reserve assignment as compared with a reserve assignment that carries into real-time.
- PJM began exploring nesting the two proposed 30-Minute Reserve products as well as the Day-Ahead Reserve products (DASR and Energy Gap Reserves) with the new 10-Min RUR and 30-Minute Reserve products.
- This nested design would result in the clearing of 10- and 30-minute reserve capability in reserve products that would carry into real-time, while any additional 60-minute reserve capability would clear for day-ahead reserves.
- All 10- and 30-minute reserve capability would be subject to the two-settlement system as exists in PJM's reserve markets today. The residual 60-minute capability (i.e., above what clears for 10- and 30-minute reserves) would be subject to the availability and performance assessment, as discussed previously.

Day-Ahead Market Example Set-Up

Product	Requirement	Clearing Price
DASR	84 MW	$1/MW
Energy Gap	34 MW	$3/MW
10-Min RUR	9 MW	$0/MW
30-Min RUR	15 MW	$0/MW
30-Min SECR	15 MW	$0/MW
SR	10 MW	$3/MW

- This example is similar to the example given in the December 10, 2025, RCSTF with changes made to illustrate the nesting of the reserve requirements.
- For simplicity and to illustrate the differences in the settlement outcomes, assume that all DASR and Energy Gap Reserves are deliverable within 30 minutes (i.e., are met by 30-Min Reserve eligible capability).

	Online?	DASR	Energy Gap	10-Min RUR	30-Min RUR	30-Min SECR	SR
R1	Yes	14 MW	14 MW	9 MW	5 MW	0 MW	0 MW
R2	Yes	20 MW	20 MW	10 MW	10 MW	0 MW	10 MW
R3	No	50 MW	0 MW	0 MW	0 MW	15 MW	0 MW

Real-Time Market Example Set-Up

Product	Requirement	Clearing Price
DASR	N/A	N/A
Energy Gap	N/A	N/A
10-Min RUR	9 MW	$4/MW
30-Min RUR	15 MW	$4/MW
30-Min SECR	15 MW	$4/MW
SR	10 MW	$4/MW

	Online?	10-Min RUR	30-Min RUR	30-Min SECR	SR
R1	Yes	9 MW	6 MW	0 MW	1 MW
R2	No	0 MW	0 MW	0 MW	0 MW
R3	Yes	0 MW	9 MW	15 MW	9 MW

Assume that R2 becomes unavailable in real-time due to an unplanned outage, and so R3 is called online to provide online reserves. As a result, the reserve clearing prices increase.

R1 Reserve Settlement

	Day-Ahead Market			Real-Time Market		
	Reserve Assignment	Clearing Price	Revenue	Reserve Assignment	Clearing Price	Revenue
DASR	14 MW	$1/MW	$14	N/A	N/A	$0
Energy Gap	14 MW	$3/MW	$42	N/A	N/A	$0
10-Min RUR	9 MW	$0/MW	$0	9 MW	$4/MW	$0
30-Min RUR	5 MW	$0/MW	$0	6 MW	$4/MW	$4
30-Min SECR	0 MW	$0/MW	$0	0 MW	$4/MW	$0
SR	0 MW	$3/MW	$0	1 MW	$4/MW	$4
		Total	**$56**		**Total**	**$8**

- R1 is available to provide energy or reserves at the level cleared day ahead, and therefore meets its Energy Gap and DASR reserve obligations
- R1's reserve assignments increase in real-time given the loss of R2, yielding it an additional $8 in reserve revenue in the real-time market and resulting in a total revenue of **$64**.

Scenario 2 R2 Reserve Settlement

	Day-Ahead Market			Real-Time Market		
	Reserve Assignment	Clearing Price	Revenue	Reserve Assignment	Clearing Price	Revenue
DASR	20 MW	$1/MW	$20	N/A	N/A	$0
Energy Gap	20 MW	$3/MW	$60	N/A	N/A	$0
10-Min RUR	10 MW	$0/MW	$0	0 MW	$4/MW	($40)
30-Min RUR	10 MW	$0/MW	$0	0 MW	$4/MW	($40)
30-Min SECR	0 MW	$0/MW	$0	0 MW	$4/MW	$0
SR	10 MW	$3/MW	$30	0 MW	$4/MW	($40)
		Total	**$110**		**Total**	**($120)**

- R2 is unavailable to provide energy or reserves at the level cleared day ahead and therefore does not meet its Energy Gap or DASR obligations. Because its Energy Gap and DASR assignments consisted of real-time reserve assignments, it is assessed no additional penalty beyond the two settlement buy-out.

- R2 has to buy out of its day-ahead 10-Min RUR, 30-Min RUR and SR assignments at the real-time market clearing prices, resulting in a charge of $80, which nets with its day-ahead review to a total of **($10)**.

Scenario 2 R3 Reserve Settlement

	Day-Ahead Market			Real-Time Market		
	Reserve Assignment	Clearing Price	Revenue	Reserve Assignment	Clearing Price	Revenue
DASR	50 MW	$1/MW	$50	N/A	N/A	$0
Energy Gap	0 MW	$0/MW	$0	N/A	N/A	$0
10-Min RUR	0 MW	$0/MW	$0	0 MW	$4/MW	$0
30-Min RUR	0 MW	$0/MW	$0	9 MW	$4/MW	$36
30-Min SECR	15 MW	$0/MW	$0	15 MW	$4/MW	$0
SR	0 MW	$3/MW	$0	9 MW	$4/MW	$36
		Total	**$50**		**Total**	**$72**

- R3 is available to provide energy or reserves at the level cleared day ahead and therefore meets its DASR obligations.
- R3's reserve assignments increase in real-time given the loss of R2, yielding it an additional $72 in reserve revenue in the real-time market and resulting in a total revenue of **$137**.

How would the nesting work?

Five services:

- 10-Min RUR
- 30-Min Spin
- 30-Min Non-Spin
- 60-Min Spin
- 60-Min Non-Spin

Reserve Clearing System-Level Constraints:

- 10-Min RUR >= 10-Min RUR Req
- 30-Min Spin >= 30-Min RUR Req
- 30-Min Spin + 30-Min Non-Spin >= 30-Min Req*
- 10-Min RUR + 30-Min Spin + 60-Min Spin >= Energy Gap Req.
- 10-Min RUR + 30-Min Spin + 30-Min Non-Spin + 60-Min Spin + 60-Min Non-Spin >= DASR*

Note that the righthand side of all above equations are a function of the ORDC segments (i.e., cleared quantities are an economic outcome of the optimization).

** Where 30-Min Req includes the 30-Min RUR Req and DASR includes the Energy Gap Req*

Reserve Offers

PJM's current position is that there are costs that resources should be allowed to reflect in their reserve offers.

1. Resources should be able to reflect and recover any costs for maintaining availability to provide reserves through their reserve offers.

2. Resources should be able to reflect any performance risk they would incur by taking on a reserve assignment through their reserve offer.

3. Resources should be able to reflect any expectation or risk of revenue loss for reserve deployment in their reserve offer.

Summary of PJM's Current Perspective on When Offers > $0 for Reserve Services Should be Allowed

Reserve Service	Offers into the Day-Ahead Market			Offers into the Real-Time Market		
	Availability Costs	Performance Risk	Deployment Revenue Loss	Availability Costs	Performance Risk*	Deployment Revenue Loss
DA Offline Reserves	✓	✓		N/A	N/A	N/A
DA Online Reserves	✓			N/A	N/A	N/A
30-Min Offline Reserves	✓	✓			✓	
30-Min Online Reserves	✓					
10-Min RUR	✓					
Offline Primary Reserves	✓	✓			✓	
Synchronized Reserves	✓	✓	✓		✓	✓

Summary of PJM's Current Perspective on When Offers > $0 for Reserve Services Should be Allowed

- Assuming no additional performance penalties for online 30-Min and 10-Min RUR reserves beyond deviation charges, the offer caps for these services would be $0 in real-time. The cost of these services for online resources would therefore solely be based on lost opportunity costs calculated by the dispatch engine.
- The offer caps for reserve services in the Day-Ahead Market would be greater than $0 across all products.
- The offer caps for offline resources would be greater than $0 in both the Day-Ahead and Real-Time Markets.
- The offer cap for Synchronized Reserves would be greater than $0 in both the Day-Ahead and Real-Time Markets.

Reserve Service	Day-Ahead Offer Cap	Real-Time Offer Cap
DA Offline Reserves	**> $0**	N/A
DA Online Reserves	**> $0**	N/A
30-Min Offline Reserves	**> $0**	**> $0**
30-Min Online Reserves	**> $0**	$0
10-Min RUR	**> $0**	$0
Offline Primary Reserves	**> $0**	**> $0**
Synchronized Reserves	**> $0**	**> $0**

Reserve Offer Rules

- Aside from Synchronized Reserves, in instances where resources are permitted to submit >$0 offers for reserve products (i.e., as described in previous slides), resources would be allowed to submit offers **up to a $10/MWh soft offer cap.**

- For Synchronized Reserves, resources would be permitted to submit offers up to the soft offer cap of $10/MWh **plus the expected penalty rate**.

- All resources would be permitted to submit **cost-based offers** above these caps, which could include fuel or opportunity costs. These offers would be subject to review and approval.

- As applicable, eligible resources would be allowed to submit three offers into PJM's markets: one for Synchronized Reserves, one for other online reserve services (i.e., to provide 10-Min RUR, 30-Min RUR and Energy Gap Reserves or to provide 30-Min Reserves or DASR while synchronized) and one for offline reserves (i.e., to provide 30-Min Reserves or DASR from an offline state).

Cost Allocation

PJM proposes to pursue a cost allocation approach aligned with status quo.

- PJM is proposing that reserve costs would be allocated based on status quo reserve cost allocation rules.
- This means that all reserve costs would be allocated to load as the service beneficiaries.
- Reserve costs would be allocated to real-time load based on load ratio share.
- Reserve costs would be allocated to load across the entire RTO.

Contact

Facilitator:
Lisa Morelli, Lisa.Morelli@pjm.com

Secretary:
Amanda Egan, Amanda.Egan@pjm.com

SME/Presenter:
Emily Barrett, Emily.Barrett@pjm.com

Reserve Nesting, Reserve Offers and Cost Allocation

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

Acronyms

Acronym	Term & Definition
SR	**Synchronized Reserves** are reserves provided by resources that are synchronized to the grid and can respond within 10 minutes.
PR	**Primary Reserves** are reserves provided by resources that are either synchronized or not synchronized to the grid and can respond within 10 minutes.
RUR	**Ramping/Uncertainty Reserves** are reserves that would be procured to manage forecasted ramp and uncertainty operational flexibility needs.
MW	A **Megawatt** is a unit of power equaling one million watts (1 MW = 1,000,000 watts) or one thousand kilowatts (1 MW = 1,000 KW).

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