PJM RCSTF Proposal Review Status Update

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RCSTF

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PJM's main priorities are in-line with the stakeholder poll response.

Alignment of operational needs and markets requirement to support reliability

Price formation – appropriate and reflect the value and cost of reserves

Top priority for discussion:

- New or updated reserve products to address ramping and uncertainty to address the challenge that PJM's markets do not value and procure ramping and flexibility needs to manage forecast uncertainty
- Market rules for reserve offers to address the challenge that the cost of advanced fuel arrangements and other availability measures to provide reserves in the next operating day may at times be unrecoverable through PJM's existing market constructs
- ORDC definition for new products and interaction between products

1) Reserve Requirements to align with operational needs
   a) Align operational scheduling needs with the Day-Ahead Market
   b) Address growing ramping and uncertainty system needs
2) Market Design Reserve Structure Changes
   a) Define Eligibility and Incentive Performance of resources
   b) Recognize the cost to provide reserves through offers
   c) Value the flexibility to address the system reserve needs

DA & RT – Status Quo

30-min. Reserves – Max(3000, PR, Gas Contg)
Replacement reserves for contingency events

Primary Reserves (PR)
(10-min. Reserves)– 150% SR
Contingency reserves and ACE recovery

Synchronized Reserves (SR)
(10-min. Reserves) – 100% MSSC*
Contingency reserves and ACE recovery

**SR Most Severe Single Contingency (MSSC) is adjusted for measured performance. Requirement is currently 130% MSSC.*

30-minute Reserves do not capture uncertainty PJM's operations deals with and needs to plan for today.

- Reserve Price Formation removed the DASR (capturing uncertainty) and proposed a downward-sloping demand curve to capture reserves for uncertainty, but implementation post-remand resulted in PJM being unable to account for uncertainty DA.

All reserve products are nested today, meaning at times today we carry no 30-minute Reserves above SR and PR.

Further, uncertainty and ramping needs are increasing due to VER integration and PJM markets are not accounting for these increased reserve needs.

Reserve Design

PJM is building a proposal around a suite of day-ahead and real-time reserve products, each of which will need reserve requirements to set the procurement targets in the market clearing engines, market design elements, demand curves and business rules for performance.

DAY AHEAD	REAL TIME
Day Ahead Reserves – New Product	
30 Min. Reserves – Updated Design	**30 Min. Reserves - – Updated Design**
10 Min Ramp/Uncertainty Reserves – Up and Down Reserves – New Products	**10 Min Ramp/Uncertainty Reserves – Up and Down Reserves – New Products**
Primary Reserves (PR)	**Primary Reserves (PR)**
Synchronized Reserves (SR)	**Synchronized Reserves (SR)**

Reserve Requirements to align with operational needs

Align operational scheduling needs with the Day-Ahead Market

Day Ahead Reserves are needed to address uncertainty Day-Ahead and to facilitate a reliable operating plan for the next day for PJM Operations

- Today, PJM Markets does not capture the energy and reserve commitments needs for a reliable operating plan going into real-time
  - A total of 3,000MW of reserves are required Day-Ahead, for all days regardless of operating risk or expectations.
- Operations supplements the Day-Ahead commitments, through the RAC process, *after* the Day-Ahead market.
  - PJM Operations uses the load forecast and the "DASR" calculation to run RAC to determine scheduling needs. (20241205-item-15---2025-dasr-presentation.pdf)

Existing Reserve Requirements

OPERATIONS

Day Ahead Scheduling Reserve (DASR) = 4.51%

*Load forecast at peak * (Underforecasted Load Forecast Error (LFE) + (FOR) Generator Forced Outage Rates)*

MARKETS

30 minute Reserves – Maximum of

(3,000, PR, Gas Contingency)

Replacement reserves for contingency events

Primary Reserves (PR) (10-min. Reserves) – 150% SR

Contingency reserves and ACE recovery

Synchronized Reserves (SR) (10-min. Reserves) – 100% MSSC*

Contingency reserves and ACE recovery

Note: Does not include wind and solar forecast accuracy risk.
**SR Most Severe Single Contingency (MSSC) is adjusted for measured performance. Requirement is currently 130% MSSC.*

30-minute Reserves do not capture uncertainty that PJM's operations deal with and need to plan for today.

The Market flat requirement (i.e., 3,000 MW) does not reflect the minimum level of risk. Any time peak load is greater 74,257 MW, 3,000 MW of 30-Minute Reserves is not sufficient to manage operational risk.

Currently all reserve products are nested, which means at times we carry no 30-minute Reserves above Synchronized Reserves (SR) and Primary Reserves (PR).

Both SR and PR have a minimum duration of 30 minutes – which could adversely impact operations.

Day Ahead Products in other ISOs

	Day-Ahead Specific Products
PJM	
MISO	
CAISO	✓
ISO-NE	✓
NYISO	
SPP	
ERCOT	

- Both CAISO and ISO-NE address load forecasting needs in real-time in their Day-Ahead market via specific products

- Additionally, all ISO are able to reflect the scheduling reserve needs (via requirements) in the Day-Ahead

- PJM is intending to bring the "DASR" Process into the Day-Ahead market *and* update the "DASR" calculation to account for the evolving resource mix and the increasing penetration of VER that increase uncertainty ("DASR 2.0").
- "DASR 2.0" will now account for the updated uncertainty needs
  - Load Forecast Error, Gen Outage Error, Renewable Uncertainty
  - Updated based on system risk level
    - High, Medium and Low risk days will be evaluated and determined by PJM's uncertainty model and that will drive reserve levels

20250716-item-02---uncertainty-in-operations.pdf
20250827-item-02---uncertainty-and-risk-framework.pdf

Risk Percentiles

Proposed Risk Values	Percentile	Load	Generator Performance	Solar	Wind
Low	80^{th} Load / 50^{th} Others	2.19%	2.03%	11.28%	9.68%
	80^{th} All	2.19%	3.12%	19.71%	21.48%
Medium	85^{th} All	2.42%	3.49%	22.50%	24.19%
High	90^{th} All	2.79%	3.88%	25.51%	26.54%
	95^{th} All	3.55%	4.68%	31.33%	32.43%

20251015-item-03---proposed-error-percentiles-for-day-ahead-scheduling-reserve-quantities.pdf

20250827-item-02---uncertainty-and-risk-framework.pdf

Expected Risk Days

Translation From Uncertainty to Risk Is Qualitative

Uncertainty		
High Falls within the **99%**	▪ High Weather Uncertainty ▪ Low System Margins ▪ Neighbors under Similar Conditions (projected interconnection wide risk)	**Elevated Day-Ahead** Reserve Requirement
Medium Falls within the **94.5%**	▪ Weather Uncertainty ▪ Tight System Margins	
Low Falls outside the thresholds	▪ Normal system conditions ▪ Normal system margins	

Based on historical analysis PJM expects:

- 1% of days as high risk
- 3% of days as medium risk

20250827-item-02---uncertainty-and-risk-framework.pdf

*99% and 94.5% is based on the uncertainty distribution from the Uncertainty Quantification model

Day Ahead Requirements

- On Low-Risk Days

Proposed Risk Values	Percentile	Load	Generator Performance	Solar	Wind
Low	80th Load / 50th Others	2.19%	2.03%	11.28%	9.68%

- Total DASR Requirement for a peak load of 120,000 MW
  - Assuming 500MW of solar and 4,500MW of wind at peak
- DASR = 120,000* 2.19% (load error) + 120,000* 2.03% (gen perf) + 500*11.28% (solar error) + 4,500*9.68% (wind error)
- DASR = 2,628MW (load error) + 2,436MW (gen perf.) + 56.4MW (solar error) + 435.6MW (wind error)
- DASR = **5,556MW**

- DASR = **5,556MW**
  - Will be allocated across the Day-Ahead Reserves, 30 Min Reserves and 10Min Reserves

Note: more details on allocation later in the deck on requirement examples

- PR = **150% SR ~ 3000MW**
- SR = **MSSC* ~ 2000MW**
- **Total Reserves = 8,556MW**

*MSSC is adjusted for resource performance

DAY AHEAD

Day Ahead Reserves – New Product

30 Min. Reserves – Updated Design

30-Min RUR Reserves

10 Min Ramp/Uncertainty Reserves – Up and Down Reserves – New Products

Primary Reserves (PR)

Synchronized Reserves (SR)

Day Ahead Requirements

- On High-Risk Days

Proposed Risk Values	Percentile	Load	Generator Performance	Solar	Wind
High	90th All	2.79%	3.88%	25.51%	26.54%

- Total DASR Requirement for a **peak load of 150,000 MW**
  - Assuming **500MW of solar** and **4,500MW of wind** at peak
- DASR = 150,000* 2.79% (load error) + 150,000* 3.88% (gen perf) + 500*25.51% (solar error) + 4,500*26.54% (wind error)
- DASR = 4,185MW (load error) + 5,820MW (gen perf.) + 127.6MW (solar error) + 1,194.3MW (wind error)
- DASR = **11,327MW**

Day Ahead Requirements

- DASR = **11,327MW**
  - Will be allocated across the Day-Ahead Reserves, 30 Min Reserves and 10Min Reserves

Note: more details on allocation later in the deck on requirement examples

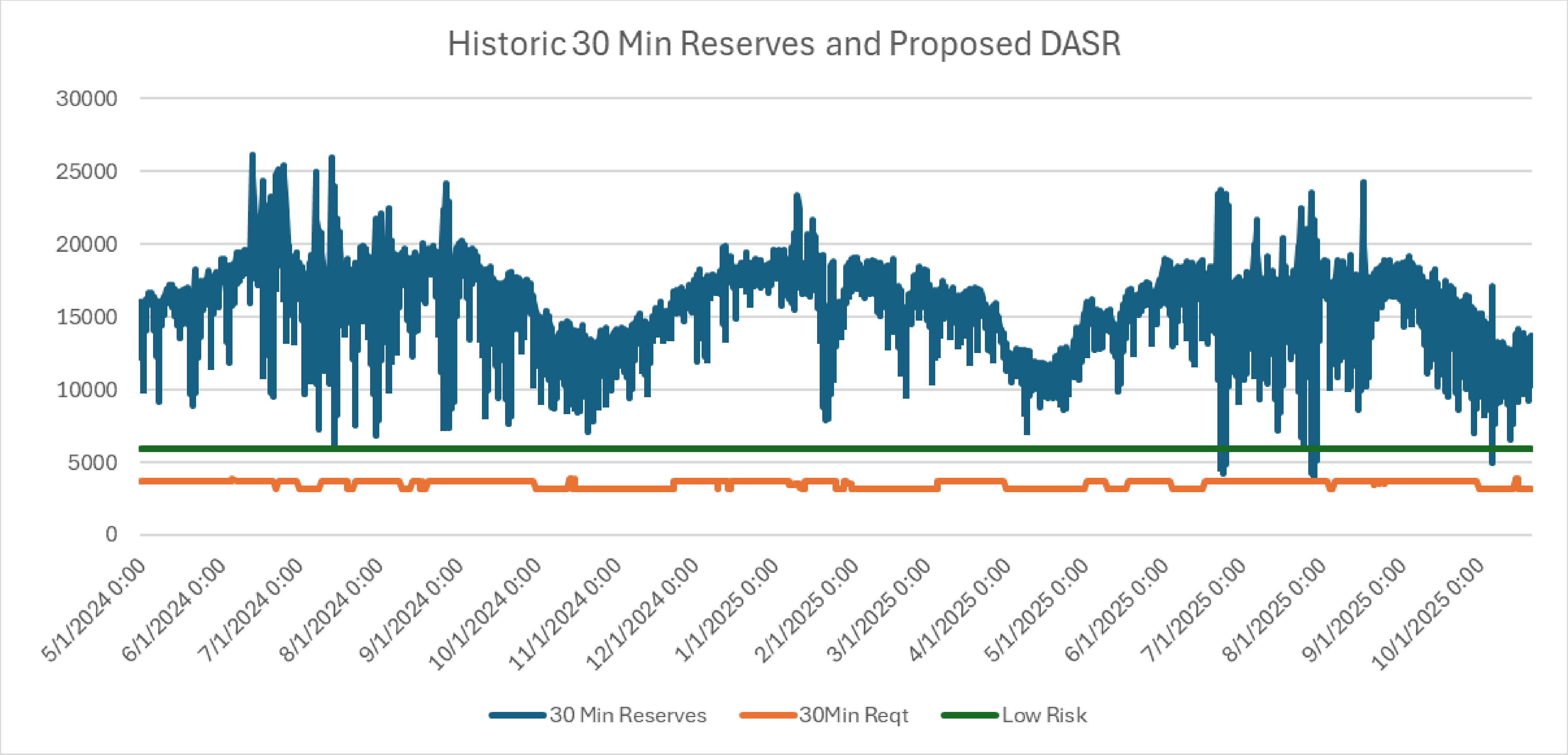
- PR = **150% SR ~ 3000MW**
- SR = **MSSC* ~ 2000MW**
- **Total Reserves = ~14,327MW**

*MSSC is adjusted for resource performance

DAY AHEAD

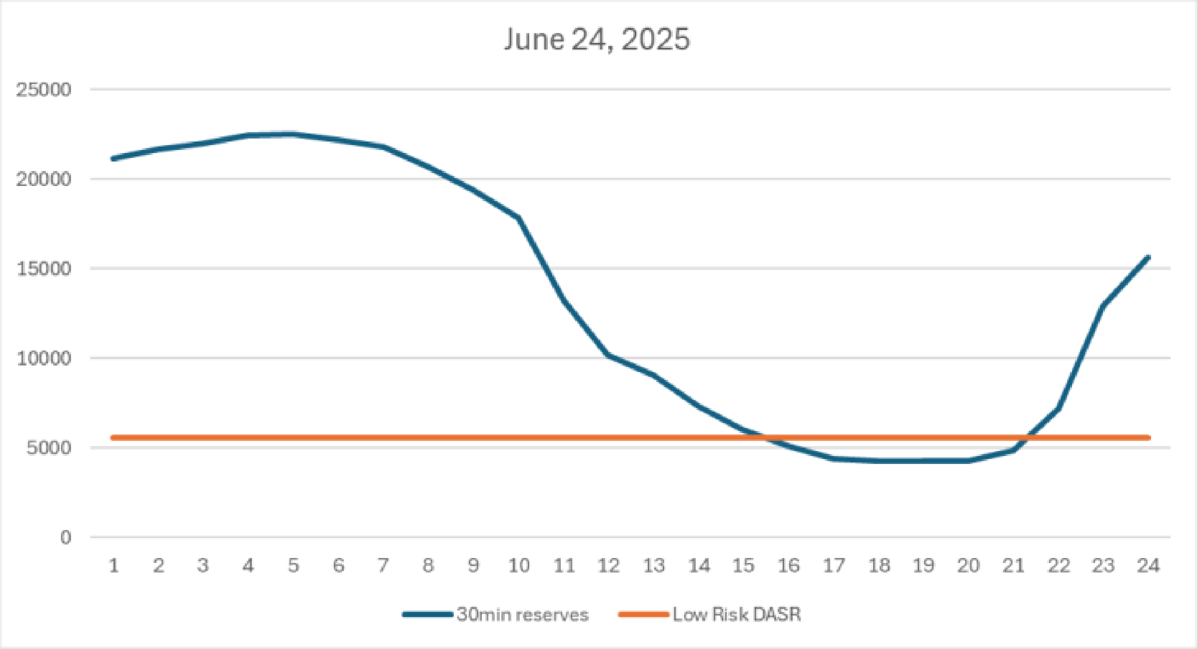
- **Operations:** Securing the generation needs for a reliable operating plan day-ahead is important for reliability
  - allows for earlier commitments, provides a day-ahead market position with explicit performance expectations, and minimizes the need for operator intervention.
- **Market Impacts:** This is minimal impact on most days as the needed reserves are ;ess than the available reserves to the system

Perspective on Day-Ahead Requirements – Historical Low Risk Days



Perspective on Day-Ahead Requirements – Historical Tight Capacity Margins

- June 24, 2025 in the PJM historical uncertainty analysis is a low risk day
- Would we actually be short reserves?
  - This data is not totally indicative given this does not address (1) necessarily all available headroom available, (2) any re-dispatch available and, (3) 60min reserve capability
- Load Management interaction
  - PJM did utilize LM on this day and we are looking at how/if that needs to be represented Day-Ahead



- RTO wide

Notification Time	Deploy Time	Release Time	Resource Type	Lead Time	Zones
13:00	15:00	22:00	Pre-Emergency	Long_120	BGE, DOM, PECO, PEPCO
13:30	15:30	22:00	Pre-Emergency	Long_120	AECO, DPL, JCPL, METED, PENELEC, PPL, PSEG
14:00	16:00	22:00	Pre-Emergency	Long_120	AEP, APS, DAY, DUQ
14:30	16:30	22:00	Pre-Emergency	Long_120	ATSI, COMED, DEOK, EKPC
14:00	15:00	22:00	Pre-Emergency	Short_60	BGE, DOM, PECO, PEPCO
14:30	15:30	22:00	Pre-Emergency	Short_60	AECO, DPL, JCPL, METED, PENELEC, PPL, PSEG
15:00	16:00	22:00	Pre-Emergency	Short_60	AEP, APS, DAY, DUQ
15:30	16:30	22:00	Pre-Emergency	Short_60	ATSI, COMED, DEOK, EKPC

- On days where there is identified elevated risk (high and medium risk days), the Day-Ahead reserve needs will include two additional components:
  - Bringing the load forecast needs into the Day-Ahead through an 'Energy Gap' reserve component
  - Putting online reserve constraints into the Day-Ahead to have a higher proportion of generation carrying reserves *online* (vs. offline)

PROVIDES GREATER RELIABILITY AND REDUCES RISK

Provides broader consistency with commitment to generators

LESS OUT OF MARKET COMMITMENTS

Earlier notification for fuel commitment and plant prep

GIVES US MORE MARGIN TO MITIGATE IDENTIFIED RISK

On average PJM observes less failures to start for CTs when units have an advanced commitment

- Utilize the Seasonal Conditional Demand Factor previously used in PJM to determine the additional reserve needs.

Energy Gap Requirement = MAX(PJM Load Forecast – (Adjusted Fixed Demand + Expected Losses), 0)

Where ; Expected Losses = Fixed Demand x Seasonal Expected Losses Factor

And ; Adjusted Fixed Demand = Fixed Demand x (1 + Seasonal Conditional Demand Factor)

- Require these MWs to be from <u>online headroom</u>, given these are needed to meet the expected load forecast

[20251015-item-04---elevated-risk-days.pdf]

Numerical Example for Energy Gap at the Peak Forecast Hour

- The peak forecast for January 15, 2025, was 130,356 MW* effective for hour beginning 7:00

- The calculated Energy Gap Adder for the DASR requirement would therefore have been:

  – ***Energy Gap Adder*** *= PJM Load Forecast – (Adjusted Demand + Expected Losses)*

  = 130,356 MW – 122,747 MW – 3,756 MW

  = 3,853 MW

Expected Losses = Fixed Demand x SLF = 121,171 MW x (0.031) = ***3,756 MW***

Adjusted Demand = Fixed Demand x (1 + SCDF) = 121,172 MW x (1 + 0.013) = ***122,747 MW***

20251015-item-04---elevated-risk-days.pdf

**As evaluated at 1/14/2025 9:45 EPT*

RECALL – HIGH RISK DAY RESERVES NEEDS

Day Ahead Requirements

- DASR = 11,327MW + *3,853 MW*
- PR = 150% SR ~ 3000MW
- SR = MSSC* ~ 2000MW
- **Total Reserves = 18,180MW**
- **>= 3,853MW are from online resources**

DAY AHEAD

Day Ahead Reserves – New Product

30 Min. Reserves – Updated Design

30-Min RUR Reserves

10 Min Ramp/Uncertainty Reserves – Up and Down Reserves – New Products

Primary Reserves (PR)

Synchronized Reserves (SR)

Day-Ahead Reserves – Summary

Issue

Operations need a reliable operating plan going into real-time. The Market Reserve requirements are divergent from the Operational needs today, and that divergence is expected to grow into the future. Further, the physical generator commitments coming out of the Day-Ahead are often less than what is needed to serve our load forecast, which is a concern on high risk days. This requires out-of-market action to maintain reliability. Operators, today, take action in the Reliability Commitment period, after the Day-Ahead.

Solution

Implement the DASR needs (‘DASR 2.0’), and the load forecasting needs (‘Energy Gap’)into the Day-Ahead market.

Day –Ahead Reserves -Summary

Day-ahead market clearing

Total Day-Ahead Scheduling Reserves (DASR 2.0) + Energy Gap on Elevated Risk Days

- **Day Ahead Reserves**
- **30-Min. Reserves – Updated**
  - **30-Min RUR Reserves**
- **10-Min Ramp/Uncertainty Reserves Up**

Contingency Reserves

- **Primary Reserves (PR)**
  - **Synchronized Reserve (SR)**

DASR 2.0 is the total reserve quantity PJM needs to carry day-ahead to schedule the system for reliability above the reserves needed for unit loss.

The total DASR 2.0 quantity would be divided across reserve products to reflect the services needed and what would be carried into real-time based on expected real-time reserve needs.

The needed Day-Ahead Reserves from “DASR” 2.0 (and Energy Gap during elevated risk days) will be allocated across the reserve products cleared day ahead to manage uncertainty, ramping and secondary reserve needs

- Day Ahead Reserves will be used to address uncertainty Day-Ahead that does not need to be carried into Real-Time
  - More uncertainty exists Day-Ahead than in Real-Time and operations needs a reliable operating plan (Energy and Reserve commitments) to go into the operating day, to meet demand and manage uncertainty.
- 30 Minute Reserves, 30 Minute RUR,10 Minute RUR, Primary Reserves and Synchronized Reserves will align with the expected real-time needs.

Reserve Requirements to align with operational needs

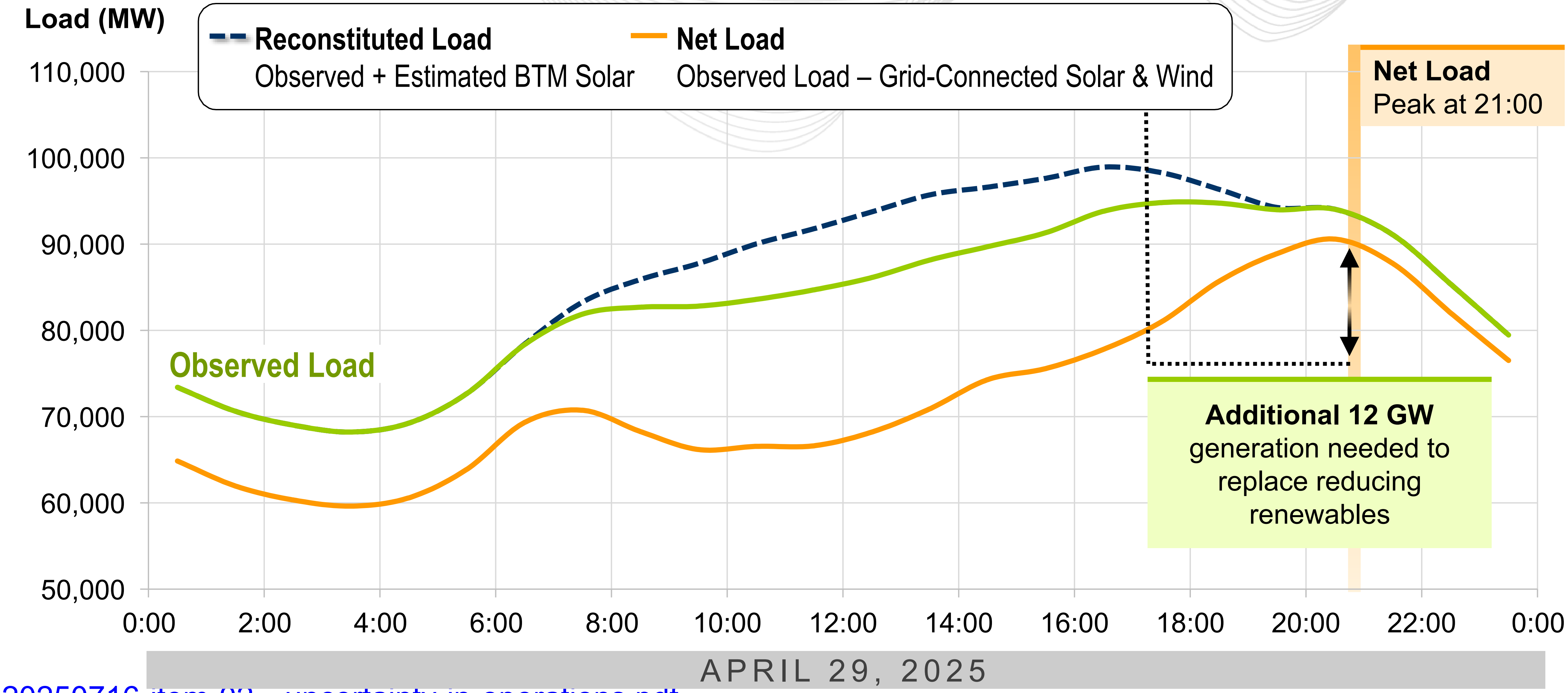
Address growing ramping and uncertainty system needs

With higher penetration of renewables, net-load ramp and uncertainty will increase significantly.

- PJM’s system is already seeing the impacts and challenges of the net load and this is expected to increase as more renewable connect to the system

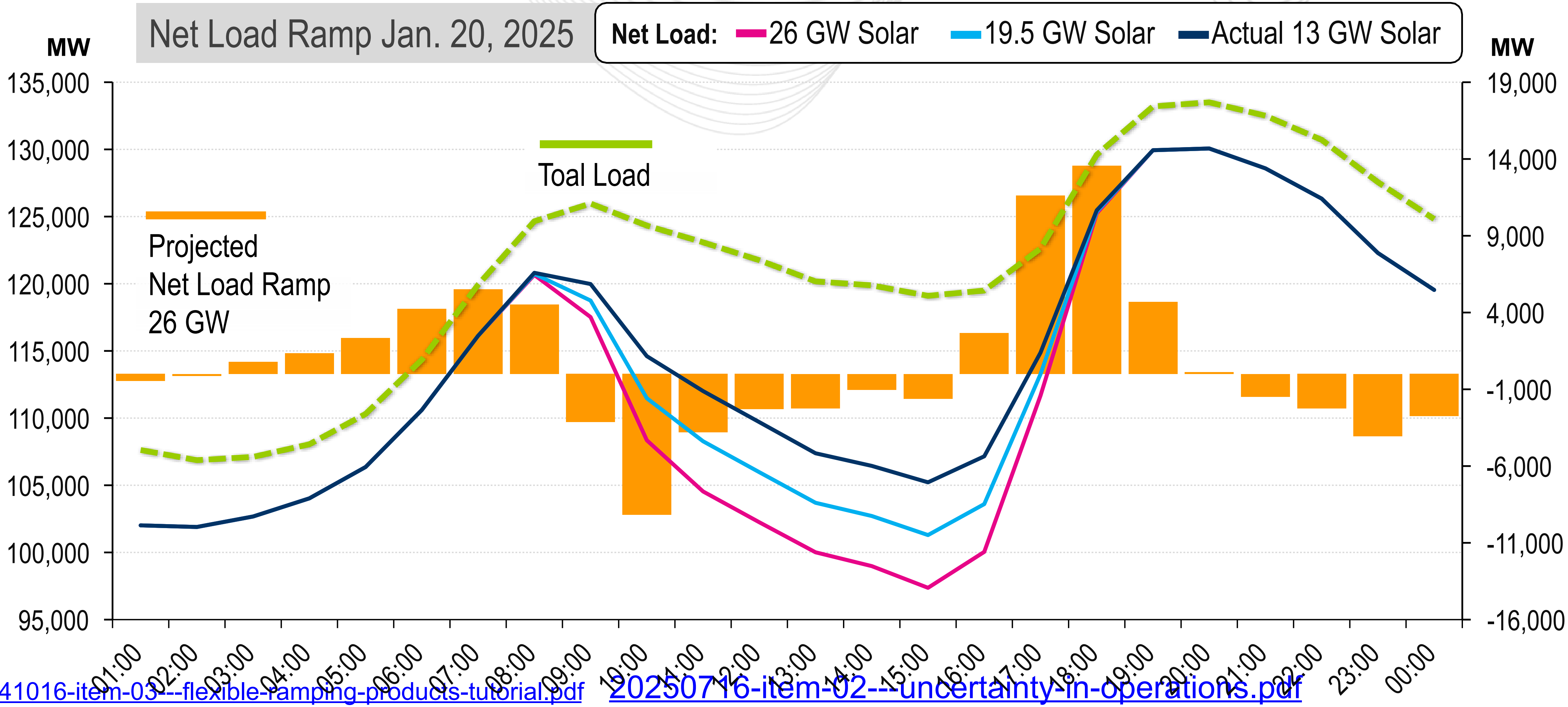
PJM’s market clearing and dispatch engines must have tools to ensure that resources are positioned now to serve forecasted load later or PJM risks having insufficient flexibility to keep the system reliable.

Ramping System Needs



[20250716-item-02---uncertainty-in-operations.pdf]

Ramping System Needs



20241016-item-03---flexible-ramping-products-tutorial.pdf 20250716-item-02---uncertainty-in-operations.pdf

Addressing the System Ramp Needs

	Forecasted Ramp & Uncertainty Reserves	Multi-Interval Dispatch*
PJM		
MISO	✓	
CAISO	✓	✓
ISO-NE		
NYISO	✓	✓
SPP	✓	
ERCOT	✓	

- Many other ISO's that have/are experiencing growing uncertainty and ramping needs on their system have implemented ramping and/or uncertainty reserve products to maintain reliability as more renewables enter the system.

**ISOs currently using multi-interval dispatch do not settle all intervals in the look-ahead window.*

Ramp and Uncertainty Needs

- To address growing ramping and uncertainty system needs in real-time PJM is proposing to represent those needs in three reserve product definitions
  - **10 Minute Reserves -Up :**
    - Include 10-Minute Net-Load Ramp-Up and 10-Minute Uncertainty
  - **10 Minute Reserves -Down:**
    - Include 10-Minute Net-Load Ramp-Down and 10-Minute Uncertainty
  - **30 Minute Reserves:**
    - Include 30-Minue Net-Load Ramp and 30-Minute Uncertainty
    - 30 Minute Reserves will also include replacement reserves

Ramp and Uncertainty Needs

- Holding the needed dispatchability to be able to serve energy in a future interval (10min or 30min from now) and by procuring these ramping reserves allows PJM to value the flexibility the system needs and not rely on out of market actions or commitment to pre-position the system for ramping periods

- Ramping products can be implemented successfully in a single interval dispatch

- PJM currently does not have a multi-interval dispatch- PJM would like to explore this in the future outside of the RCSTF as this is a complex implementation and would require large system changes and a full settlement re-write

20241016-item-03---flexible-ramping-products-tutorial.pdf

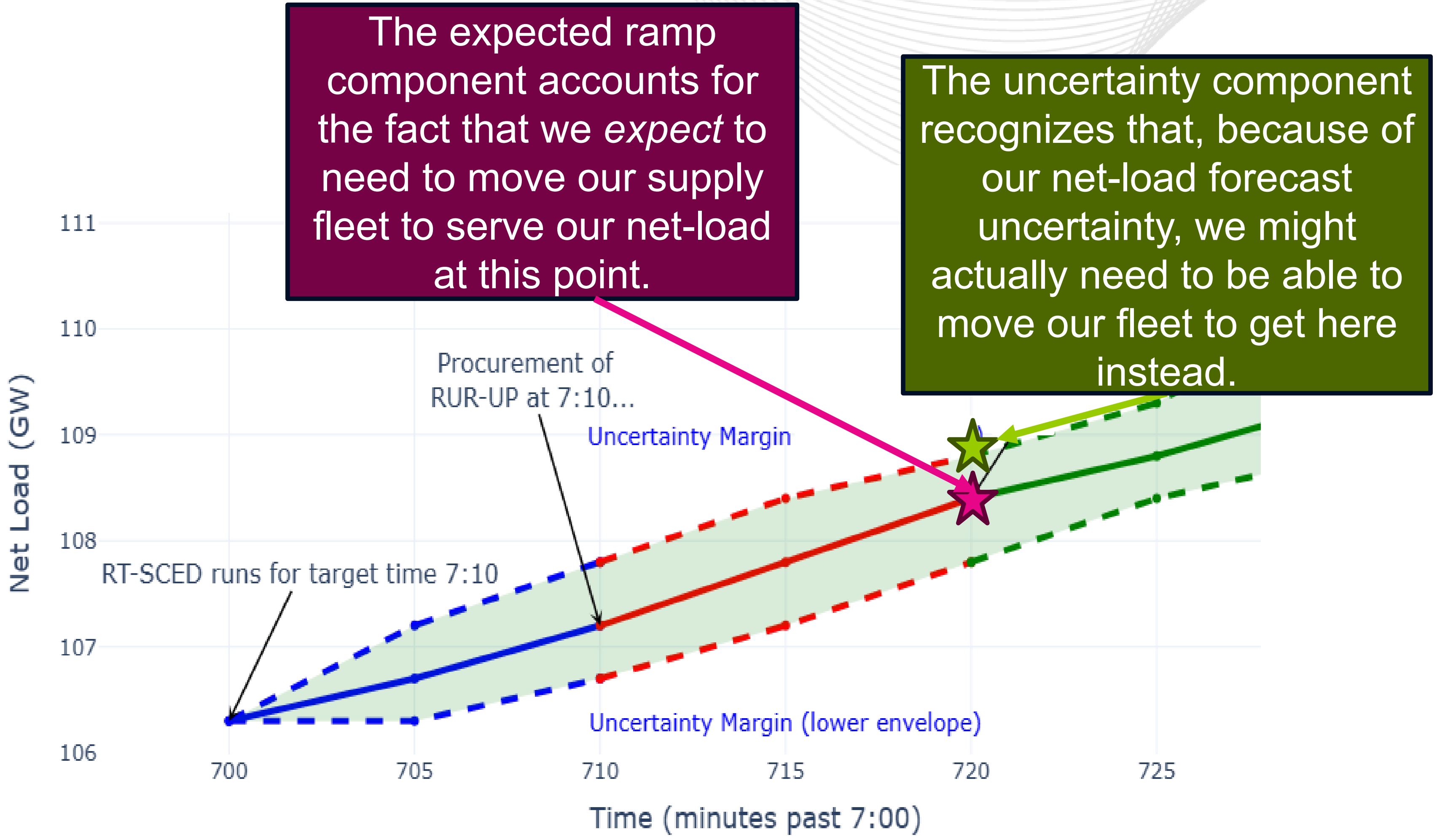
Ramping Reserves Difference

- **Ramping Reserves vs. Regulation:** Regulation reserves address short-term, second-by-second fluctuations (between SCED intervals), while ramping reserves are designed for larger, slower variations in net load and will be dispatched by SCED in future intervals.

- **Ramping Reserves vs. Contingency Reserves:** Contingency Reserves are held to be deployed in case of a contingency event (loss of a unit) and dispatch via All-CALL and AGC basepoint updates. Ramping reserves handle the more gradual, expected, and unexpected (uncertainty) energy needs.

- The ramp and uncertainty on the system will be calculated as a function of *net load/ net load forecast*
  - This is to make sure we are capturing the impacts of the load, solar and wind on the system
    - Net-Load Forecast = Load Forecast – Wind Forecast – Solar Forecast
    - Net Load Ramp = Net-Load Forecast$_{T+x}$– Net-Load Forecast$_{T}$

10 Min Ramp and Uncertainty



20250917-item-05---real-time-reserve-requirements.pdf

10Min RUR will be defined as:

- **10-Min Net Load Ramp + 10-Min Uncertainty**

- Calculating the 10 Min Uncertainty
  - % Load Forecast Uncertainty x Forecasted Load + % Wind Forecast Uncertainty x Forecasted Wind + % Solar Forecast Uncertainty x Forecasted Solar

- The % Uncertainty values are determined based on historical analysis looking at the Δ forecast over the uncertainty window (the difference in the forecast at one look-ahead time vs. the other)

	10-Min Ramp/Uncertainty Reserve		
Uncertainty Percentile	Load	Wind	Solar
95^{th}	0.4%	1.9%	3.1%

20250917-item-05---real-time-reserve-requirements.pdf

- Calculating the 30 Min Uncertainty
  - % Load Forecast Uncertainty x Forecasted Load + % Wind Forecast Uncertainty x Forecasted Wind + % Solar Forecast Uncertainty x Forecasted Solar

- The % Uncertainty values are determined based on historical analysis looking at the Δ forecast over the uncertainty window (the difference in the forecast at one look-ahead time vs. the other)

	30-Min Ramp/Uncertainty Reserve		
Uncertainty Percentile	Load	Wind	Solar
95th	0.6%	2.7%	4.0%

20250917-item-05---real-time-reserve-requirements.pdf

Ramp & Uncertainty Reserves – Summary

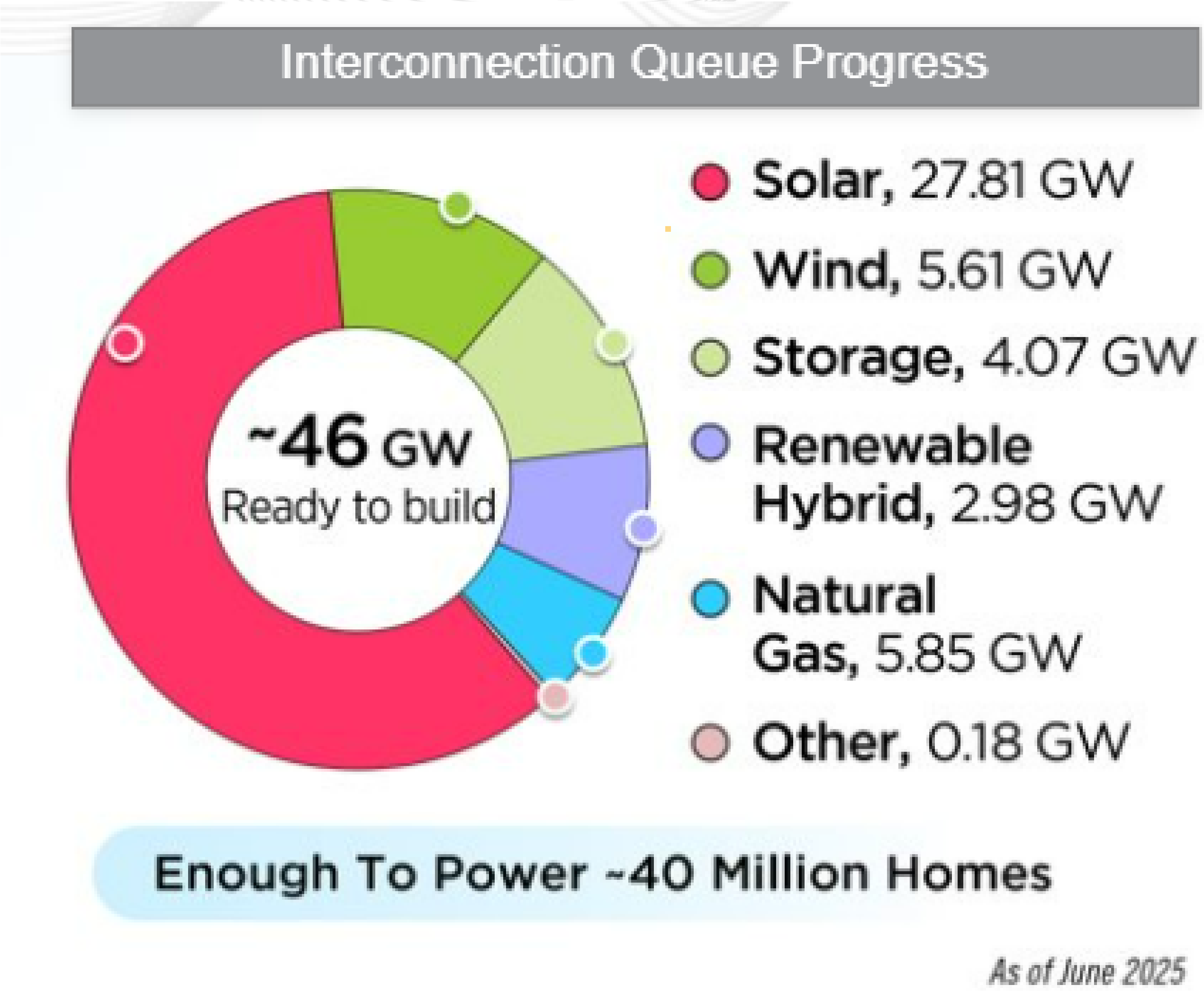
Issue

The growing renewable penetration and expected growth is increasing both the uncertainty on the system and the net load ramp periods PJM dispatch needs to manage. Without sufficient reserves to manage the ramp and uncertainty, the system can become unbalanced leading to reliability issues.

Solution

Implement a 10 min and 30 min ramp and uncertainty product to procure the ramping needs of the system. By setting the requirement needs for the system and procuring ramp/uncertainty reserves we can ensure the system has the flexible/dispatchable resources it needs.

Interconnection Queue



Requirement Examples

Day- Ahead & Real-Time Reserves

30-min. Reserves – Max(3000, PR, Gas Contg)
Replacement reserves for contingency events

Primary Reserves (PR)
(10-min. Reserves)– 150% SR
Contingency reserves and ACE recovery

Synchronized Reserves (SR)
(10-min. Reserves) – 100% MSSC*
Contingency reserves and ACE recovery

**SR Most Severe Single Contingency (MSSC) is adjusted for measured performance. Requirement is currently 130% MSSC.*

Real-Time – RCSTF

30-Min Reserves – UPDATED
Addresses net-load ramping, net-load forecast uncertainty and the need for replacement reserves for system recovery.

30-Min RUR Reserves
Addresses net-load ramping and net-load forecast uncertainty

10-Min Ramp/Uncertainty Reserves – Up and Down Reserves - NEW
Addresses net-load ramping and net-load forecast uncertainty

Primary Reserves (PR) (10-minute reserves) – 150% SR
Contingency reserves and ACE recovery

Synchronized Reserves (SR) (10-minute reserves) – 100% MSSC*
Contingency reserves and ACE recovery

Day-Ahead - RCSTF

Day Ahead Reserves -NEW
Addresses uncertainty DA that does not need to be carried into RT.
Inclusive of the need to have energy and reserve commitments to meet the next day load forecast (energy gap)

30-Min Reserves – UPDATED
Addresses net-load ramping, net-load forecast uncertainty and the need for replacement reserves for system recovery.

30-Min RUR Reserves
Addresses net-load ramping and net-load forecast uncertainty

10-Min Ramp/Uncertainty Reserves – Up and Down Reserves- NEW
Addresses net-load ramping and net-load forecast uncertainty

Primary Reserves (PR) (10-minute reserves) – 150% SR
Contingency reserves and ACE recovery

Synchronized Reserves (SR) (10-minute reserves) – 100% MSSC*
Contingency reserves and ACE recovery

Real-Time Requirement HE6 for the 5 min interval 05:00-5:05

- SR = MSSC* = 2324MW PR = 150% *SR = **3487MW**
- 10MIN RUR - UP = Expected Ramp + Uncertainty = **1133MW**
  - *755 MW + 378 MW = 1133 MW*
- 10MIN RUR - DOWN = Expected Ramp + Uncertainty = **0MW**
- 30MIN RUR Reserves = Expected Ramp + Uncertainty = **2385MW**
  - *1813MW + 572MW = 2,385MW*
- 30MIN Reserves = MSSC = **1788MW**

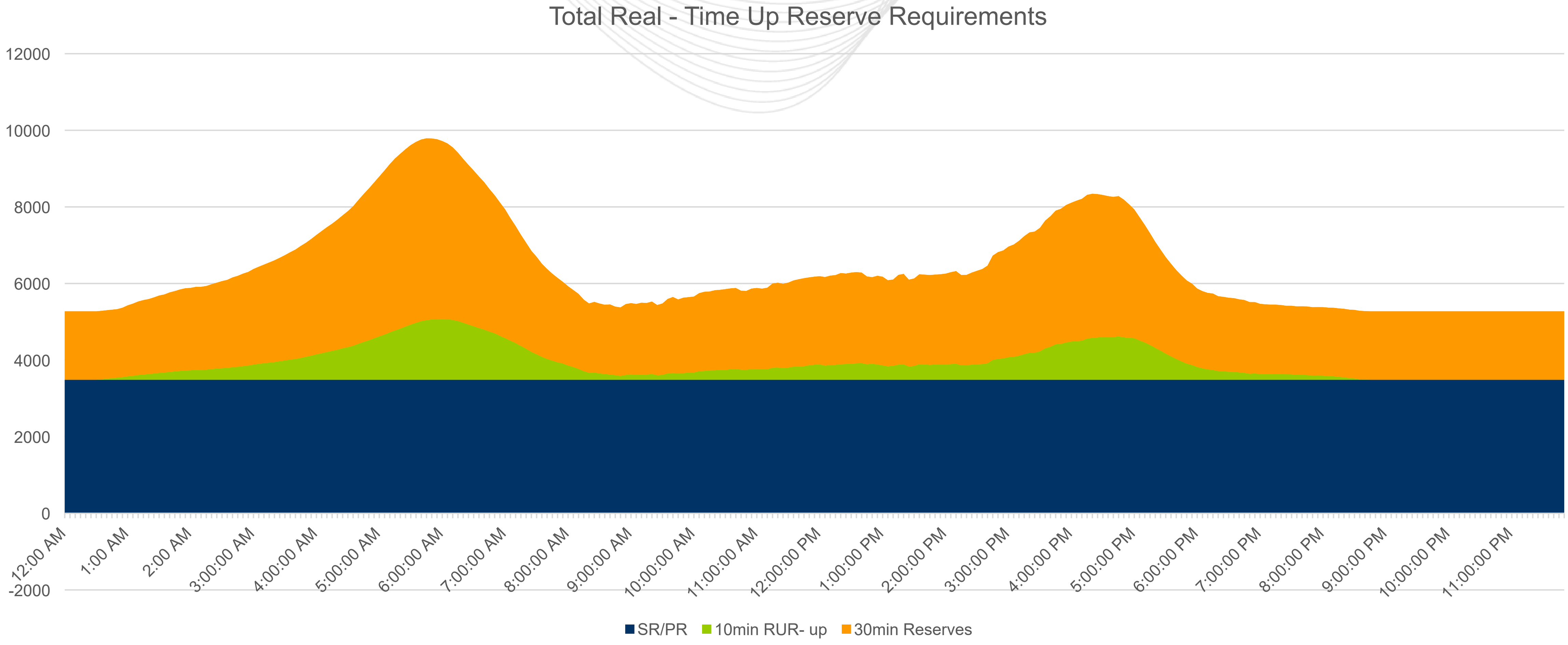
8,793MW would be the total RT Up Reserve needs

Real-Time Requirement HE1 for the 5 min interval 00:00-00:05

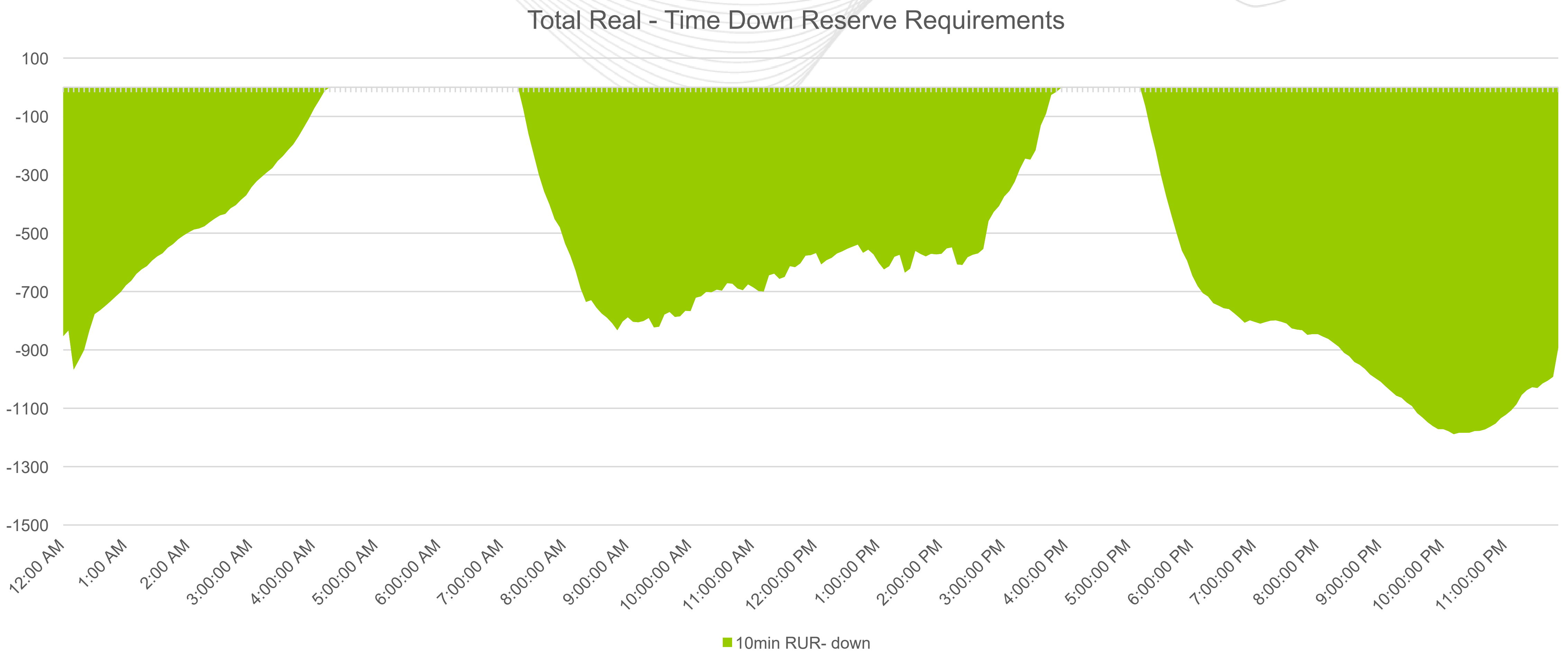
- SR = MSSC* = 2324MW PR = 150% *SR = **3487MW**
- 10MIN RUR - UP = Expected Ramp + Uncertainty = **0MW**
- 10MIN RUR - DOWN = Expected Ramp + Uncertainty = **853MW**
  - *457 + 396 = 853MW*
- 30 MIN RUR = Expected Ramp + Uncertainty = 0MW
  - *(-829) + 581 = -249 MW → 0 MW*
- 30MIN Reserves = MSSC = **1,788MW**

Total Up Reserve MW is **5,275MW,** Total Down Reserve MW is **853MW**

Real-Time Requirements
December 10, 2024



Real-Time Requirements
December 10, 2024



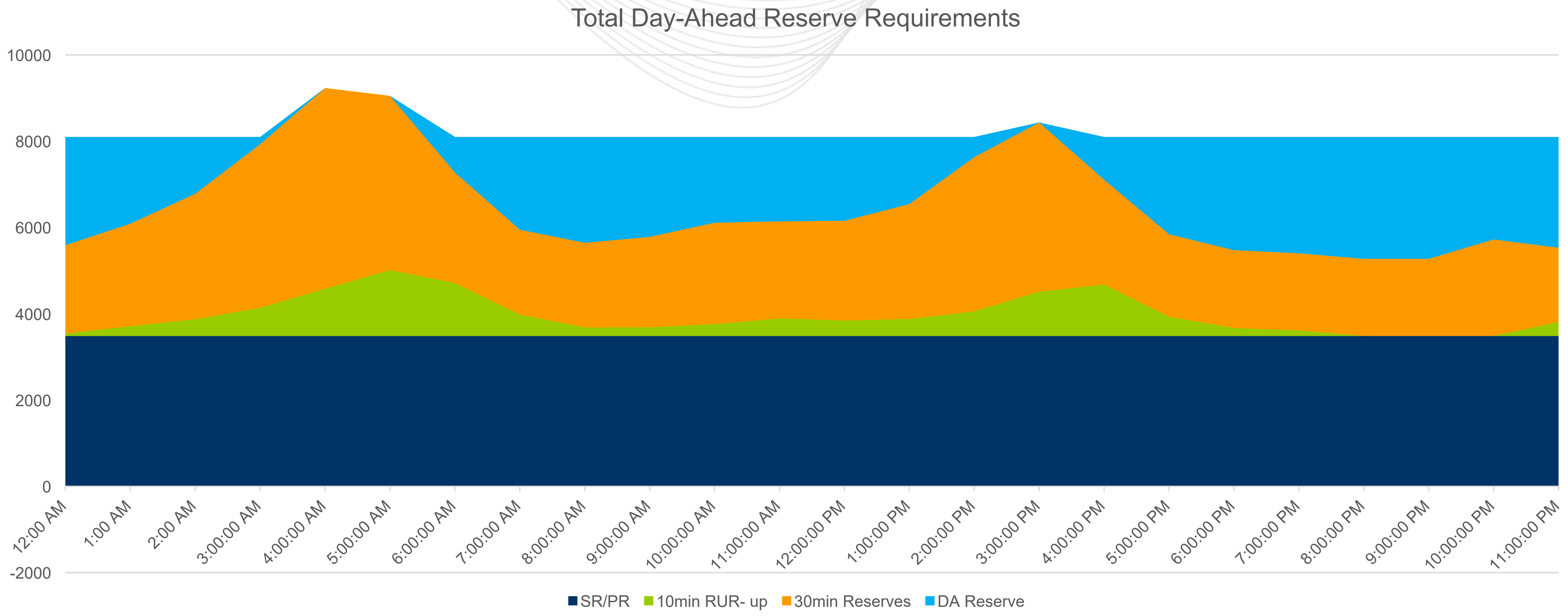
Day- Ahead Requirement HE5

Load Forecast	Wind Forecast	Solar Forecast
98,970	4,278	178

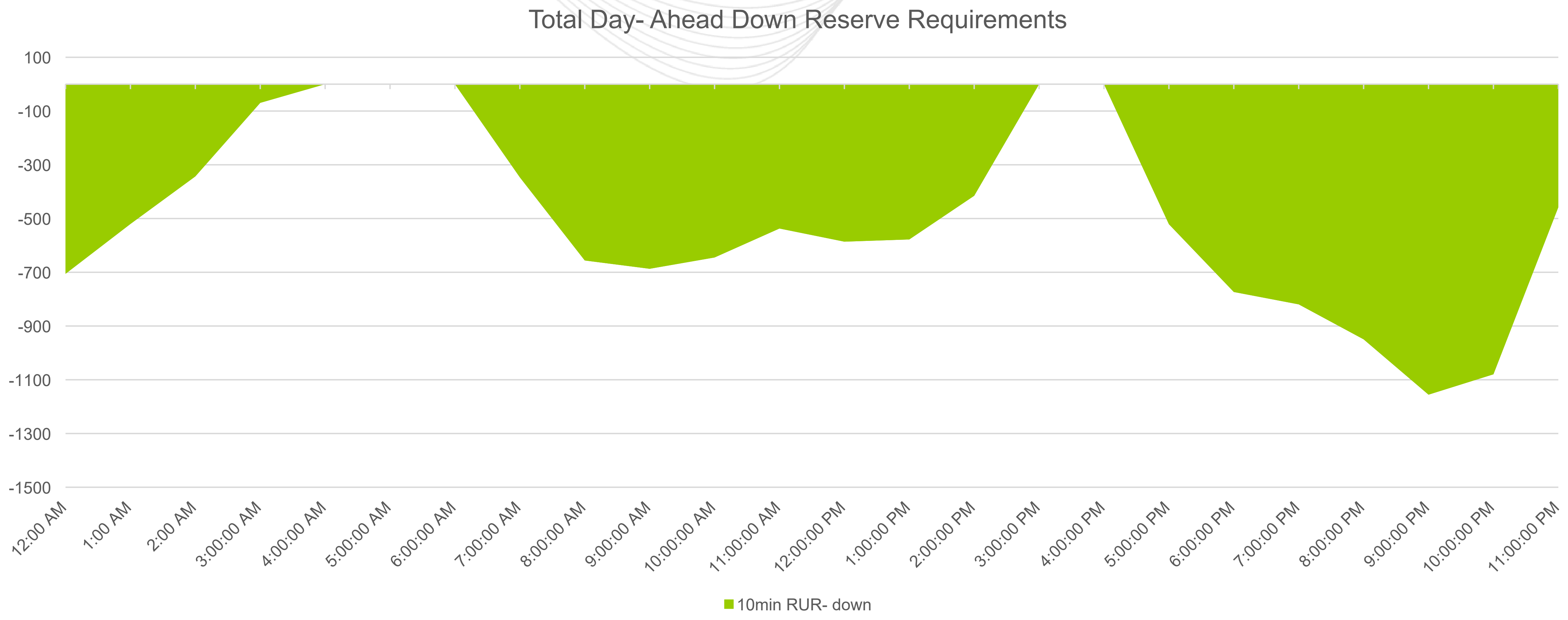
- DASR = @ peak
  - DASR= 98,970* 2.19% (load error) + 98,970* 2.03% (gen perf) + 178*11.28% (solar error) + 4,278*9.68% (wind error) = **4,611MW**
- SR = MSSC* = 2343MW PR = 150% *SR = **3487MW**
- 10MIN RUR = Expected Ramp + Uncertainty = **1108MW** *(732 MW + 376 MW)*
- 30MIN RUR = Expected Ramp + Uncertainty = **2862MW** *(2303MW + 560MW)*
- 30MIN Reserves = MSSC = **1,788MW**
- Day Ahead Reserves = DASR – [10Min RUR+30Min RUR+ 30Min Reserves] = **0MW**

*4611 – [1108 + 2862 + 1802] = -1161 -> **0MW***

Day-Ahead Requirements December 10, 2024



Day-Ahead Requirements
December 10, 2024



Market Design Reserve Structure Changes

$ Tenants of the Capacity Market and Price Formation

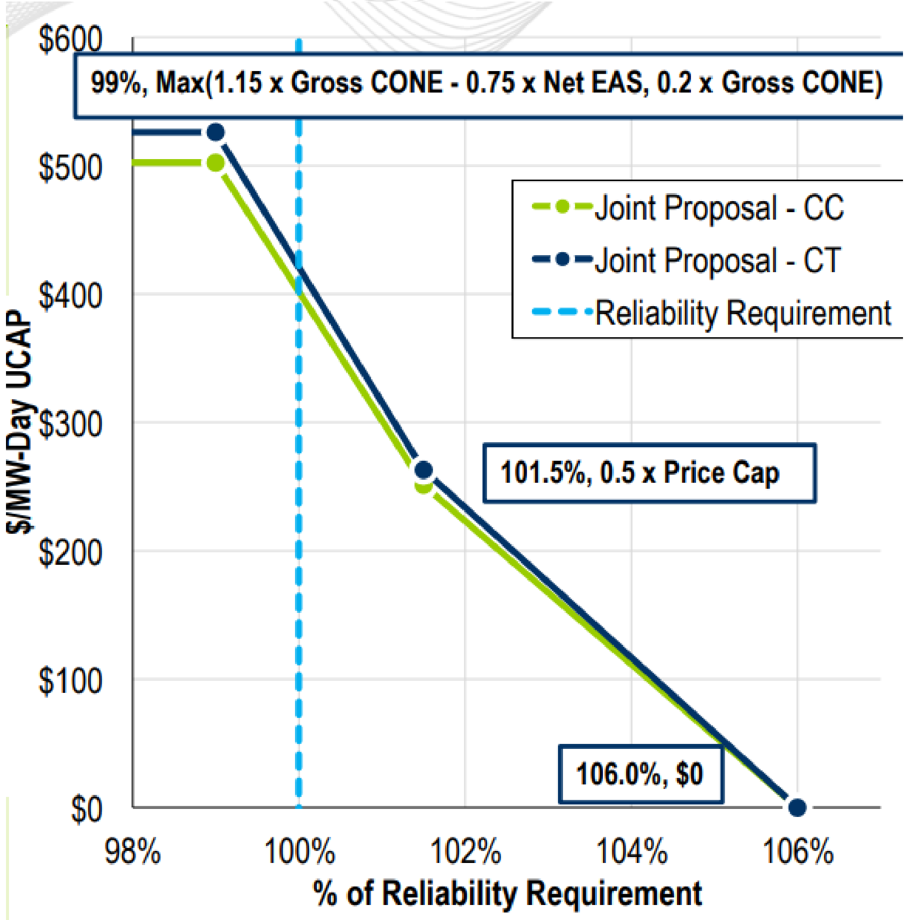
An Administrative Demand Curve (“VRR Curve”) is used in RPM

- Objective to procure sufficient capacity to maintain resource adequacy
- Price Cap and Price at the reliability target are set as a function of Net CONE, generally
- Net CONE = Gross CONE – **Net Energy & Ancillary Services**

As Energy Revenues increase, Net CONE will decrease, reducing the upward pressure on capacity prices and shifting costs to the timeframe in which they are incurred

- Endorsed by stakeholders at the September MRC is a proposed VRR curve that sets:
  - Price Cap = Max(1.15 x Gross CONE - **0.75 x Net EAS**, 0.2 x Gross CONE)
  - Point B = .5*Price Cap

Accounting for 75% of Net E&AS decreases the price cap volatility and lowers the price cap in high Net CONE areas



Product	Definition
Day-Ahead Reserves	• MWs that can be delivered within 60 minutes and can remain on the system for minimum 4hours • MWs can be online or offline
30 Minute Reserves	• MWs that can be delivered within 30 minutes and can remain on the system for minimum 4hours • MWs can be online or offline
30 Minute Reserves - RUR	• MWs that can be delivered within 30 minutes and can remain on the system for minimum 4hours • MWs must be online

Product	Definition
10 Minute Ramp/Uncertainty Reserves	• MWs that can be delivered within 10 minutes and can remain on the system for minimum 1 hour • MWs must be online
Primary Reserves	• MWs that can be delivered within 10 minutes and can remain on the system for minimum 30 minutes – responding to all-call • MWs can be online or offline
Synchronized Reserves	• MWs that can be delivered within 10 minutes and can remain on the system for minimum 30 minutes – responding to all-call • MWs must be synchronized

Resource Ramp Capability calculations to meet the requirements:

- Ramp Capability will not be shared across products
  - SR, PR and 10min RUR: 10 minutes * ramp rate
  - 30-minute reserves: 30 minutes * ramp rate
  - Day-Ahead Only Reserves: 60 minutes * ramp rate
- Resources *coming online* will be considered to meet the Ramp & Uncertainty reserve requirements in real-time, and resources *coming offline* will be ineligible to meet the requirement
  - Align with the reserve needs and manage under/over procurement

Unnesting

- Individual reserve products will need to be unnested (except for SR/PR)
- Motivation: All reserves are not equal in the services provided to the system.
  - Example: 30-minute reserves are too slow to provide 10-minute ramping or synch reserve needs, and Synchronized Reserves are not sustainable (30min duration requirement) enough to meet the 30-minute reserve needs.
- This does not mean the result is over procurement of reserves because the requirements will be adjusted appropriately
- This also means the Demand Curves will not be additive as they are today.
  - A shortage in 30-minute reserves will not necessarily price 10-minute reserves at the penalty factor

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- *Demonstrated* Example of Requirement Unnesting

Nested Reserve Reqts.	Unnested Reserve Reqts.
Sync Reserve = 1000MW	Sync Reserve = 1000MW
Primary Reserve = 1500MW	Primary Reserve = 500MW
30 Min Reserve = 3000 MW	30 Min Reserve = 1500MW
Total Reserves = 3000MW	Total Reserves = 3000MW

Define Resource Capability and Incentive Performance of Resources

Day-Ahead Reserves – Capability

- Must Offer Requirements: All resources available for energy would be required to offer reserves, this excludes nuclear, wind and solar
- Bid parameters/Eligibility:
  - For **offline** Resources: start time <= 30 minutes
  - Dispatchable range between ecomin/max
  - Energy Adequacy (SOC and/or Fuel Availability)

- Day-Ahead Reserve resource will be expected to be available to PJM in Real-Time. If resources are not available to PJM, non-performance penalties will be assessed.
  - PJM is proposing a tiered approach where lack of *availability* has a lesser consequence than lack of performance
- **Availability** – resource appears available for PJM to dispatch at a level commensurate with its day-ahead reserve + energy commitments
- **Performance** – if a resource is called by PJM to come online, it successfully comes online in line with the resources parameters

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- **Availability:** If a resource is unavailable to provide energy in real-time at a level commensurate with its day-ahead reserve assignment plus its day-ahead energy commitment it would be assessed a non-performance change
  - Greater of (1.25*day-ahead reserve revenue or 30-Min Reserve real-time Market Clearing Price)
- **Performance:** If a resource fails to convert procured day-ahead reserves into energy when instructed to do so it would be assessed a non-performance change
  - Greater of (1.5*day-ahead reserve revenue or 1.25*30-Min Reserve real-time Market Clearing Price)

- Day-Ahead 30 Minute Reserves will be balanced against Real-Time 30 Minute Reserves (same balancing settlement as today)
- Real-Time 30 Minute Offline Reserves will be subject to a performance requirement if called upon to provide energy
- **Performance:** If a resource holding a 30min offline reserve assignment fails to convert into energy when instructed to do so it would be assessed a non-performance charge
  - MW shortfall claw back at the clearing price for previous assigned intervals and MW shortfall at 1.5* the RT clearing price for the intervals in which they fail to perform

Market Design Reserve Structure Changes

Recognize the cost(s) to provide reserves through offers

Reserve Offers.

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

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

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

PJM believes that this limitation leads to inefficient and uneconomic market outcomes and can create disincentives for resources to take actions that are needed to support reliability.

Reserve Offer Reforms to Allow Resources to Reflect Costs

- PJM's reserve markets should provide competitive mechanisms for resources to recover avoidable costs for maintaining availability to provide these services.
- All other ISO/ RTO's allow some reflection of these avoidable costs in their reserve markets.
- Today, PJM only recognizes an average penalty risk in its synchronized reserve offers, which is $0/MW for 2025.

	Reserve Offers > $0
PJM	✓
MISO	✓
CAISO	✓
ISO-NE	✓
NYISO	✓
SPP	✓
ERCOT	✓

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	✔	✔	✔		✔	✔

**The light gray check marks reflect that there may be additional performance risk for providing these services depending on the performance obligation and consequences for non-performance.*

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

- The offer caps for **online 30-Min and 10-Min RUR reserves in real time would be $0.**
- The offer caps for **all other reserve services would be greater than $0.**

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

- Implementation of Reserve Offers
  - Offer cap determined for each reserve product
  - Costs above the defined offer cap would be allowed through cost based reserve offers and methodology documented into Manual 15
    - Performance/risk adder
    - Availability and Deployment costs, differentiated by tech/ fuel type

Further discussion for PJM’s final proposal on the details on what the costs for reserves look like, addressing fuel arrangements, limited duration resources opportunity cost, and performance/risk management costs

Value the flexibility to address the system reserve needs

Operating Reserve Demand Curves (ORDC)

An ORDC is an administrative curve that defines the relationship between the quantity of reserves and the maximum price at a given reserve level.

- Y-axis is the reserve penalty factor in $/MWh that sets the maximum price for reserves
- X-axis is the reserve quantity in MW
- The willingness to pay increases as the system approaches reserve shortage or as reserve shortages become more severe. This is sometimes called “Scarcity Pricing.”

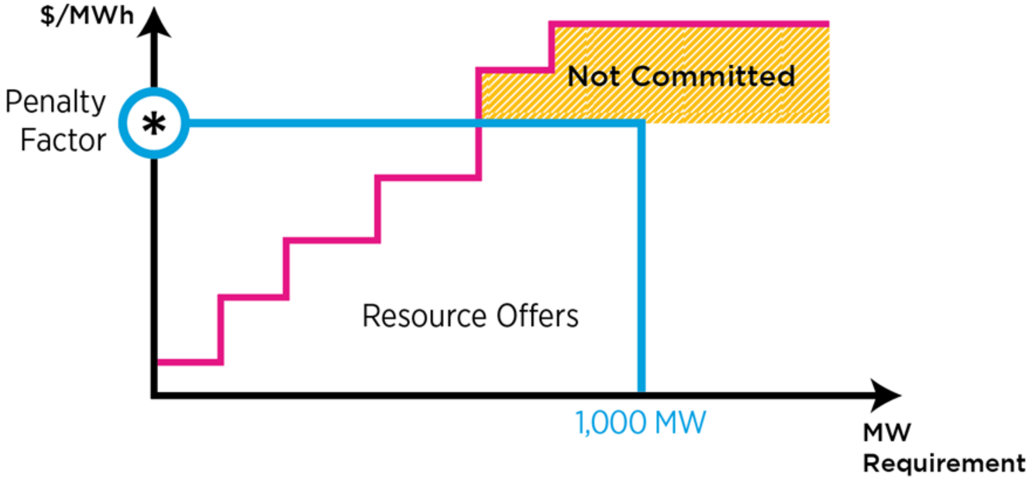
https://www.pjm.com/-/media/DotCom/committees-groups/task-forces/rcstf/2025/20251015/20251015-item-05---ordc-shapes-and-examples.pdf

20250813-item-03---operating-reserve-demand-curves.pdf

Practical impacts of the Penalty Factor

- The penalty factor acts as a cap on the cost willing to be incurred to satisfy the reserve requirement, a resource will not be committed for reserves if the cost exceeds the penalty factor.
  - This means PJM's system will 'go short' reserves, even if physical units/MWs are available to the system, because the cost is too high
  - Operationally, PJM would still assign reserves out-of-market if available and the cost of those reserves would be recovered in "uplift" or Balancing Operating Reserve charges - these costs are not being transparently signaled to the market

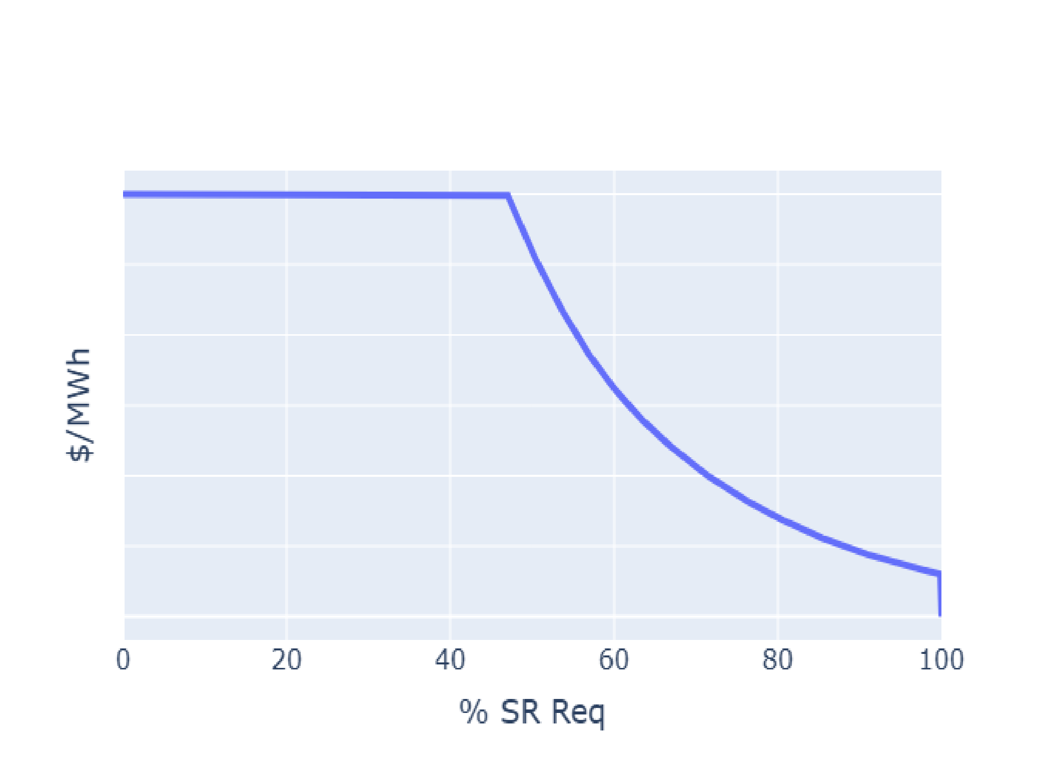
The penalty factor must be set high enough so that shortage being signaled is due to running out of reserves rather than going short for economic reasons, misaligned with PJM Operations.



- Defining the **shape of the curve**: Uncertainty analysis based on Generation Outage reporting, considering only outages starting within an hour of reporting.

- Defining the **x-axis**: this is the sync reserve requirement
  - Defined as MSSC*

- Defining the **y-axis**: driven by the cost of commitments to avoid shortage



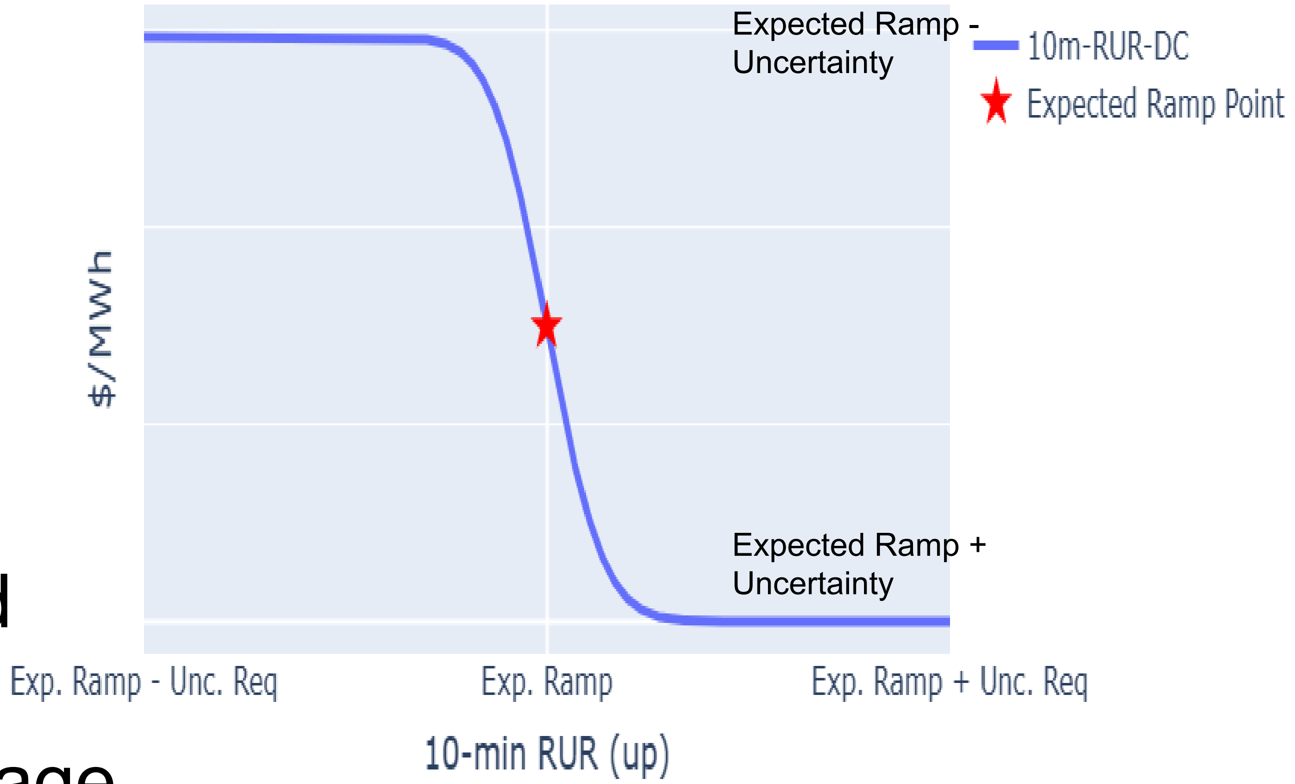
*MSSC is adjusted for resource performance

10-min Up RUR Demand Curve

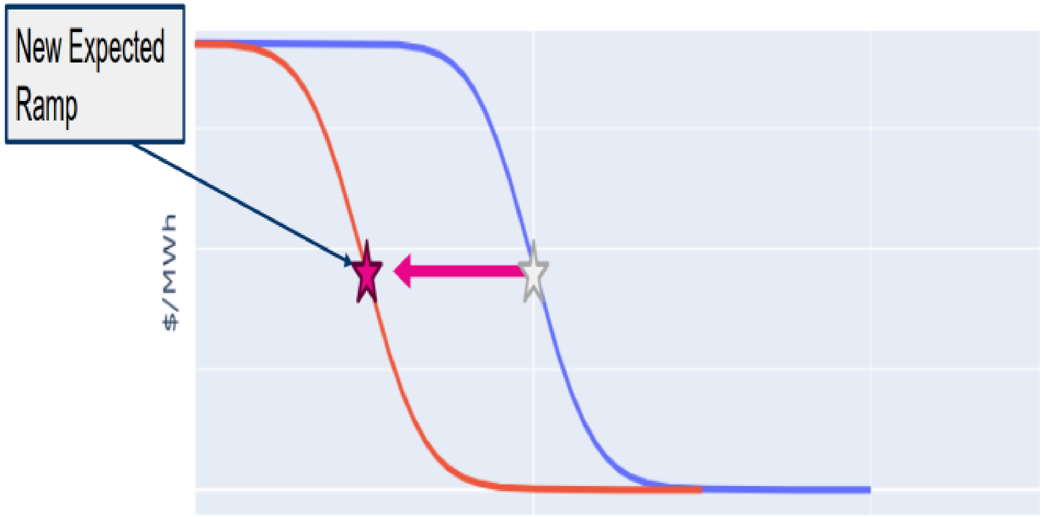
Defining the **shape of the curve**: Uncertainty analysis based on bi-directional uncertainty around 10-min expected net-load ramp

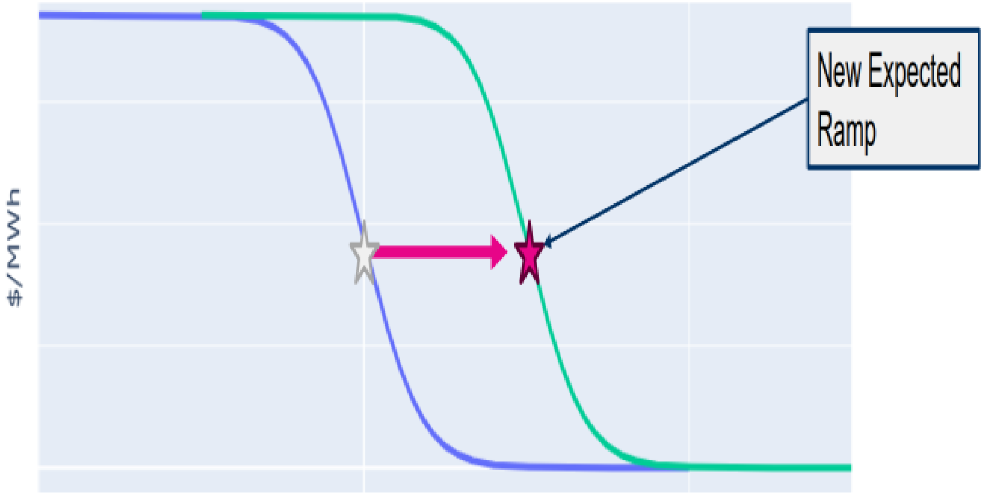
Defining the **x-axis**: this is expected ramp +/- uncertainty

Defining the **y-axis**: driven by the cost of commitments, will be defined below the SR curve to reflect the willingness to pay to avoid SR shortage



- As the expected ramp changes, the 10-Min RUR Demand Curve will shift.

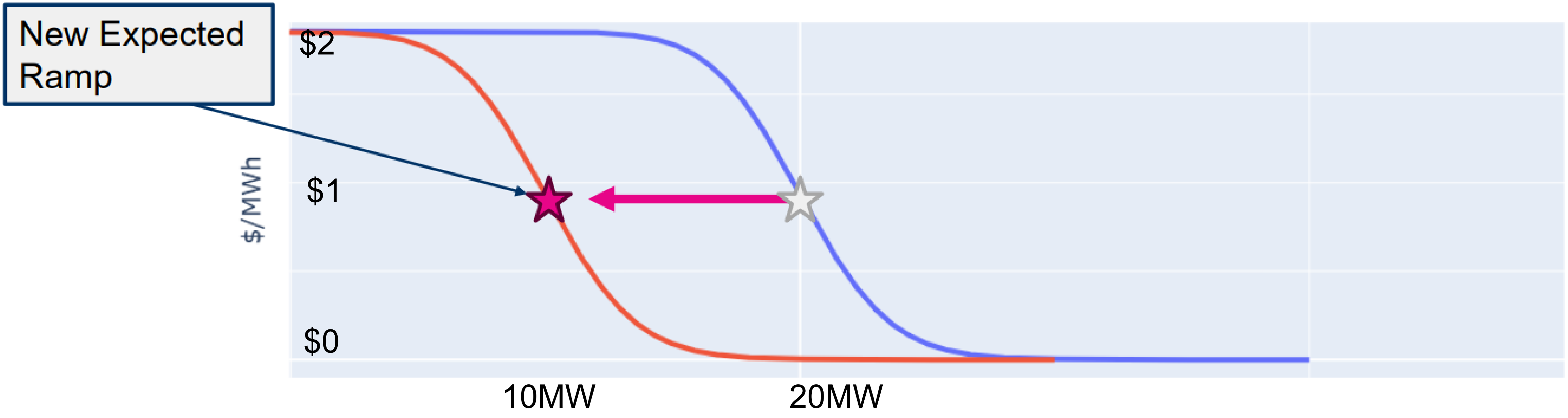




Impact: We have the same willingness to pay for the expected ramp MWs at all times.

- On the **BLUE curve** (right most curve) – the expected ramp is 20MW and the ORDC represents a willingness to pay $1.

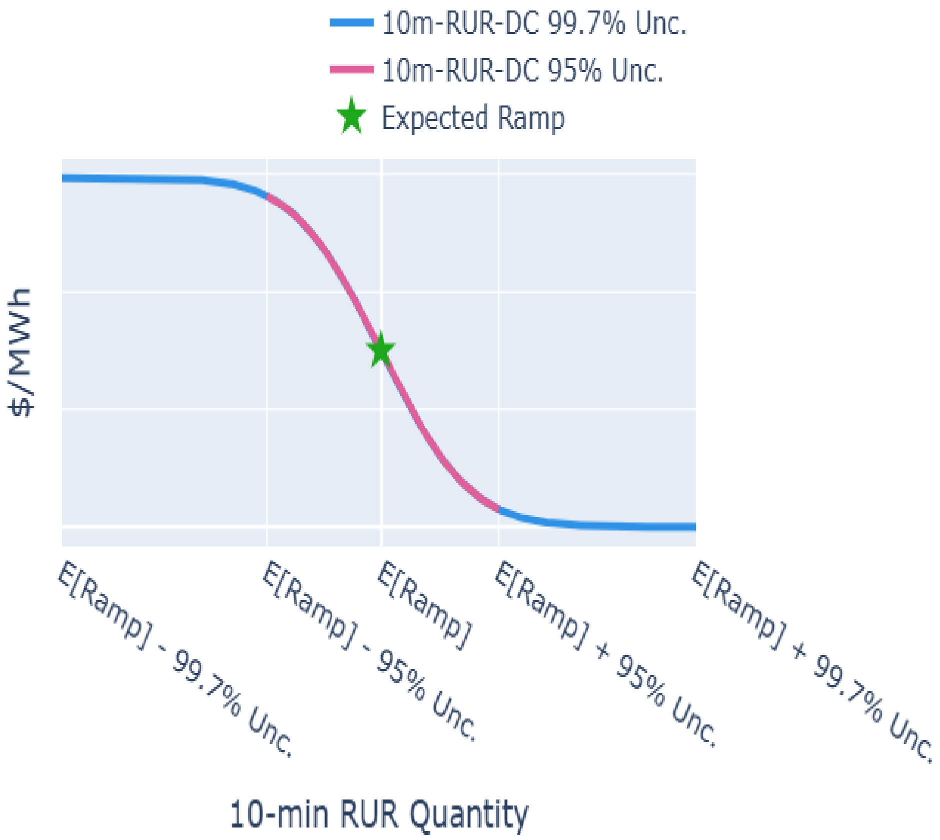
- However, on the **RED curve** (left most curve) – the expected ramp is 10MW and the ORDC represents a willingness to pay $1 for the 10MW, and approximately $0 for 20MW of ramp



Putting the 10Min Ramp Needs together

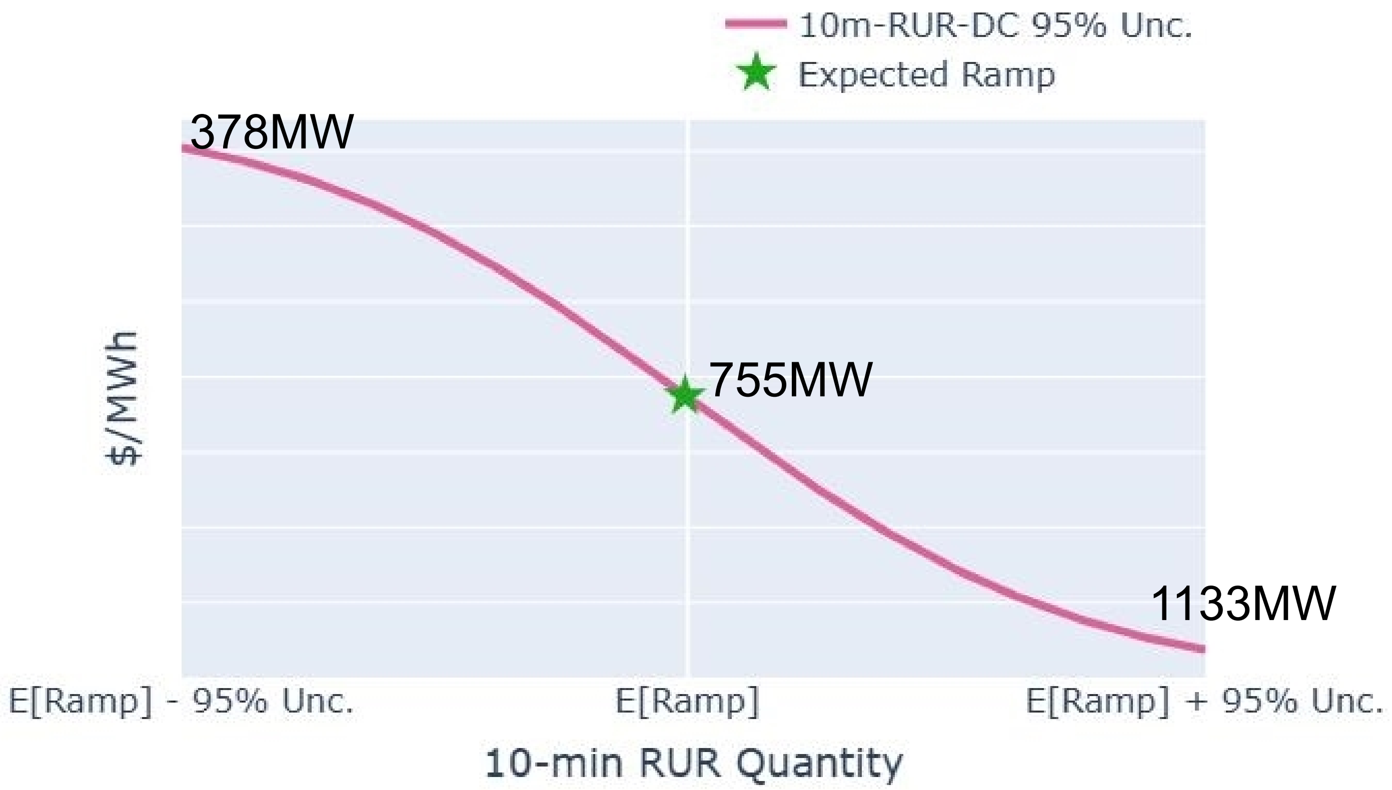
- Overlaying the requirement definitions for 10Min RUR to the demand curve, the market representation of the curve will be truncated at the uncertainty we are using for RT operations
  - Current proposal at 95^{th}-percentile uncertainty

	10-Min Ramp/Uncertainty Reserve		
Uncertainty Percentile	Load	Wind	Solar
95^{th}	0.4%	1.9%	3.1%



Putting the 10Min Ramp Needs together

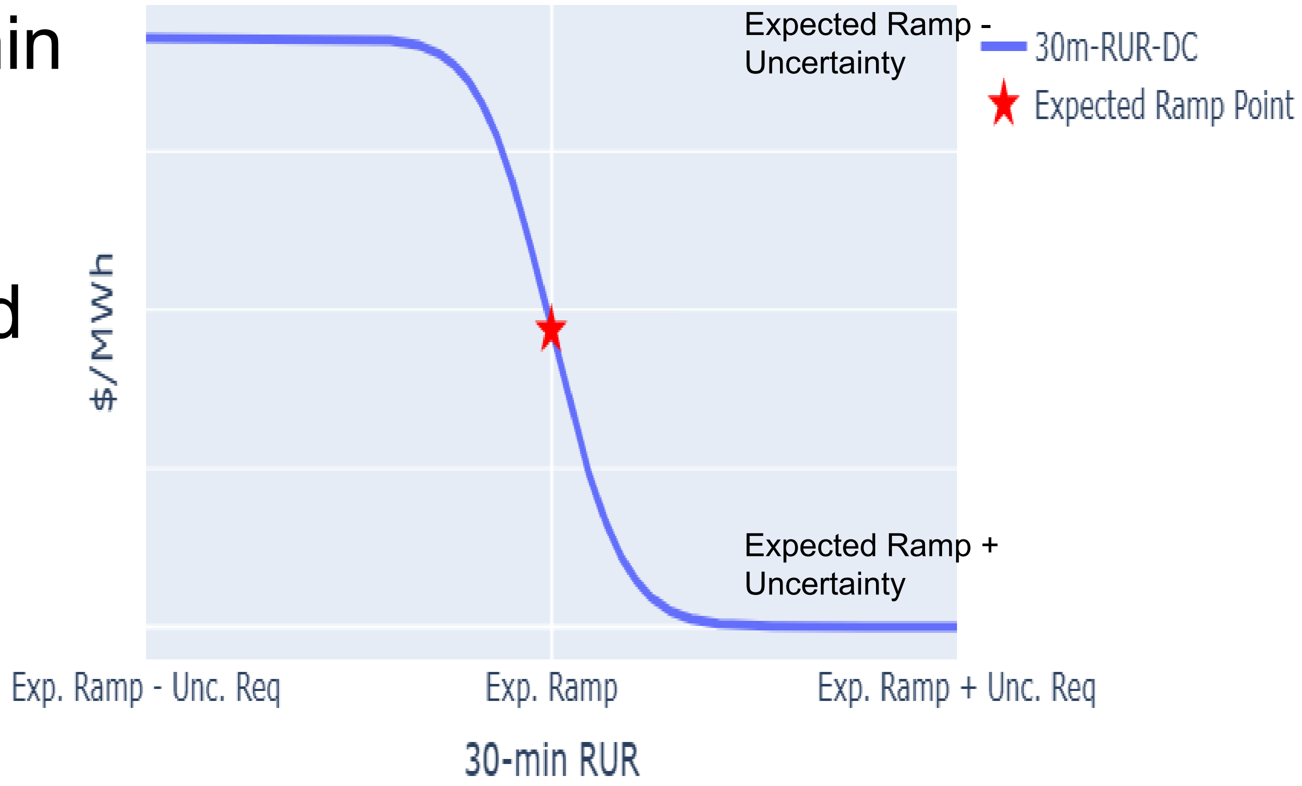
- From the previous example *(Slide 46)*
  - 10MIN RUR = Expected Ramp + Uncertainty = **1133MW**
  - *755 MW (expected ramp)+ 378 MW (uncertainty) = 1133 MW*



Defining the **shape of the curve**: Uncertainty analysis based on bi-directional uncertainty around 30-min expected net-load ramp

Defining the **x-axis**: this is expected ramp +/- uncertainty

Defining the **y-axis:** driven by the cost of commitments made to meet expected energy needs in future intervals



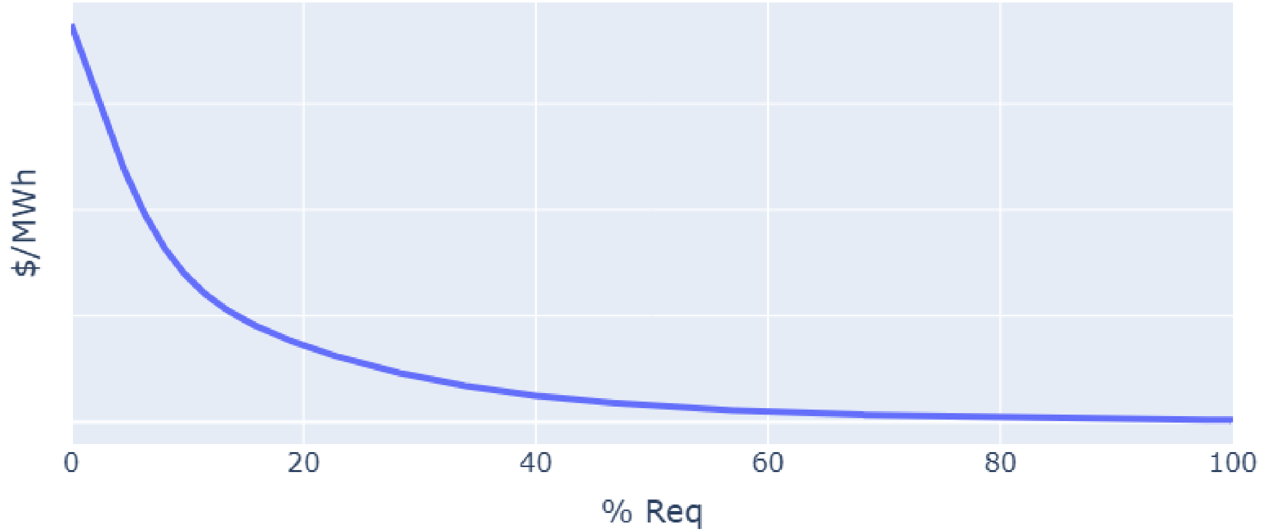
30 Minute Reserves ORDC

- Defining the **shape of the curve**: Uncertainty analysis based on generator outage reporting

- Defining the **x-axis**: MSSC

- Defining the **y-axis**: driven by the

cost of commitments, will be defined below the 30min RUR curve to reflect the willingness to pay



- Day Ahead Reserve ORDC
  - Defining the **shape of the curve**: Single step ORDC
  - Defining the **x-axis**: Additional reserves needed Day Ahead to address the day-ahead scheduling reserves
  - Defining the **y-axis**: informed by commitment costs

Issue

PJM's ORDCs for the current reserve products are based on an old market design and incomplete with the reserve price formation implementation. Further, new reserve products introduced need to properly reflect the marginal cost of serving load or align with the operational actions required to maintain reliability

Solution

Implement Updated Demand Curves to:

- Be consistent with operational needs and willingness to pay to mitigate reserve shortage and ultimately to avoid loss of load
- Ensure that all more-cost effective measures are exhausted before triggering shortage pricing or shedding firm load
- Appropriately value reserve services in the context of system conditions

Locational Definition

The Objective

- Reserves held should be deliverable to the system when needed to provide energy. We will need to balance operational effectiveness, efficient and fair pricing, and simplicity
- PJM is determining the needed locational definition for Day-Ahead reserves, 30-minute reserves and 10-minute reserves

- **Options:** Keep the subzone approach, Nodal reserves, Zonal reserves
- SR/PR is proposed to remain status-quo

Next Steps: PJM has been doing on-going analysis and plan to introduce our thoughts for discussion in Nov/Dec

Settlement & Cost allocation

Settlements

Reserve Assignments	Settlements
Day-Ahead Only Reserves	Day-Ahead Only Settlement
30 Minute Reserves	Day-Ahead & Balancing Settlements
10 Minute RU Reserves	Day-Ahead & Balancing Settlements
Primary Reserves	Day-Ahead & Balancing Settlements
Synchronized Reserves	Day-Ahead & Balancing Settlements

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PJM is currently proposing to keep cost allocation status quo

- *Simplified Status Quo:* PJM calculates each Market Participant's hourly Reserve Obligation Share based on their Load Ratio Share

Not proposing to change cost allocation to renewables or other resources causing uncertainty

- There are merits to this approach based on causation, but many complexities exist to implementation, including identifying resources to be allocated costs and potential performance incentives
- This still allows for the opportunity for charges to resources unable to follow dispatch and offset to load for reserve costs

Depending on locational definition decisions the allocation of the cost to load informed by network congestion will be further explored

Next Steps

- Stakeholder request: written feedback on issues PJM is addressing and solutions PJM is proposing
- PJM will update paper to include our proposal and associated technical details

Finalizing Design

- Locational Definition
- Offer Structure
- Cost Allocation/ Settlements
- Finalized ORDC proposal – penalty factors

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Appendix

October 2024
CAISO provided an overview of their Flexible Ramping and Imbalance Reserve products, including the uncertainty and variability drivers they face, implications for price formation and the move to locational procurement. (Presentation)
SPP provided an overview of their Operating Reserve products, including their Ramping Capability and Uncertainty Reserve products, and how they set their requirements. (Presentation)

November 2024

NYISO provided an overview of their Balancing Intermittency project, including how they are extending their existing 10- and 30-Minute reserve products to include their net-load forecast uncertainty. (Presentation)

ISO-NE provided an overview of their Day-Ahead Ancillary Services Initiative, including the development of a Day-Ahead Energy Imbalance Reserve product and how they will settle their day-ahead reserves as energy call-options. (Presentation)

MISO provided an overview of their recent Shortage Pricing efforts, including proposed changes to their Operating Reserve Demand Curve (ORDC) and Value of Lost Load (VOLL). (Presentation)

MISO also provided an overview of how they set their 30-minute reserve requirement to reflect their risk level and uncertainty to the RCSTF in February, 2024. (Presentation)

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