RCSTF Supporting Documentation

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Where to find the supporting documents

- PJM has posted several documents and data sets to support understanding of its RCSTF proposal
- These documents are posted on the RCSTF page on pjm.com alongside the Issue Charge and Problem Statement: https://www.pjm.com/committees-and-groups/task-forces/rcstf
- These documents will continue to be updated as needed

Reserve Certainty Senior Task Force

The Reserve Certainty Senior Task Force (RCSTF) will investigate enhancements to PJM's reserve markets. Immediate-term topics to be explored include the quantity of reserves procured, how reserves are deployed, event performance and penalty structure, and alignment of offer structure with fuel procurement practices. Additionally, the group will explore long-term system needs due to an evolving generation fleet, including reserve product participation requirements and incentives for resource flexibility. The RCSTF reports to the Markets and Reliability Committee (MRC).

View issues the RCSTF is currently tracking.

Chair/Facilitator: Lisa Morelli
Secretary: Amanda Egan

During the meeting, if you are experiencing issues with connectivity or teleconference, please contact Meeting Support. For registration issues, contact PJM.

Roster PDF | Updates

	Date
PJM's RCSTF Package and Rationale PDF	4.7.2026
PJM's RCSTF Proposal Summary PDF	4.7.2026
Incentive Compatibility via Interactions between Reserve and Energy Prices PDF	4.7.2026
Reserve Service Nesting, Unnesting and Price Formation PDF	4.7.2026
2025 Reserve Requirements XLS	4.7.2026
RCSTF Product Explainer PDF	4.7.2026
Supplement Product Nesting and Resource Level Constraints PDF	4.7.2026
Visualizations of 2025 RCSTF Reserve Requirements PDF	4.7.2026
Operation Uncertainty Quantification PDF	3.12.2026
Real-Time Net-Load Uncertainty Quantification PDF	3.12.2026
Supplement Locational Constraints for Reserve Services PDF	3.13.2026
Day-Ahead Uncertainty and Risk Framework WEB	10.29.2025
Issue Charge PDF	10.3.2023
Problem Statement PDF	9.25.2023

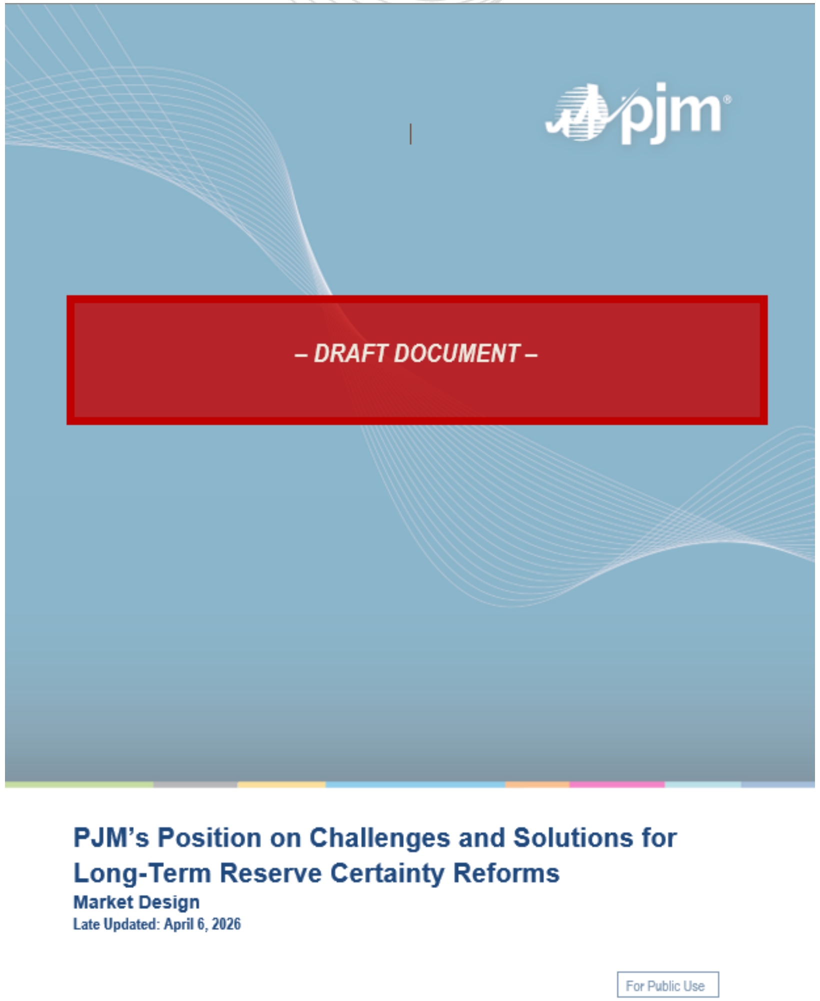
List of Supporting Documents

- PJM's RCSTF Package and Rationale *(previously "PJM Position on Long-Term RCSTF Scope")*
- Summary Presentation on PJM's RCSTF Proposal
- Operation Uncertainty Quantification
- Real-Time Net-Load Uncertainty Quantification
- Locational Constraints for Reserve Services - **UPDATED**
- Product Nesting and Resource-Level Constraints
- Reserve Service Explainer Table
- 2025 Day-Ahead and Real-Time Reserve Requirements
- Graphical Visualizations of the 2025 Requirement Values
- Reserve Service Nesting, Unnesting and Price Formation Examples
- Incentive Compatibility via Interactions between Reserve and Energy Prices

PJM's RCSTF Package and Rationale

A detailed explanation of the challenges PJM is attempting to address as well as a comprehensive description of PJM's package to address the long-term RCSTF scope.

Updated to reflect a simplification of the 30-Min Reserve congestion constraint to reduce from two to one constraints in the formulation. More details on this provided in the Locational Constraints for Reserve Services supplemental document.


– DRAFT DOCUMENT –

PJM's Position on Challenges and Solutions for Long-Term Reserve Certainty Reforms

Market Design

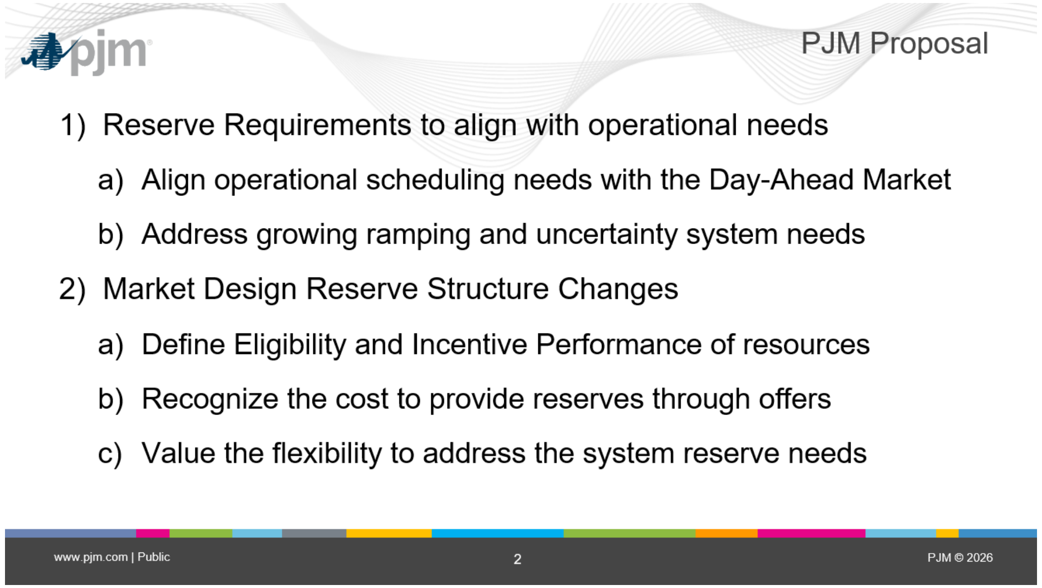
Late Updated: April 6, 2026

For Public Use

[Link to the document]

A slide deck summarizing PJM's proposal package.

Previously posted, no updates have been made.



Link to the document

Operation Uncertainty Quantification

A short (two-page) document explaining how uncertainty is quantified to inform PJM’s risk assessment and to inform the Day-Ahead Scheduling Reserve quantities.

Previously posted, no updates have been made.

[Link to the document]

Operation Uncertainty Quantification

Introduction

PJM system operation is facing increased uncertainty due to extreme weather events and higher renewable penetration. To ensure grid reliability, it is necessary to establish an uncertainty framework, which quantifies uncertainty for the next operating day, so that markets and operations can proactively factor the appropriate level of uncertainty and secure necessary reserves correspondingly, so that energy and reserve prices are consistent with system needs and conditions.

Uncertainty Components

Load and renewable (wind and solar) forecast accuracy, generation performance and interchange are the main uncertainty components that system operation faces when securing the appropriate level of reserves for the next operating day.

Reliability Assessment Commitment (RAC) runs daily between 14:30 and 15:30. 14:00 Day-ahead forecast is used in RAC run. Choosing 14:00 Day-ahead forecast aligns with the timing of the RAC run. The difference between 10:00 and 14:00 is covered by RAC. Using PJM RTO wind and solar power forecast gives better overall prediction compared to using wind and solar DA bid-in values. And generation tripping and de-rating that happen before 15:00 are accounted for by the RAC process. The following hourly uncertainty components were collected for the historical days since March 2018:

- Load Forecast Error (LFE)
  - LFE = Load Forecast – Actual Load
  - Load Forecast used is the 14:00 Day-ahead Load Forecast.
- Wind Power Forecast Error (WFE)
  - WFE = Wind Power Forecast – Actual Wind Power
  - Wind Power Forecast used is the 14:00 Day-ahead Wind Power Forecast.
- Solar Power Forecast Error (SFE)
  - SFE = Solar Power Forecast – Actual Solar Power
  - Solar Power Forecast used is the 14:00 Day-ahead Solar Power Forecast.
- Interchange Error (IE)
  - IE = DA Interchange – Actual Interchange
  - DA interchange is the 14:00 Day-ahead scheduled interchange.

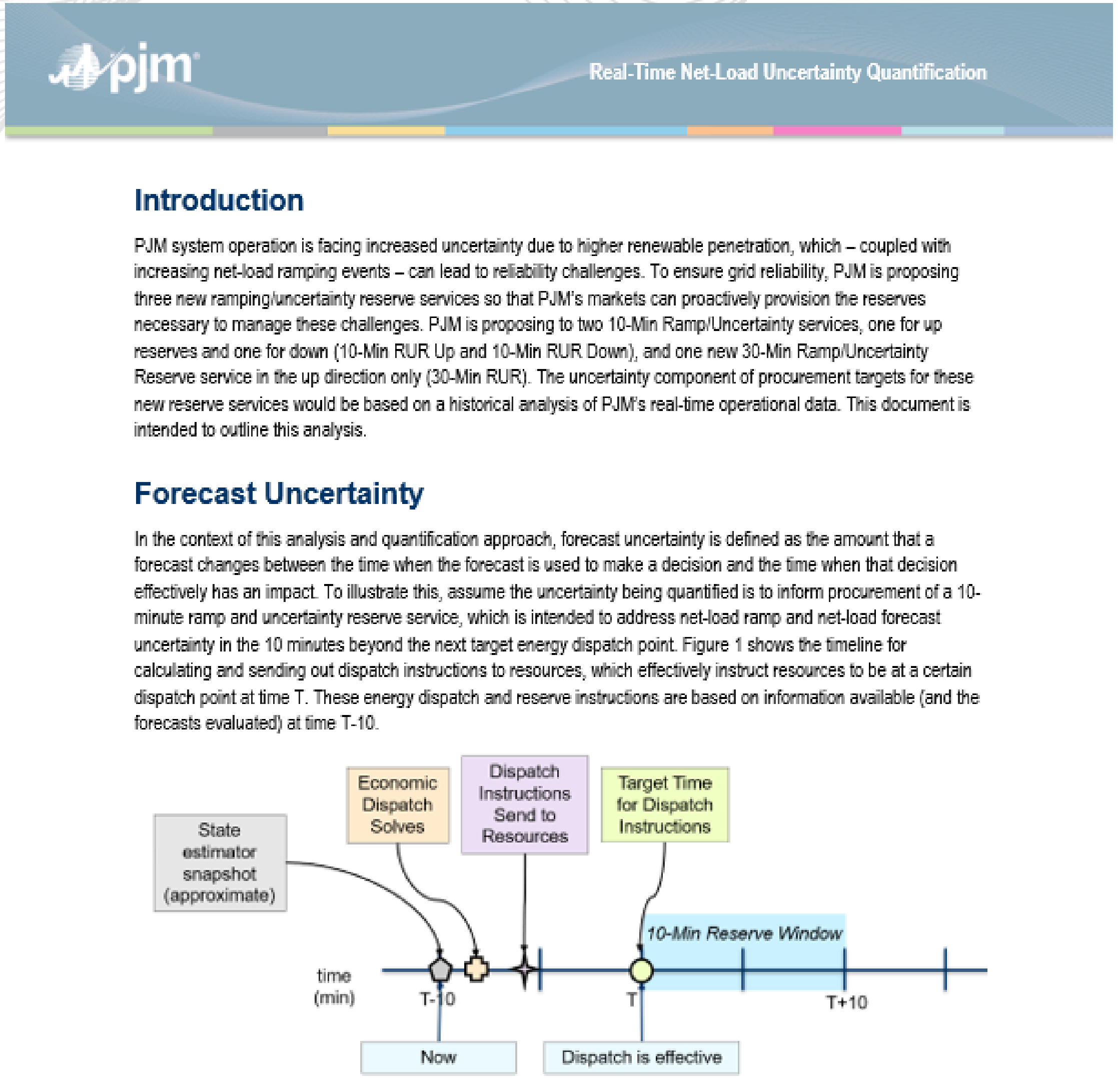
Real-Time Net-Load Uncertainty Quantification

A short (three-page) document explaining how real-time net-load uncertainty is quantified to inform PJM's proposed real-time reserve requirements, specifically:

- 10-Min RUR Up
- 10-Min RUR Down
- 30-Min RUR

Previously posted, no updates have been made.

[Link to the document]



pjm Real-Time Net-Load Uncertainty Quantification

Introduction

PJM system operation is facing increased uncertainty due to higher renewable penetration, which – coupled with increasing net-load ramping events – can lead to reliability challenges. To ensure grid reliability, PJM is proposing three new ramping/uncertainty reserve services so that PJM's markets can proactively provision the reserves necessary to manage these challenges. PJM is proposing to two 10-Min Ramp/Uncertainty services, one for up reserves and one for down (10-Min RUR Up and 10-Min RUR Down), and one new 30-Min Ramp/Uncertainty Reserve service in the up direction only (30-Min RUR). The uncertainty component of procurement targets for these new reserve services would be based on a historical analysis of PJM's real-time operational data. This document is intended to outline this analysis.

Forecast Uncertainty

In the context of this analysis and quantification approach, forecast uncertainty is defined as the amount that a forecast changes between the time when the forecast is used to make a decision and the time when that decision effectively has an impact. To illustrate this, assume the uncertainty being quantified is to inform procurement of a 10-minute ramp and uncertainty reserve service, which is intended to address net-load ramp and net-load forecast uncertainty in the 10 minutes beyond the next target energy dispatch point. Figure 1 shows the timeline for calculating and sending out dispatch instructions to resources, which effectively instruct resources to be at a certain dispatch point at time T. These energy dispatch and reserve instructions are based on information available (and the forecasts evaluated) at time T-10.

Locational Constraints for Reserve Services

A technical document detailing the locational procurement design for each reserve service, including the mathematical formulations for how these locational constraints would be modeled in the market clearing engines.

Updated to include the Transmission Constraint Penalty Factors for the nodal reserve congestion constraints and to reflect a simplification of the 30-Min Reserve congestion constraint to reduce from two to one constraints in the formulation.

RCSTF Supplement: Locational Constraints for Reserve Services

Contents

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1. Purpose

The goal of this document is to provide details of the locational constraints for the different reserve services that are part of the RCSTF proposal.

[Link to the document]

Product Nesting and Resource-Level Constraints

A technical document detailing the how the product nesting would work for each reserve service as well as how the resource-level constraints would be modeled in the market clearing engines.

Previously posted, no updates have been made.

[Link to the document]

RCSTF Supplement: Product Nesting and Resource-Level Constraints

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   5.2. Offline Reserve Constraints 6
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1. Purpose

The goals of this document are to provide details of the following:

- System-level constraints for the different reserve services
- The nesting of the different reserve products in the system-level constraints, and the implications to the system marginal prices of the reserve products
- The resource-level constraints for the different reserve products

Reserve Service Explainer Table

A table summarizing key aspects of each reserve service.

Previously posted, no updates have been made.

[Link to the document](#)

RCSTF Explainer: Reserve Products and Services

Service	Eligible Products	Market	Purpose	Response Time	Response Duration	Online Only?	Response Mechanism	Offers	Locational?	Max requirement	At other ISOs	ORDC Key characteristics
Synchronized Reserves	SR (online)	RTM + DAM	Post-contingency response to restore ACE levels	10-Minutes	30-Minutes	Synchronized, but need not be SCED dispatchable	All Call (automated response to spin event; not through RT-SCED)	Soft Cap of $10 + expected penalty rate	Yes	Most Severe Single Contingency (MSSC) with a potential performance adder	SR (NYISO/MISO/SPP/CAISO); ECRS (ERCOT); TMSR (ISO-NE)	A single step demand curve priced at $2,100/MWh till SR requirement, and $0 beyond it
10-Min Ramp/Uncertainty Reserves (RUR) Up	10-Min RUR (Up)	RTM + DAM	Address 10-Min forward net-load ramp up following energy dispatch along with associated uncertainty in the ramp up direction	10-Minutes	1-Hour	Yes + SCED dispatchable	Economically dispatched through RT-SCED at applicable time	$0 offer in RTM; Soft Cap of $10 in DAM	Yes	Max(10-Min expected netload up ramp (50/50 forecast) + 95-th percentile ramp uncertainty following SCED target, 0). In this case, a netload down ramp is considered negative	Ramp Capability (SPP/MISO); 5-Min Flexible Ramp Up Product (CAISO)	Downward sloping: priced at ~$1,900/MWh at expected ramp - 95th pecercentile uncertainty, $1,000/MWh at expected ramp, and ~$100/MWh at expected ramp + 95th percentile uncertainty
10-Min Ramp/Uncertainty Reserves (RUR) Down	10-Min RUR (Down)	RTM + DAM	Address 10-Min forward net-load ramp down following energy dispatch along with associated uncertainty in the ramp down direction	10-Minutes	1-Hour	Yes + SCED dispatchable	Economically dispatched through RT-SCED at applicable time	$0 offer	Yes	Max(10-Min expected netload down ramp (50/50 forecast) + 95-th percentile ramp uncertainty following SCED target, 0). In this case, a netload up ramp is considered negative	Ramp Capability (SPP); 5-Min Flexible Ramp Down Product (CAISO). MISO also has product defined, but does not currently clear it.	Downward sloping with the shape similar to the 10-Min RUR Up flipped along the X-axis at expected ramp, but priced at 10% of the 10-Min RUR Up curve
30-Min Ramp/Uncertainty Reserves (Up-only)	30-Min RUR	RTM + DAM	Address 30-Min forward net-load ramp following energy dispatch along with associated uncertainty, residual to 10-Min RUR	30-Minutes	4-Hour	Yes + SCED dispatchable	Economically dispatched through RT-SCED at applicable time	$0 offer in RTM; Soft Cap of $10 in DAM. If qualifying for both 10-Min and 30-Min Spin, the offer price has to be the same	Yes	30-Min expected netload ramp (50/50 forecast) less 10-Min expected ramp + 95-th percentile of ramp uncertainty between 10-Min and 30-Min following SCED target	No ISO in the US has an equivalent product/service	Downward sloping: priced at ~$1,900/MWh at expected ramp - 95th pecercentile uncertainty, $1,000/MWh at expected ramp, and ~$100/MWh at expected ramp + 95th percentile uncertainty, where expected ramp is between minutes 10 and 30 following SCED target
30-Min Reserves	30-Min RUR; 30-Min SecR (offline secondary reserves). Same RUR product can satisfy both 30-Min RUR and 30-Min Reserve requirement	RTM + DAM	Backfill to free up synchronized reserves following a spin event in addition to the 30-Min RUR reserves	30-Minutes	4-Hour	No	Non-Spin resources are called online by operator as needed; Economically dispatched through RT-SCED at applicable time	Soft Cap of $10 on 30-Min Non-Spin	Yes	MSSC + 30-Min expected netload ramp (50/50 forecast) less 10-Min expected ramp + 95-th percentile of ramp uncertainty between 10-Min and 30-Min following SCED target	30-Min Reserves (NYISO); TMOR (ISO-NE); STR (MISO); 60-Min Uncertainty Reserves (SPP); Non-Spinning Reserve Service (ERCOT)	The 30-Min Reserve curve is a version of the 30-Min RUR demand curve, right shifted by MSSC, and priced at 10% of the RUR curve
Energy Gap Reserves	10-Min RUR (Up); 30-Min RUR; 60-Min Spin. 10/30-Min RUR can satisfy this requirement in addition to the previous requirements	DAM only	Procure sufficient physical generation to meet DA load forecast on elevated risk cold-weather days	60-Minutes	4-Hour (potentially reduced to 1-Hour for 10-Min Spin)	Synchronized, but need not be SCED dispatchable	Economically dispatched as energy or RT reserves through RT-SCED at applicable time	60-Min Spin has same offer price as 30-Min Spin	No	90-th percentile of historical energy gap in winter. Applied only on elevated risk days in winter	Energy Imbalance Reserves (ISO-NE); however, no explicit online requirement	Downward sloping from $500/MWh till the 90th percentile of historical energy gap in winter, and priced at $0 beyond the requirement. The slope is based on distribution of energy gap in historical observations
Day-ahead scheduling reserves (DASR)	10-Min RUR (Up); 30-Min RUR; 30-Min SecR; 60-Min Spin; 60-Min Non-spin. 10/30-Min/60-Min Spin can satisfy this requirement in addition to the previous applicable requirements	DAM only	Address uncertainty (errors) in DA-forecasts for load and renewables as well as generator performance	60-Minutes	4-Hour (potentially reduced to 1-Hour for 10-Min Spin)	No	Non-Spin resources are called online by operator as needed; Economically dispatched as energy or RT reserves through RT-SCED at applicable time	60-Min Non-Spin has same offer price as 30-Min Non-Spin	No	Different percentiles of forecast errors (as percentages of load / renewable forecast) based on low/medium/high risk day + energy gap requirement if applicable	Imbalance Reserves (CAISO)	Single step priced at $50/MWh till DASR requirement and $0 beyond it.

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2025 Day-Ahead and Real-Time Reserve Requirements

An excel spreadsheet with interval day-ahead and real-time reserve quantities for 2025, assuming the proposed reserve reforms had been in place.

Previously posted, no updates have been made.

	A	B	C	D	E	F	G	H
1	Timestamp (UTC)	SR	10-min RUR Up	10-min RUR Down	30-min RUR	30-min Reserves	EG	DASR
2	1/1/2025 5:00	2324.4	414.33729	513.14629	585.50807	2373.50807	0	4111.949
3	1/1/2025 6:00	2324.4	123.632403	800.671403	4.919599	1792.919599	0	4096.997
4	1/1/2025 7:00	2324.4	267.5887927	643.3234593	296.0870913	2084.087091	0	4019.918
5	1/1/2025 8:00	2324.4	345.734502	559.803502	453.603266	2241.603266	0	3983.359
6	1/1/2025 9:00	2324.4	533.7956017	376.5042683	828.2121883	2616.212188	0	3986.172
7	1/1/2025 10:00	2324.4	732.317329	189.169329	1222.217257	3010.217257	0	4028.482
8	1/1/2025 11:00	2324.4	938.7107263	0	1632.881936	3420.881936	0	4085.09
9	1/1/2025 12:00	2324.4	960.0676913	0	1671.406281	3459.406281	0	4189.017
10	1/1/2025 13:00	2324.4	642.3183107	334.1919773	1028.133	2816.133	0	4321.698
11	1/1/2025 14:00	2324.4	369.3784217	719.7310883	445.0999803	2233.09998	0	4603.918
12	1/1/2025 15:00	2324.4	439.455165	809.315165	531.16313	2319.16313	0	4833.988
13	1/1/2025 16:00	2324.4	555.3081623	789.0864957	730.4776127	2518.477613	0	4833.988
14	1/1/2025 17:00	2324.4	657.2692247	735.8378913	918.0850103	2706.08501	0	4833.988
15	1/1/2025 18:00	2324.4	742.603132	664.849132	1084.118829	2872.118829	0	4833.988
16	1/1/2025 19:00	2324.4	922.4594687	468.8051353	1449.519665	3237.519665	0	4833.988
17	1/1/2025 20:00	2324.4	1301.681165	31.414165	2228.550546	4016.550546	0	4833.988
18	1/1/2025 21:00	2324.4	1587.537734	0	2844.282231	4632.282231	0	4833.988
19	1/1/2025 22:00	2324.4	1593.772949	0	2898.850997	4686.850997	0	4833.988
20	1/1/2025 23:00	2324.4	766.1657347	328.1444013	1247.016145	3035.016145	0	4956.59
21	1/2/2025 0:00	2324.4	460.3490493	624.4993827	638.4008117	2426.400812	0	4956.59
22	1/2/2025 1:00	2324.4	421.2219397	644.8036063	565.3376423	2353.337642	0	4890.835
23	1/2/2025 2:00	2324.4	279.5632613	765.9965947	287.6290907	2075.629091	0	4816.902

Information | Day-Ahead Requirements | Real-Time Requirements

[Link to the document]

Graphical Visualizations of the 2025 Requirement Values

Graphical visualizations of the 2025 raw requirement values (posted separately). These visualizations are intended to illustrate averages and trends based on season, time of day, risk level, etc.

Previously posted, no updates have been made.

[Link to the document]

Reserve Service Nesting, Unnesting and Price Formation Examples

Simple numerical examples that illustrate how the nested and unnested reserve designs impact market clearing outcomes and price formation.

Previously posted, no updates have been made.

Introduction

This document is intended to provide education on the price formation implications of the nesting or unnesting of PJM's reserve services by walking through a few simple numerical examples. PJM is providing this document to be responsive to stakeholder questions about the implications of reserve nesting/unnesting on energy price formation as well as to illustrate the incentive compatibility between energy and reserve prices that result from the co-optimization. These examples are not intended to be indicative of actual market clearing outcomes but simply to build a fundamental understanding of outcomes of the co-optimization. This document is also not intended to provide a comprehensive overview of how the optimization would be structured or to provide a detailed explanation of the unnested design. An in-depth description of the product nesting proposed in PJM's package is provided in *RCSTF Supplement: Product Nesting and Resource Level Constraints* and a detailed mathematical description of the optimization and incentive compatibility has been provided in *RCSTF Supplement: Incentive Compatibility via Interactions between Reserve and Energy Prices*. These two documents are intended to provide more rigorous technical detail and to be complementary with this set of illustrative examples.

The numerical examples provided in this document use only two generators for simplicity. The implied system is lossless and has no congestion, and so there is a single system marginal energy price. In each of the numerical examples, the generator offers and parameters are held constant, and the reserve requirements are fixed. The only difference in each scenario is an increase in load, which results in a tightening of reserve margins, ending with shortage across all reserve services. For simplicity and to better illustrate the implications of the reserve and energy co-optimization, these examples assume that the two generators do not submit reserve offers, and reserve prices are driven only by lost opportunity cost and the reserve penalty factors. Total reserve quantities and the reserve penalty factors are the same between the nested and unnested cases.

Numerical Examples

Example Set Up

Assume there are two generators on a system serving demand. Both are online and capable of providing reserves. There is no congestion on the system and no losses, and therefore there is a single system marginal energy price. There are three reserve services that are cleared, all of them only in the up direction:

- Synchronized Reserves (SR)
- 10-Min Ramp/Uncertainty Reserves (10-Min RUR)
- 30-Min Ramp/Uncertainty Reserves (30-Min RUR)

In the case where the reserve services are nested, SR can meet the SR Requirement, the 10-Min RUR Requirement and the 30-Min RUR Requirement; 10-Min RUR can meet the 10-Min RUR Requirement and the 30-Min RUR requirement; and 30-Min RUR can only meet the 30-Min RUR Requirement. In the case where the reserve services are unnested, SR can only meet the SR Requirement, 10-Min RUR can only meet the 10-Min RUR Requirement and 30-Min RUR can only meet the 30-Min RUR Requirement. The equations for how each reserve service requirement would be met in both the nested and unnested designs are given below.

Nested Reserve Constraints

[Link to the document]

Incentive Compatibility via Interactions between Reserve and Energy Prices

A detailed mathematical explanation of the how the co-optimization of energy and reserves endogenously reflects opportunity costs in market clearing prices to ensure incentive compatibility.

Previously posted, no updates have been made.

Incentive Compatibility

RCSTF Supplement: Incentive Compatibility via Interactions between Reserve and Energy Prices

Key Takeaways:

- When the same resource clears both SR and 10-Min RUR (Up) products, then the clearing price of SR is equal to the sum of the clearing price of 10-Min RUR (Up) product and the incremental SR offer of the resource
- When the same resource clears both 10-Min RUR (Up) and 30-Min RUR products:
  - The 10-Min RUR (Up) clearing price may be greater than the 30-Min RUR clearing price if the 10-Min ramp rate constraint is binding for the resource
  - The 10-Min RUR clearing price is equal to the 30-Min RUR clearing price if the 10-Min ramp rate constraint is not binding
- If a resource is infra-marginal for energy and clears 10-Min RUR (Up) and 30-Min RUR products without binding on the 10-Min or 30-Min ramp rate constraints, then the clearing price of the 10-Min RUR and 30-Min RUR products equal the infra-marginal energy rent of the resource (the difference between the clearing price of energy and the incremental energy offer of the resource)
- If a resource is marginal for energy, but binding on the 10-Min or 30-Min ramp rate constraints and there is a systemwide reserve shortage, indicating that the system is more constrained on flexibility than on capacity, then the clearing price of energy can potentially be lower than the clearing price of the reserve products
- If a resource is dispatched above its ECOMIN to provide 10-Min RUR Down reserves, then the energy price can potentially be lower than the incremental energy offer of the resource at its dispatch point, but this difference is "made whole" through the clearing price of the 10-Min RUR Down product.

Link to the document

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