PJM's Preliminary Solution Options for the RCSTF Long-Term Scope

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System Operating Reserve Needs

Reforms needed to capture operational need.

Day-Ahead Reserves

Addresses uncertainty day ahead; these reserves do not need to be maintained in real time but available to the system, if needed. These reserves are needed to ensure a reliable operating plan to meet the next-day demand.

These reserves are generally longer lead resources (10–60 minutes).

30-min Operating Reserves

Replacement reserves for contingency events and capturing uncertainty needs in day ahead and real time. *Secondary/30-minute Reserves*

Ramping Reserves

Addresses net load ramping needs and allows PJM to meet interval by interval energy and reserve needs

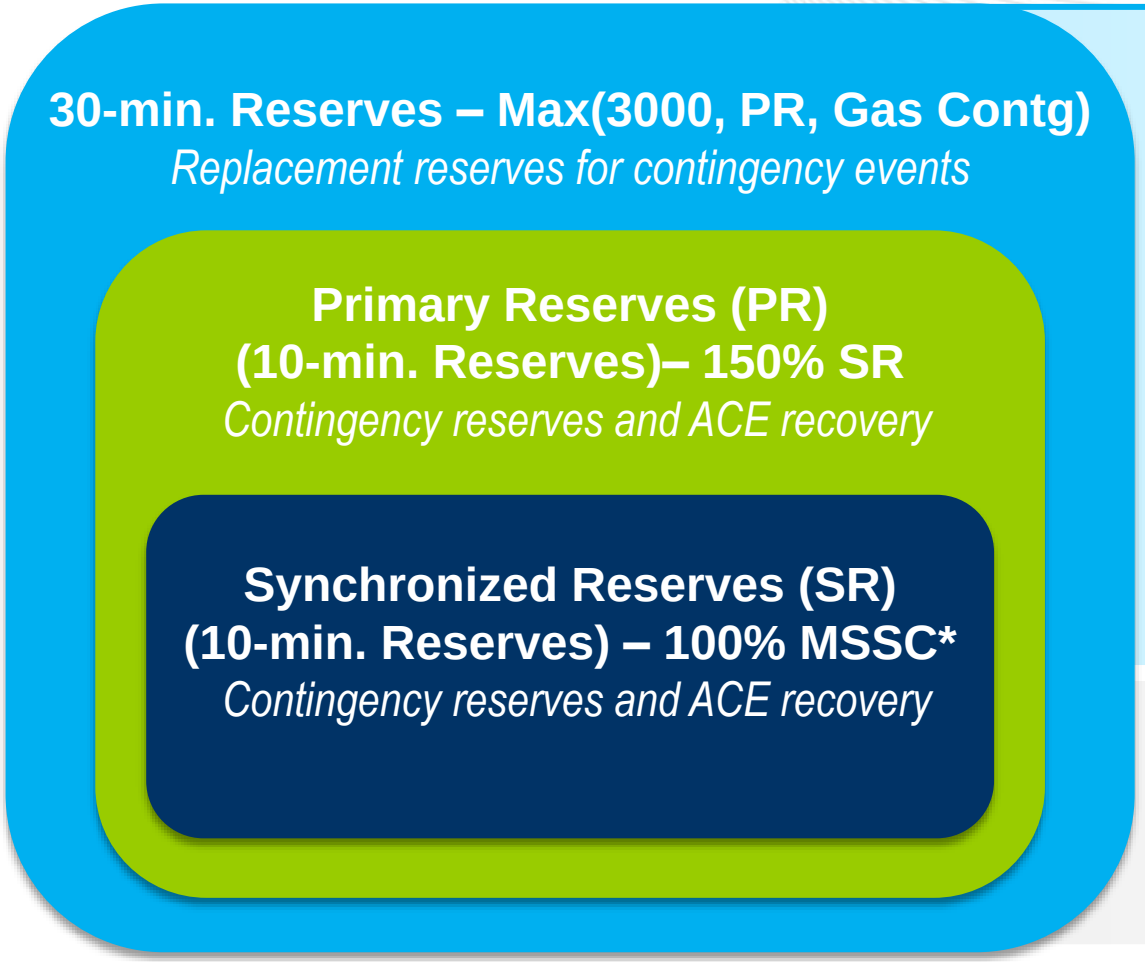
These reserves would be defined in both the up and down direction to address increased renewable variability.

Contingency Reserves

Used for ACE and frequency recovery after contingency event

Includes online spinning reserves or offline fast start (<10 min.) reserves

DA & RT – Status Quo



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.

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

DA – RCSTF

Day-Ahead Reserves
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
Replacement reserves for contingency events and capturing uncertainty

10-min. Reserves – Ramp/Uncertainty Up and Down Reserves
Addresses net load ramping needs and allows PJM to meet interval by interval energy and reserve needs

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

Reserve products would not be nested; SR/PR would remain nested.

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

RT – RCSTF

30-min. Reserves – Updated
Replacement reserves for contingency events and capturing uncertainty

10-min. Reserves – Ramp/Uncertainty Up and Down Reserves
Addresses net load ramping needs and allows PJM to meet interval by interval energy and reserve needs

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

Reserve products would not be nested; SR/PR would remain nested

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

Day-Ahead-Only Reserves

Day-Ahead-Only Reserves: Challenges Addressed

In PJM's existing market constructs, the Day-Ahead Energy Market does not procure sufficient reserves to manage operational risk.

- Every day, PJM uses its Reliability Assessment Commitment tool (RAC) to ensure that sufficient physical supply is available for the next operating day to meet the load forecast and to provide sufficient operating reserves for reliability.
- These reliability needs are not reflected in the Day-Ahead Market, meaning that resources may not get an assignment day-ahead and may not know they are being relied upon for reliability.

Managing these reliability needs through RAC is no longer sufficient for reliability given the increased dependence on resources to make fuel arrangements day-ahead and to manage growing uncertainty.

Day-Ahead Reserves: Alignment with Operational Reliability Needs

- Today, PJM runs the Reliability Assessment Commitment (RAC) tool every day after the Day-Ahead Market runs.
- PJM has provided education on how the RAC is used to:
  a) evaluate whether the Day-Ahead Market has cleared sufficient physical supply to meet the PJM load forecast and day-ahead scheduling needs, and
  b) when necessary, recommend additional resource commitments.
- A day-ahead-only reserves product would provide a mechanism – in conjunction with complementary reforms to PJM's existing 30-Minute Reserve product definition – to reflect these reserve needs in PJM's Day-Ahead Market.

Why Consider a Day-Ahead-Only Product?

- PJM must clear more reserves day-ahead to schedule the system for reliability than need to be maintained in real-time.
- Forecast and weather uncertainty and generator performance risk are higher day-ahead than in real-time.
- The gap between physical supply cleared and the load forecast is a day-ahead scheduling concern, mainly on high-risk days.
- These reserves are needed to schedule the system day-ahead for reliability, and to ensure that resources providing these services have sufficient advanced notice, a mechanism for cost recovery, and a binding commitment.

Day-Ahead-Only Reserves: Core Design Concepts

- A day-ahead-only reserve product would provide a procurement mechanism for reserves that are needed day-ahead to schedule the system for reliability but that do not need to be procured every 5 minutes throughout the operating day.
- These reserves would be incremental to PJM's 30-Minute Reserves.
- Day-ahead-only reserves would provide a mechanism for resources to reflect and recover their costs for actions taken day-ahead to be available to provide energy in real-time, if needed (e.g., fuel arrangements).
- The performance obligation, evaluation and consequences for non-performance for day-ahead-only reserves would be different than for PJM's other reserve services in part because there would be no settlement of the day-ahead reserve assignment against a real-time reserve product.

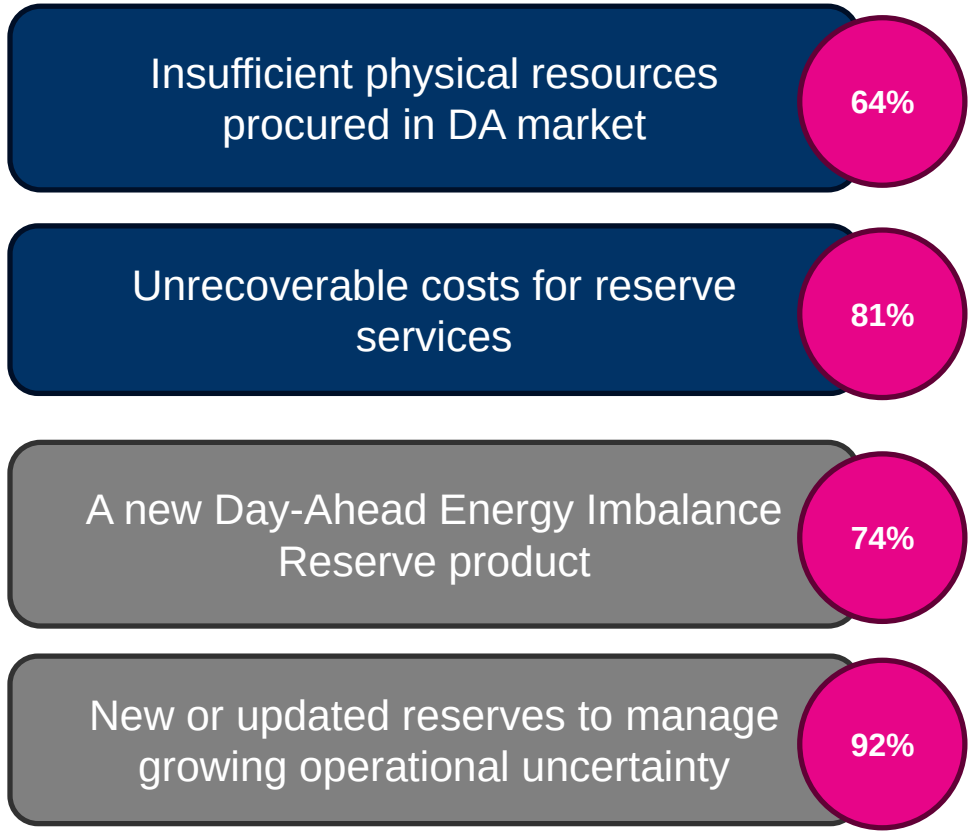
Day-Ahead-Only Reserves: Alternatives Considered

Instead, we could have a single product (such as our existing 30-Minute Reserves) but with a larger requirement in day-ahead than in real-time, which would eliminate the need to create a new and separate product.

- ☑ This approach could result in the clearing of significantly more reserves day-ahead than in real-time, causing many resources to buy out of the day-ahead reserve assignment at the real-time reserve clearing price and then having no reserve obligation in real-time.
- ☑ PJM has concerns about whether this structure would have the appropriate performance incentives and believes that a day-ahead product with a separate set of performance obligations and expectations may be a cleaner market design.
- ☑ Defining two separate products would also allow for different cost allocation methodologies for each product. Today, the costs for PJM's existing 30-Minute Reserves are allocated to real-time load plus exports.
- ☑ Note that this approach could still be proposed/explored in the CBIR matrix by simply specifying "status quo" for the day-ahead-only product and designing the 30-Minute product accordingly.

Preliminary Stakeholder Feedback and Polling

- Most poll respondents supported pursuing solutions related to aligning PJM's Day-Ahead Market with PJM's operational reserve needs.
- The challenge *"The Day-Ahead market does not consistently procure sufficient physical generation (energy and reserve commitments) to meet day-ahead forecasted load and reserve needs, which leads to out-of-market commitments,"* received 64% agreement.
- We heard concerns in stakeholder discussions as well as from the IMM about designing a product that would allow additional physical supply to be cleared for energy to meet a day-ahead energy imbalance need.
- In the written poll responses, many stakeholders asked whether the "energy gap," or the difference between physical supply cleared and the load forecast, is a challenge that needs to be addressed every day or primarily during higher risk operating days.



Incorporation of Preliminary Stakeholder Feedback: Reserves vs. a Trade-off with Committed Energy

- In the January presentation and issue paper, PJM presented multiple options on how to structure a day-ahead reserve product to manage the energy gap, including purely as a reserve service or as a trade-off with additional energy commitments, which might be more like an energy option product.
- Based on feedback and discussion, PJM is evaluating ways to clear day-ahead reserves to manage any shortfall in physical supply to meet the forecast as a reserve product rather than allowing the trade-off between reserve procurement and additional *energy* assignments.
- This would simplify clearing, eliminate some of the settlement concerns around deliverability of the service, and mitigate some stakeholder concerns about the financial nature of the Day-Ahead Energy Market.
- This reserve construct would then be flexible enough to address any day-ahead reserve needs that don’t carry into real-time (such as day-ahead uncertainty) in a day-ahead only reserve product.
- PJM recognizes that any solutions to address the gap between physical supply and the forecast need to incent market participation that supports both reliability and market efficiency. PJM is still exploring different market design options for how these reserves could be cleared.

Incorporation of Preliminary Stakeholder Feedback: Addressing the Energy Gap as Mitigation on Higher Risk Days

- In written comments, several stakeholders expressed an interest in understanding whether the gap between physical supply committed day-ahead and the PJM load forecast is a problem every day or whether this is something that primarily needs to be addressed on higher risk days.
- PJM's position is that reserve needs are a function of operational risk and that reserves markets should reflect the level of operational risk on a day-to-day basis, and that these reserve needs become a more significant reliability issue during high-risk days.
- At a minimum, PJM is open to evaluating market solutions that would allow reserves to be cleared to manage the gap between physical supply cleared and the forecast only on higher risk days to see whether that meets the reliability needs.
- Day-ahead-only reserves would still be procured on lower risk days, but the requirement would be set based on day-ahead uncertainty and other day-ahead reserve needs and not include the gap between physical supply and the load forecast.

Day-Ahead-Only Reserves: Factors that Dictate Procured Quantities

1. Day-ahead uncertainty, including wind, solar, and load forecast error, generator performance risk, and interchange and weather-related uncertainty.

2. The gap between the physical supply cleared in the market for energy and the PJM load forecast as needed to manage operational risk.

3. During times of elevated risk, a constraint would also be introduced to ensure that an adequate level of day-ahead-only reserves be held on online dispatchable resources.

Day-Ahead-Only Reserves Initial Solution Options: Product Definition and Resource Eligibility

	Design Component	Initial Solution Option(s)
Product Definition	**Time to respond:** How quickly do the reserves need to be fully convertible into energy?	60 minutes
Product Definition	**Duration requirement:** How long do resources need to be able to sustain response once deployed?	4 hours to meet the daily reliability need
Resource Eligibility	**Resource types:** What resource types are eligible?	Like PJM's existing reserve products, wind, solar and nuclear resources would be ineligible except by exception.
Resource Eligibility	**Offline resources:** What offline resources are eligible?	Offline resources with a time to start of less than or equal to 30 minutes would be eligible.

Day-Ahead-Only Reserves Initial Solution Options: Performance Evaluation

Design Component	Initial Solution Option(s)
Performance evaluation: How would PJM evaluate whether resources had met their reserve performance obligation?	**Online resources** would be evaluated for following PJM dispatch in the same way that they are for energy. **Offline resources** would be evaluated based on whether they reach EcoMin within the required time to start after they are called online for energy. Additionally, **all resources** would be evaluated on whether their bid-in parameters reflect that they are available to provide assigned reserves in real-time.

Day-Ahead-Only Reserves Initial Solution Options: Consequences for Non-Performance

Design Component	Initial Solution Option(s)
Consequences for not being *available* to provide energy to meet reserve assignments	If a resource is unavailable to provide energy in real-time at a level commensurate with its day-ahead reserve assignment it would have to pay back its day-ahead reserve revenue times some multiplier for that shortfall in availability.
Consequences for non-performance when assigned reserves are converted into energy	If a resource is called for energy during a period in which it held a day-ahead reserve assignment and fails to perform (e.g., does not reach EcoMin within the defined time to start) that resource must pay back its day-ahead reserve revenue times some multiplier that would be greater than the multiplier above.

30-Minute Reserves

30-Minute Reserves: Alignment with Operational Needs

Today, PJM's 30-Minute Reserve Requirement is the greater of our Primary Reserve Requirement, our largest active gas contingency, or 3,000 MW. This requirement definition does not align with the Operating Reserve needs of the system to maintain reliability.

- The 30-Minute Reserves carried throughout the operating day should provide sufficient replacement megawatts to backfill our Primary Reserves should they be deployed for a contingency.

- Additionally, PJM's real-time 30-Minute Reserve needs should be sufficient to manage any real-time uncertainty, driven by wind, solar and load forecast error, to maintain reliably operations, which may extend beyond the requirement to carry replacement reserves.

Why redesign our existing 30-Minute Reserve product?

- PJM's current 30-Minute Reserve Requirement does not align with operational needs. Moving forward, our 30-Minute Reserve Requirement should be based on data-driven uncertainty and risk analysis.
- The nesting of PJM's existing reserve products, and the product substitution it enables, implicitly means that the duration (or sustainability) requirement for our 30-Minute Reserve product is the same as for our Synchronized and Primary Reserve products (i.e., 30 minutes). This is problematic when 30-Minute Operating Reserves are intended to be used for longer-term reliability needs.
- The current nesting approach could result in clearing mostly 10-minute reserves that have a minimum duration of 30 minutes, which does not address the minimum duration required for operating risk.

30-Minute Reserves: Core Design Concepts

- PJM must maintain a minimum level of 30-Minute Reserves for reliability throughout the operating day.
- Unlike the previously discussed day-ahead-only reserves, these reserves are cleared in every interval in real-time to ensure that sufficient 30-Minute Reserves remain available.
- These reserves are procured both day-ahead and in real-time. This provides notice and a binding commitment day-ahead to allow resources to take any necessary actions (and reflect/recover any costs for these actions) to make themselves available for the next day.
- Resources with a day-ahead 30-Minute Reserve assignment that don’t clear in real-time must buy out of that day-ahead assignment at the real-time market clearing price.

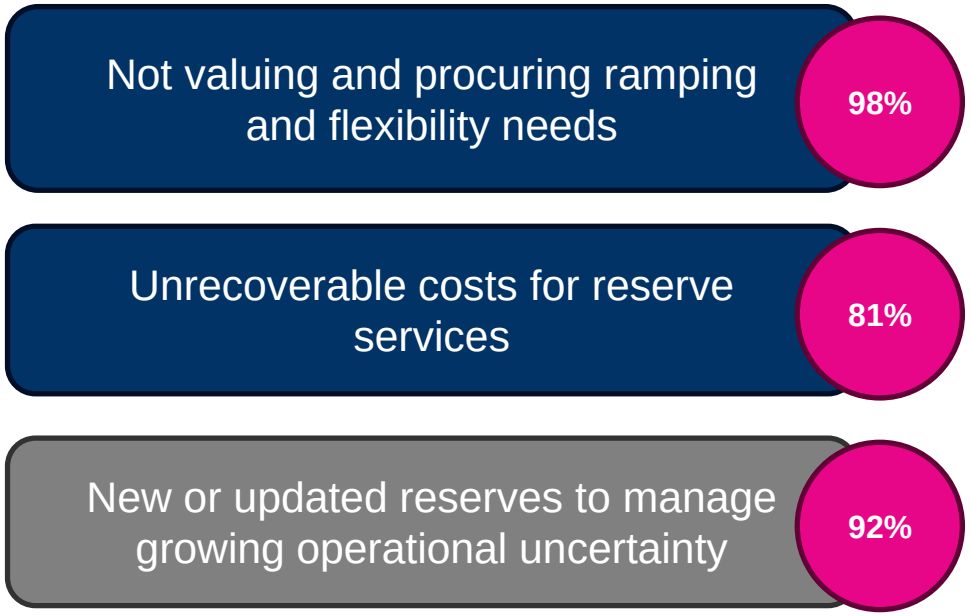
Preliminary Stakeholder Feedback and Polling

- Poll responses showed strong support for pursuing solutions related to new or updated reserve products to manage forecast uncertainty and to procure flexibility needs to manage operational risk.

- Poll respondents overwhelming agreed (98%) with the statement *"PJM's markets do not value and procure ramping and flexibility needs to manage forecast uncertainty (i.e., load, wind, solar, interchange and forced outage rates)."*

- There was also strong agreement (81%) with the statement *"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."*

- 92% of poll respondents support developing *"new or updated reserve products to manage growing operational uncertainty, including a clear and documented process for how uncertainty and other factors driving the reserve requirements are quantified."*



30-Minute Reserves: Factors that Dictate Procured Quantities

1. The largest contingency to ensure sufficient replacement energy is available following unit loss.

2. Real-time uncertainty, including wind, solar, and load forecast error, and generator performance risk.

30-Minute Reserves Initial Solution Options: Performance Evaluation

Design Component	Initial Solution Option(s)
Performance evaluation: How would PJM evaluate whether resources had met their reserve performance obligation?	**Online resources** would be evaluated for following PJM dispatch in the same way that they are for energy. **Offline resources** would be evaluated based on whether they reach EcoMin within the required time to start after they are called online for energy. Additionally, **all resources** would be evaluated on whether they maintain availability to provide assigned reserves as instructed by PJM.

30-Minute Reserves Initial Solution Options: Consequences for Non-Performance

Design Component	Initial Solution Option(s)
Consequences for not being *available* to provide energy to meet reserve assignments	Resources with a day-ahead 30-Minute Reserve assignment are subject to the buyback if they become unavailable to provide reserves in real-time. Additionally, if a resource does not follow PJM instructions and is therefore unable to provide reserves (e.g., does not follow dispatch and therefore does not maintain sufficient headroom to provide reserves) it must pay back its reserve revenue times some multiplier for that shortfall in availability.
Consequences for non-performance when assigned reserves are converted into energy	If a resource is called for energy during a period in which it has a 30-Minute reserve assignment and fails to perform (e.g., does not reach EcoMin within 30 minutes) and/or fails to follow PJM's dispatch instructions for a certain number of intervals within an hour that is has a reserve assignment that resource must pay back its reserve revenue for that shortfall times some multiplier.

10-Minute Ramping and Uncertainty Reserves

10-Minute Ramping and Uncertainty Reserves: Alignment with Operational Needs

A 10-Minute Ramping and Uncertainty Reserve product would be used to manage short-term uncertainty and ramping needs, such as renewable intermittency and to meet forecasted net-load ramps.

10-Minute products for meeting these flexibility needs have been adopted widely across the country to support reliability given the changing resource fleet.

- CAISO, MISO and SPP all have separate 10-minute ramping or uncertainty products.
- NYISO plans to extend its existing 10-minute Synchronized Reserve requirement to also manage forecast uncertainty.

10-Minute Ramping and Uncertainty Reserves: Core Design Concepts

- During times of high levels of renewable intermittency or periods of significant net-load ramp, slower moving resources that can meet longer reserve requirements (e.g., 30-Minutes) may not be fast enough to meet short-term balancing needs. CAISO has observed this given high-levels of solar.
- Because there will be different duration requirements, ramping and uncertainty reserves would not nest/cascade. However, the requirements should be set to ensure that the sum of all reserves procured meet the reliability needs without over-procuring reserve services.
- These reserves would be procured both day-ahead and in real-time. This allows resources to take any necessary actions to make themselves available for the next day and ensures that adequate reserve levels are maintained throughout the day.
- Resources with a day-ahead 10-Minute Reserve assignment that don't clear in real-time would need to buy out of that day-ahead assignment at the real-time market clearing price.
- 10-Minute Ramping and Uncertainty Reserves would have both an up and a down product requirement and definition.

10-Minute Ramping and Uncertainty Reserves: Alternatives Considered

Instead of introducing a new 10-minute ramping and uncertainty reserve product, we could extend our existing Synchronized Reserve requirement to also procure sufficient reserves to meet our additional ramping and uncertainty needs.

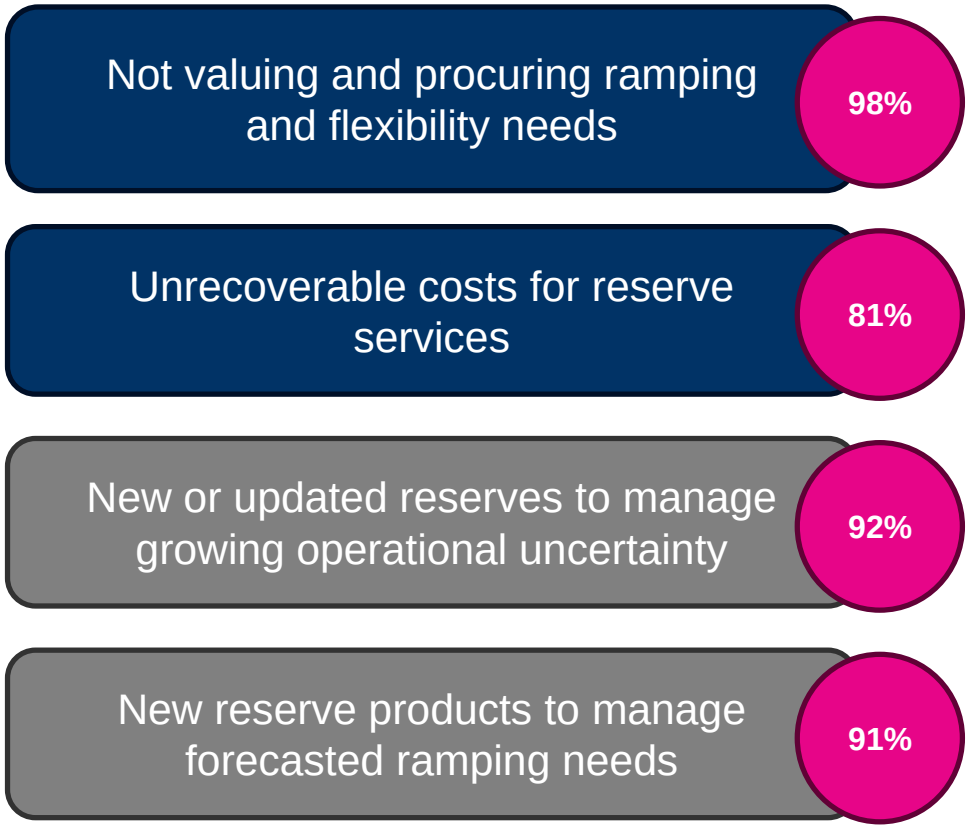
- PJM believes that developing a new product may be more appropriate given that 10-minute uncertainty reserves would be deployed by PJM's economic dispatch engine through normal dispatch whereas Synchronized Reserves are deployed during an event.

- The locational procurement driven by deliverability needs for 10-minute ramping and uncertainty reserves may be different than for Synchronized Reserves given the different deployment paradigm.

- Also, Synchronized Reserves are only an "up" reserve service, and to the extent that we will need up and down 10-Minute Ramping and Uncertainty Reserves, a new product definition is needed.

Preliminary Stakeholder Feedback and Polling

- Poll responses showed strong support for pursuing solutions related to new or updated reserve products to manage forecast uncertainty and to procure flexibility needs to manage operational risk.
- Poll respondents overwhelming agreed (98%) with the statement *"PJM's markets do not value and procure ramping and flexibility needs to manage forecast uncertainty (i.e., load, wind, solar, interchange and forced outage rates)."*
- 92% of poll respondents support developing *"new or updated reserve products to manage growing operational uncertainty, including a clear and documented process for how uncertainty and other factors driving the reserve requirements are quantified."*
- 91% of poll respondents support developing *"new reserve products to manage forecasted ramping needs."*



30-Minute Reserves: Factors that Dictate Procured Quantities

1. Real-time uncertainty, including wind, solar, and load forecast error.

2. Forecasted net-load ramp.

10-Minute Ramping and Uncertainty Reserves
Initial Solution Options: Definition and Resource Eligibility

	Design Component	Solution Option(s)
Product Definition	**Time to respond:** How quickly do the reserves need to be fully convertible into energy?	10 minutes
Product Definition	**Duration requirement:** How long do resources need to be able to sustain response once deployed?	60 minutes
Resource Eligibility	**Resource types:** What resource types are eligible?	Like PJM's existing reserve products, wind, solar and nuclear resources would be ineligible except by exception. All other online resources would be eligible.
Resource Eligibility	**Offline resources:** What offline resources are eligible?	Offline resources would not be eligible to provide this service.

10-Minute Ramping and Uncertainty Reserves Initial Solution Options: Performance Evaluation

Design Component	Solution Option(s)
Performance evaluation: How would PJM evaluate whether resources had met their reserve performance obligation?	Resources would be evaluated for following PJM dispatch in the same way that they are for energy. Additionally, resources would be evaluated on whether they maintain availability to provide assigned reserves as instructed by PJM.

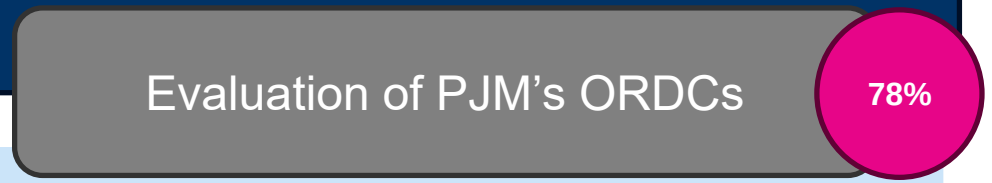
10-Minute Ramping and Uncertainty Reserves
Initial Solution Options: Consequences for Non-Performance

Design Component	Solution Option(s)
Consequences for not being *available* to provide energy to meet reserve assignments	Resources with a day-ahead 10-Minute Ramping and Uncertainty Reserve assignment would be subject to the buyback if they become unavailable to provide reserves in real-time. Additionally, if a resource does not follow PJM instructions and therefore is unable to provide reserves (e.g., does not follow dispatch and therefore does not maintain sufficient headroom to provide reserves) it would need to pay back its reserve revenue times some multiplier for that shortfall in availability.
Consequences for non-performance when assigned reserves are converted into energy	If a resource fails to follow PJM's dispatch instructions for a certain number of intervals within an hour in which it has a reserve assignment that resource must pay back its reserve revenue times some multiplier.

SR and PR Enhancements

Evaluation of PJM's Operating Reserve Demand Curves (ORDCs)

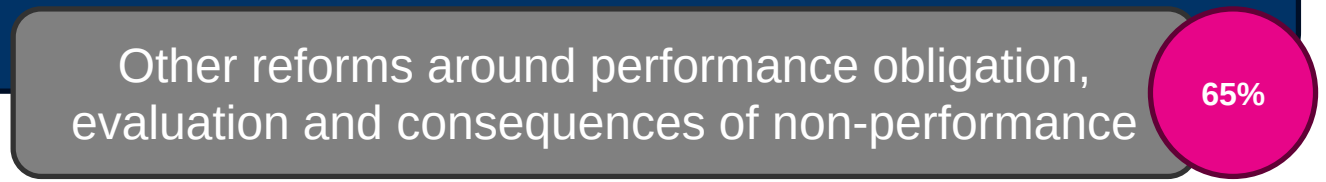
78% of poll respondents support pursuing solutions in this area. PJM also continues to believe this is an important area for improvement.



- PJM's existing ORDCs are outdated.
- Accurate ORDCs are important in transparently representing the value of reserves to the market and for appropriately valuing flexibility services.
- •Reforms to PJM's existing ORDCs will be needed to work coherently with any new or updated products, including PJM's existing 30-Minute Reserves.

Reforms Concerning Performance Obligation, Evaluation and Consequences of Non-Performance

65% of poll respondents support pursuing “other potential reserve market reforms around the following areas: Performance Obligation, Evaluation and Consequences of Non-Performance for Resources with a Reserve Assignment.”



- This was the lowest level of support across the solutions areas.
- PJM believes that as other solutions are developed/pursued, these discussions may be necessary to ensure an overall coherent market design. However, in recognition of the poll results, PJM does not currently view this as the highest priority area.

Reforms around Resource Reserve Offers to Better align with Resource Capabilities and/or Costs

87% of poll respondents support pursuing solutions in this area. PJM also continues to believe this is an important area for improvement.

Other reforms around resource offers to better align with resource capabilities and costs **87%**

- Instances where either a) reserve capability is not captured as accurately as feasible or b) reserve costs are not recoverable compromise reserve certainty and therefore system reliability.

- Resource costs that are not reflected in PJM's markets can lead to a lack of transparency, perverse incentives and/or market inefficiency.

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PJM's Preliminary Solution Options for the RCSTF Long-Term Scope

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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 to the grid or not synchronized to the grid and can respond within 10 minutes.
CBIR	**Consensus Based Issue Resolution** is the process used by PJM and its stakeholder community to pursue reforms to address identified issues.
RAC	The **Reliability Assessment Commitment** tool is used by PJM to evaluate whether sufficient generation and reserves are available to meet PJM's reliability 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).
ORDC	An **Operating Reserve Demand Curve** is a market mechanisms that dictates the maximum willingness to pay for reserves at different levels.

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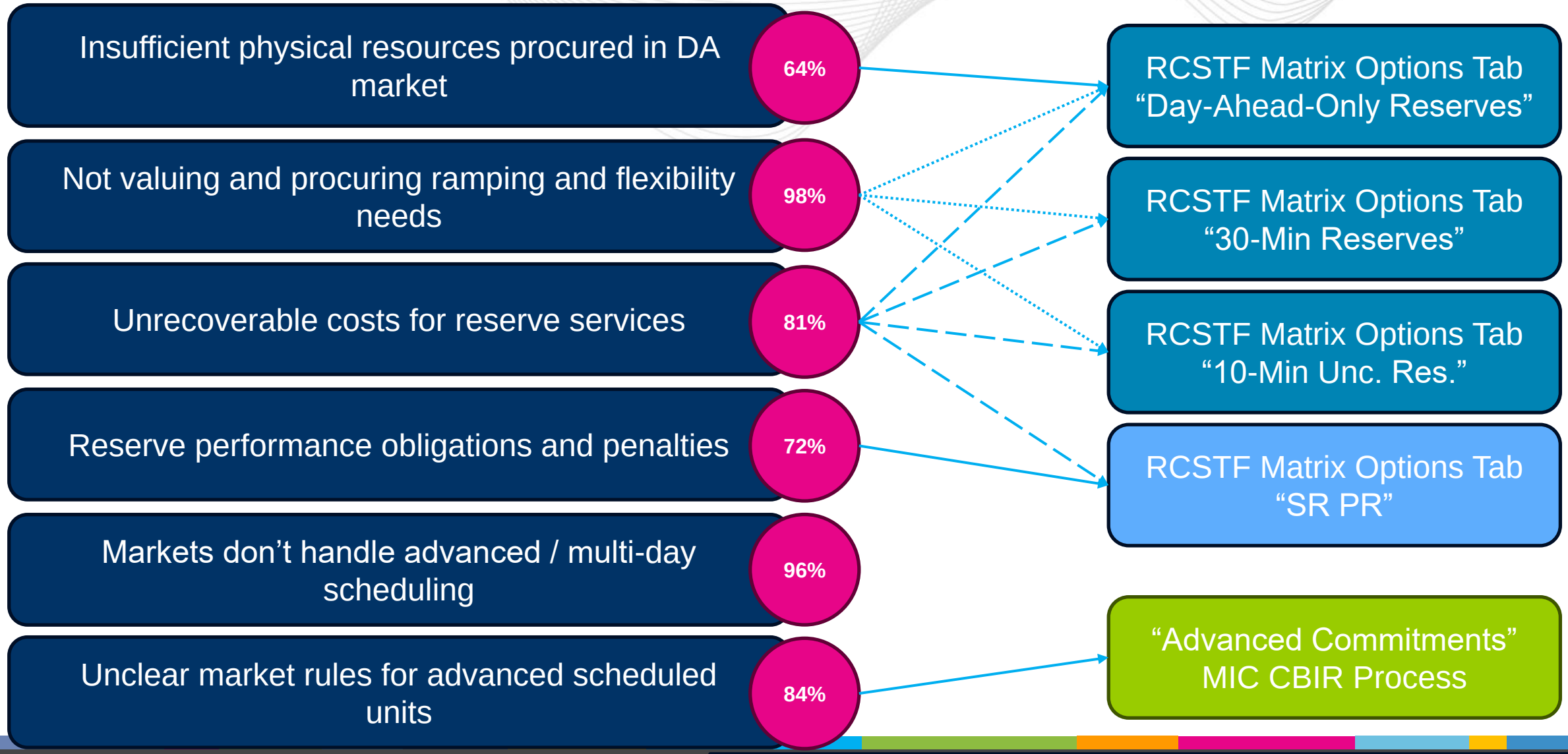
Appendix:
Summary Mapping between Polled Challenges and Solutions and the CBIR Process

High-Level Mapping between Challenges and CBIR Process



New or updated reserve products

Existing contingency reserve products

Outside of the RCSTF

High-Level Mapping between Solutions and CBIR Process