PJM’s Perspective on Enhancements to PJM’s Existing Reserve Markets

Keyur Patel & Emily Barrett

Market Design

Reserve Certainty Senior Task Force

March 12, 2025

Focus of this presentation

Overview of Identified Reforms

Challenges to be Addressed	Proposed Solutions to Explore
• The Day-Ahead Energy Market does not procure sufficient reserves to manage operational risk, leading to out-of-market reliability actions. • PJM's markets do not procure flexibility to manage forecast uncertainty (i.e., load, wind, solar, interchange and forced outage rates). • PJM's real-time dispatch engine does not account for flexibility and ramping needs forecasted in future intervals. • PJM's ORDCs are based on an old market design. • The cost of advanced fuel arrangements and other availability measures to provide reserves may at times be unrecoverable through PJM's existing market constructs.	**Enhancements to Existing Reserve Markets** • Updates to PJM's ORDCs • Changes to resource offer rules into reserve markets to enable cost recovery • IT SCED enhancements to better manage upcoming flexibility needs • Performance evaluation and incentives to ensure alignment with operational needs • Incentives to follow PJM dispatch • Locational procurement of reserves for reliability **New Reserve Products** • Day-ahead reserve product(s) to better align with day-ahead operational needs • Ramping/uncertainty reserve products to manage growing operational uncertainty

Operating Reserve Demand Curve Design

PJM’s ORDCs are based on an old market design.

- Under Reserve Price Formation, PJM proposed a holistic re-design of PJM’s reserve markets, including updates to our ORDCs.
- These reforms were initially approved by FERC and then later remanded, leaving PJM to implement an incomplete market design.

Operating Reserve Demand Curves Design Principles

To be effective ORDCs should:

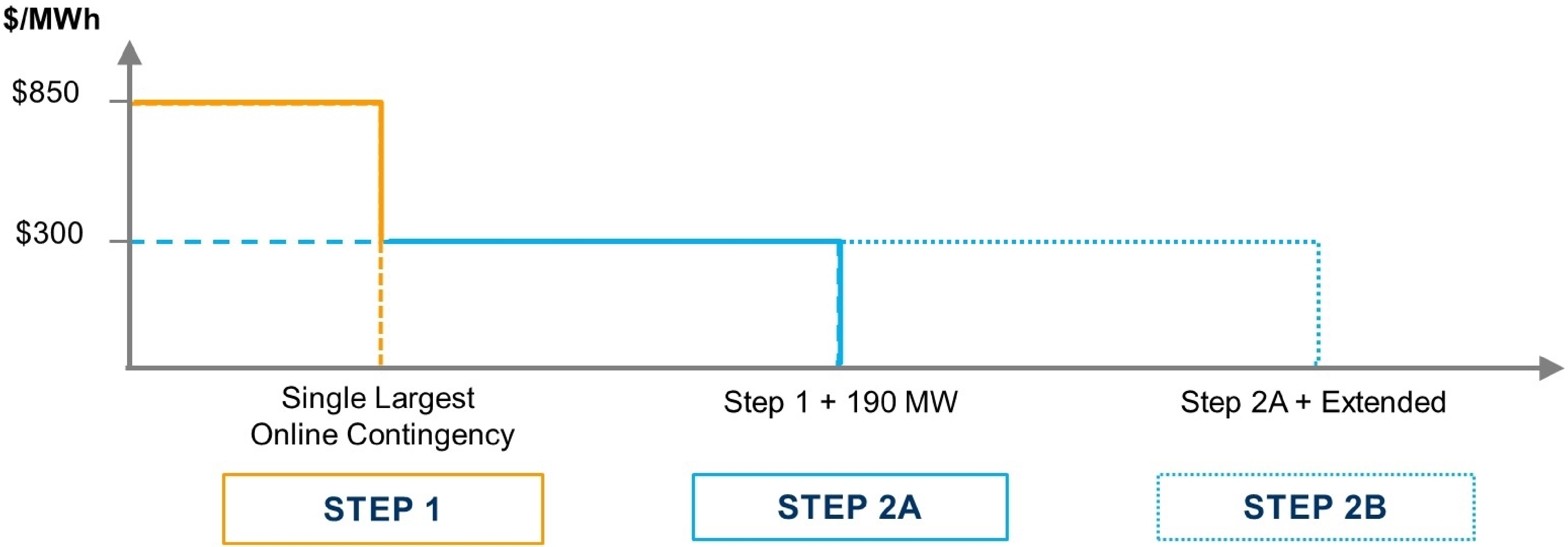
- Accurately and transparently quantify reserve needs within the market.
- Reflect the willingness to pay to mitigate reserve shortage and avoid loss of load.
- Ensure all cost-effective measures are exhausted before shedding firm load.
- Reflect the value of reserve services as a function of operational conditions.

FERC Statement on Energy Price Formation for Reserve Deficiencies

"To the extent that actions taken to avoid reserve deficiencies are not priced appropriately or not priced in a manner consistent with the prices set during a reserve deficiency, the price signals sent when the system is tight will not incent appropriate short- and long-term actions by resources and load."

-- Federal Energy Regulatory Commission on Energy Price Formation (ferc.gov)

PJM's Existing Operating Reserve Demand Curves



PJM's Concerns About the Existing ORDCs

Stale Operational Data

PJM's existing ORDC penalty factors are based on lost opportunity cost information from an event in August 2007 and do not accurately reflect current operational reality.

Market Inefficiency

As we consider reforms to PJM's reserve markets, our ORDCs need to be updated to reflect the reliability value being provided by each service, to ensure a cohesive market design and to promote market efficiency.

Lack of Alignment

The existing ORDCs do not align with operational needs and the reliability actions that need to be taken to avoid loss of load.

What happens if reserve penalty costs are lower than our actual willingness to pay for reserve services?

When making commitment decisions	When making dispatch decisions
If the penalty for going short reserves in the market's commitment optimization is lower than resources' commitment costs, the optimization will not commit those resources to provide reserves.	If the penalty for going short reserves in the market's dispatch optimization is lower than resources' lost opportunity costs for providing reserve services, the optimization will not redispatch the system to make those reserves available.

PJM will commit resources to ensure that sufficient reserves are available to maintain reliability. If the market does not reflect this, there is a misalignment between market outcomes and reliability needs.

Example 1: Commitment

Inputs:

Resource	EcoMin (MW)	EcoMax (MW)	Energy Offer ($/MWh)	SR Offer ($/MWh)	Start-up Cost ($)	No Load Cost ($)
Gen1	0	600	50	0	0	0
Gen2	0	600	60	0	851	0

Load	599 MW
SR Requirement	2 MW

Results:

$850 Penalty Factor			
System Energy Price ($)			900
SR Clearing Price ($)			850
SR Deficit (MW)			1
	Commit Status	Energy Dispatch (MW)	SR Assignment (MW)
Gen1	online	599	1
Gen2	*offline*	0	0

$852 Penalty Factor			
System Energy Price ($)			50
SR Clearing Price ($)			0
SR Deficit (MW)			0
	Commit Status	Energy Dispatch (MW)	SR Assignment (MW)
Gen1	online	599	1
Gen2	*online*	0	1

Key takeaway:
When the commitment costs for a resource are above the penalty cost for the reserve service, the commitment optimization goes short reserves rather than commit the resource.

Example 2: Dispatch

Inputs:

Resource	EcoMin (MW)	EcoMax (MW)	Energy Offer ($/MWh)	SR Offer ($/MWh)	Ramp Rate (MW/min)
Gen1	0	200	1000	0	1
Gen2	0	200	20	0	5
Gen3	0	300	10	0	5

Load	600 MW
SR Requirement	20 MW

Results:

$850 Penalty Factor	
System Energy Price ($)	1000
SR Clearing Price ($)	850
SR Deficit (MW)	10

	Energy Dispatch (MW)	SR Assignment (MW)
Gen1	100	10
Gen2	200	0
Gen3	300	0

$1000 Penalty Factor	
System Energy Price ($)	1000
SR Clearing Price ($)	980
SR Deficit (MW)	0

	Energy Dispatch (MW)	SR Assignment (MW)
Gen1	110	10
Gen2	190	10
Gen3	300	0

Key takeaway:
When the lost opportunity cost a resource would incur to provide reserves is above the penalty cost for the reserve service, the dispatch optimization goes short reserves rather than redispatch the system to make those reserves available.

Analysis of a Recent SR Shortage Event

- PJM’s current $850 penalty factor at the first step of the ORDC is based on lost opportunity cost data from 2007.

- PJM experienced a Synchronized Reserve (SR) shortage on February 5th for two intervals, and in both intervals, there were reserves available above the $850 penalty factor.

- The following slide includes a simple example in one of these intervals of how outcomes would have changed in RTSCED if the penalty factor had been higher.

Analysis of a Recent SR Shortage Interval in RTO

February 5, 2025, 10:15

First Step Penalty Factor	SR Deficit (RTO)	SR MCP (RTO)	Deficit type
$850 *(status quo)*	258 MW	$850	Minimum reliability requirement (i.e., first step)
$1,500	190 MW	$1,361	Extended reserve requirement (i.e., second step)

- PJM had a SR shortage of 258 MW in RTO, which included a 68 MW deficit below the first step of the ORDC ($850 penalty) and 190 MW deficit below the second step of the ORDC ($300 penalty).
- Increasing the $850 penalty factor to $1,500 cleared the shortage experienced at the minimum reliability requirement but left the willingness to pay at the extended reserve requirement unchanged, resulting in a 190 MW deficit of the extended reserve requirement.

Key takeaway: PJM's current ORDC penalty factors are not high enough to reflect the lost opportunity costs that resources could reasonably be expected to incur to provide reserve services.

ORDC Design

- What is our maximum willingness to pay for reserve services and to avoid loss of load?
- What are our required reserve quantities?
- What ORDC shape best reflects the value of reserve services at different levels?
- How do the ORDCs for different reserve products fit together to form a cohesive market design?

What is our maximum willingness to pay for reserve services and to avoid loss of load?

What factors might we want to consider when determining our willingness to pay for reserve services?

- What is the value of lost load?
- What other, more cost-effective actions could be taken prior to shedding firm load and what are the costs of those actions?
- What are the reliability implications and costs associated with going into reserve shortage?
- Others?

Value of Lost Load

Various approaches are used to estimate the value of lost load, including:

1. **Customer surveys**, such as interviews to identify direct costs or to elicit customer willingness to pay to avoid outages.
2. **Market behavior observations**, such as direct observations of customer willingness to accept increased interruptions for reduced prices.
3. **Proxy/macroeconomic analysis**, such as the ratio of gross domestic product to load or input/output models.
4. **Case studies of historical outage events** where actual events are analyzed to quantify the economic impacts of electrical service interruption.

Several other ISOs (or the IMMs of other ISOs) have used Lawrence Berkeley National Laboratory's Interruption Cost Estimate (ICE) Calculator to estimate the value of lost load, which uses a broad set of customer survey data.

Value of lost load varies based on context and customer. It's unlikely that we will be able to arrive at a single, definitive value, but exploring this topic may help bound the problem and provide directional guidance.

Actions to Remediate Reserve Shortage and Load Shed

The purpose of clearing reserves through the markets is to position the system to make those reserves available. This positioning can entail costs, including:

1. **Lost opportunity costs**, or the costs incurred by resources to provide reserves in lieu of providing energy.

2. **Commitment costs**, or the costs incurred to commit resources, such as start up and no load costs, to make reserves available.

An effective ORDC should ensure that 1) all more cost-effective actions are taken prior to engaging more expensive emergency procedures up to and including Manual Load Dump and 2) that those costs are made transparent to the market. ORDC penalty factors must therefore be high enough to trigger these remediation actions rather than allowing us to go short reserves unnecessarily.

Progressive actions taken during a Capacity Emergency*

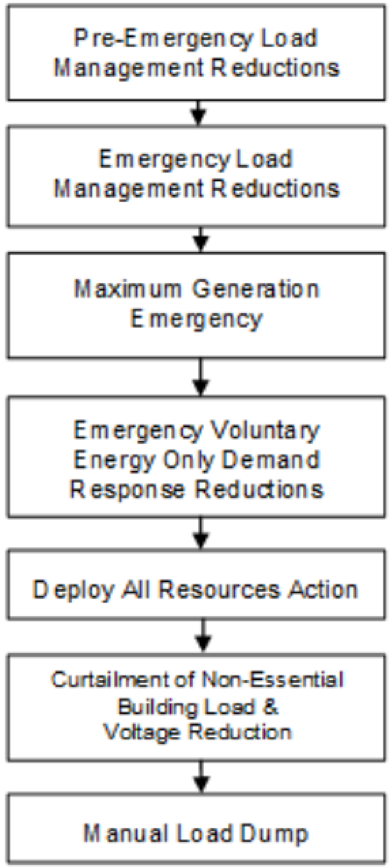
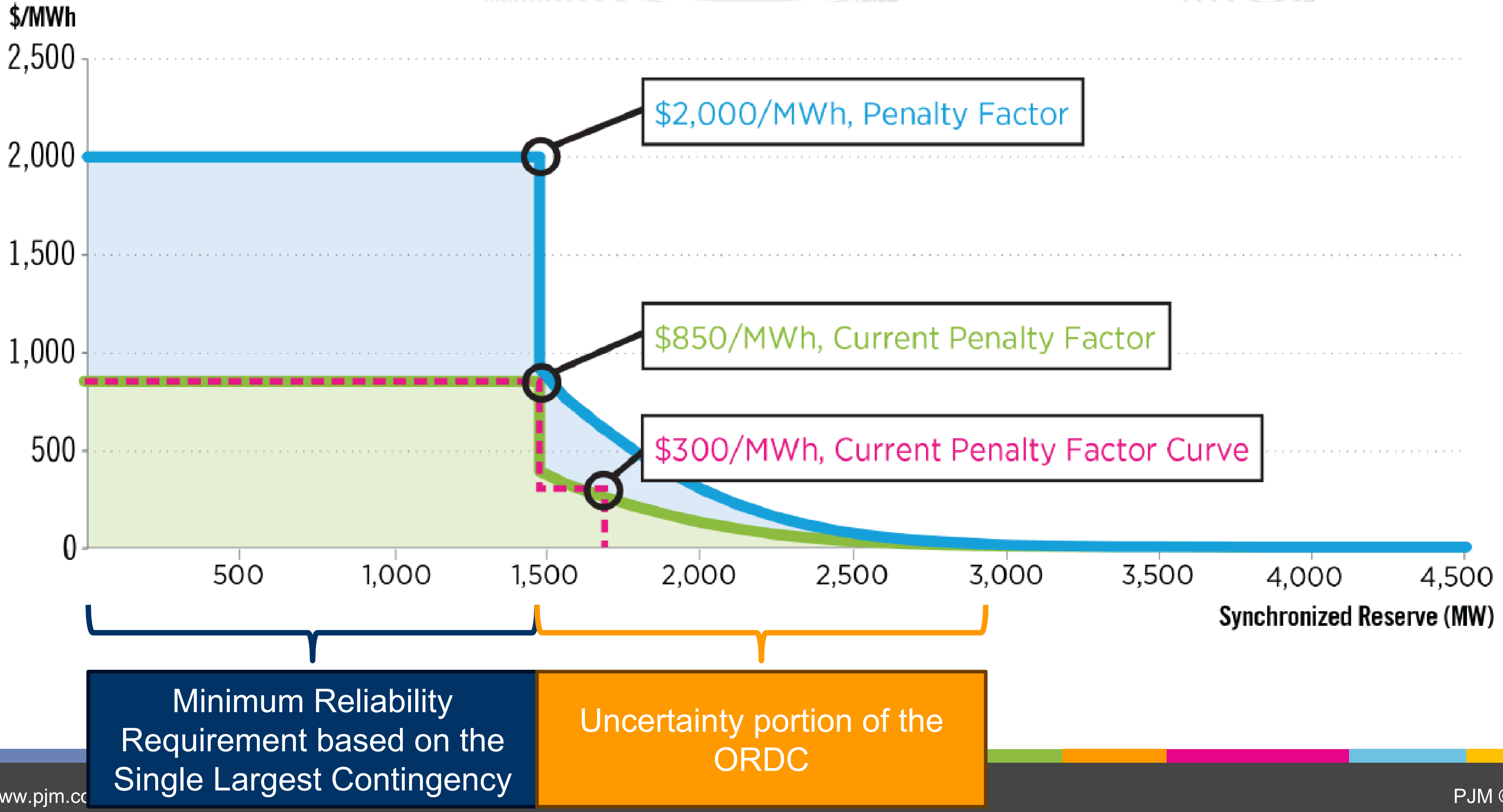


*Figure taken from [PJM Manual 13: Emergency Operations Section 2.3 Capacity Emergencies]

How do the ORDCs for different products fit together to form a cohesive market design?

- Each reserve product has its own ORDC, which should reflect the procurement quantities and willingness to pay for that essential reliability service.
- The willingness to pay for a reserve product is based on the “quality” of that product. In other words, the willingness to pay for a lower quality product will likely be lower than for a higher quality product.
- The outcome of the above points is that procuring one type of reserve can mitigate the likelihood of going short another type of reserve. For example, we see this in the market design of other ISOs where uncertainty reserves help mitigate contingency reserve shortage.
- PJM proposes to evaluate and reform its existing ORDCs for Synchronized, Primary and 30-Minute Reserves to ensure that the reliability value of these services is appropriately captured for each in the context of the broader reserve reforms being discussed.

ORDCs Proposed Under Reserve Price Formation



Summary

1. PJM believes that reforms are needed to our ORDCs to better reflect the value of reserve services into the market and to align with system operational needs.

2. Analysis of a recent shortage event showed that reserves were available on the system above the current $850 penalty factor.

3. PJM is considering factors such as the value of lost load, the costs incurred to make reserves available and the costs of emergency actions that would be taken during Capacity Emergencies to inform our willingness to pay for reserve services.

4. Ultimately, the design of PJM's ORDCs should be product specific and the ORDCs for different reserve products should fit together to promote market efficiency and overall market coherence.

Other Potential Reserve Market Reforms

Performance Obligation, Evaluation, and Consequences of Non-Performance

Why might we need to consider reforms?

- Consequences of non-performance today do not always reflect the impact to the system or how reserve products are used for reliability.
- Consequences of non-performance may not be structured to sufficiently promote reserve certainty.
- As PJM relies more heavily on reserves to manage uncertainty, it is critical that resources follow PJM dispatch instructions.

Possible design discussions

- New settlement impacts when reserve resources fail to perform.
- Reforms to performance evaluation rules.
- Changes or clarification to reserve performance obligation and resource qualification.
- New incentives to follow PJM dispatch, including reforms to deviation charges

Open Questions

- Should performance evaluation and consequences for non-performance for following dispatch be different for resources with and without a reserve assignment?
- Would performance-based reserve qualification increase reserve certainty?

Resource Offers for Providing Reserve Services

Why might we need to consider reforms?

- Resources may not currently be able to reflect avoidable costs such as fuel arrangements or charging for reserve services into their reserve offers. These costs may therefore be unrecoverable through PJM's markets

Possible design discussions

- New offer rules allowing resources to reflect avoidable costs into reserve offers

Open Questions

- In addition to costs, are there other structural reforms needed to reserve offers to reflect resource capability, such as reserve-specific parameters?

Updates to the Technical Paper Since Last Posting

Previously posted material

New content added, including some additional discussion around the willingness to pay for reserves and a breakdown of the presented examples.

Not yet populated

Contents

Contact

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

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

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

PJM's Perspective on Enhancements to PJM's Existing Reserve Markets

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

Acronyms

Acronym	Term & Definition
RTO	A **Regional Transmission Organization is** an entity, such as PJM Interconnection, that manages and coordinates the flow of electricity across a large geographical region.
ISO	An **Independent System Operator** is an organization that manages and coordinates the electric grid in a geographical region.
FERC	The **Federal Energy Regulatory Commission** is an independent agency of the United States government that regulates the interstate transmission and wholesale sale of electricity and natural gas and regulates the prices of interstate transport of petroleum by pipeline.
LMP	**Locational Marginal Price** is the marginal price for energy at the location where the energy is delivered or received. LMP is a pricing approach that addresses transmission system congestion and loss costs, as well as energy costs.
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.

Acronyms

Acronym	Term & Definition
VOLL	**Value of Lost Load** the willingness to pay to avoid electrical service interruption, often considered in dollars per megawatt-hour.
SR	**Synchronized Reserves** are reserves held on resources that can convert their reserve assignment to energy in 10 minutes or less and are synchronized to the grid.
PR	**Primary Reserves** are reserves held on resources that can convert their reserve assignment to energy in 10 minutes or less and are either synchronized or not synchronized to the grid.

PROTECT THE POWER GRID

THINK BEFORE YOU CLICK!

Be alert to malicious phishing emails.

Report suspicious email activity to PJM.

(610) 666-2244 / it_ops_ctr_shift@pjm.com