Continued Solution Option Discussion and Examples

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Purpose of this Presentation

This presentation provides some discussion and examples to facilitate further discussion around the following topics:

1) Reserve Service Nesting/Unnesting

2) Day-Ahead-Only Reserves Performance Evaluation and Consequence for Non-Performance

3) Consideration of Resource Ramp Rate in Reserve Market Clearing

Reserve Service Nesting/Unnesting

Motivation

- There is no explicit duration or energy endurance requirement for 30-Minute Reserves today.
- Given the current energy fleet, this has not presented operational issues to date, but as more energy limited resources begin participating in PJM’s energy markets, this could create reliability challenges.
- Moving forward, PJM recognizes the need to introduce clear and explicit duration or energy endurance requirements for its reserve services to accommodate the changing energy fleet.
- Duration requirements should be appropriate to how each reserve service will be used to support reliability without compromising market efficiency.

Nested Requirements, Status Quo

Inputs

Resource Information				
	Ramp (MW/min)	Headroom (MW)	Max Run (min)	Reserve Cost ($/MW)
R1	1	21	30	0
R2	1	21	240	5

Reserve Product Information		
	Reserve Requirement	Duration
SR	10 MW	30 minutes
30-Min	20 MW	N/A

Results

Cleared Reserves		
	SR	30-Min
R1	10 MW	10 MW additional *(meeting the 30-Min Req)*
R2	0 MW	0 MW

Clearing Prices	
SR	$0/MW
30-Min	$0/MW

Constraint Formulation:

Cleared SR >= SR Requirement

Cleared SR + Additional Cleared 30-Min* >= 30-Min Requirement

**i.e., Secondary Reserves (SECR)*

Observations:

- R1 has sufficient no-cost reserves to meet both the SR and 30-Min requirements, and so all 20 MW of reserves are cleared on this resource.
- However, given that the duration requirement for 30-Minute Reserves will be longer than 30 minutes, this outcome will no longer work because R1 has a Max Run of 30 minutes.

Nested Requirements, New Duration Requirement

Inputs

Resource Information				
	Ramp (MW/min)	Headroom (MW)	Max Run (min)	Reserve Cost ($/MW)
R1	1	21	30	0
R2	1	21	240	5

Reserve Product Information		
	Reserve Requirement	Duration
SR	10 MW	4 hours
30-Min	20 MW	4 hours

Results

Cleared Reserves		
	SR	30-Min
R1	0 MW	0 MW
R2	10 MW	10 MW additional *(meeting the 30-Min Req)*

Clearing Prices	
SR	$5/MW
30-Min	$5/MW

Constraint Formulation:

Cleared SR >= SR Requirement

Cleared SR + Additional Cleared 30-Min* >= 30-Min Requirement

**i.e., Secondary Reserves (SECR)*

Observations:

- R1 does not meet the duration eligibility requirement for providing either reserve service, so does not clear.
- R2 meets the 4-hour duration requirement and so all 20 MW of reserves are cleared on this resource.
- The 4-hour duration requirement is needed for the 30-Minute Reserve service, but may be overly conservative for the SR service, which could lead to market inefficiency, higher costs, and stranded energy on energy storage resources.

Unnested Requirements, New 30-Min Duration Requirement

Inputs

Resource Information	Ramp (MW/min)	Headroom (MW)	Max Run (min)	Reserve Cost ($/MW)
R1	1	21	30	0
R2	1	21	240	5

Reserve Product Information	Reserve Requirement	Duration
SR	10 MW	30 minutes
30-Min	10 MW	4 hours

Results

Cleared Reserves	SR	30-Min
R1	10 MW	0 MW
R2	0 MW	10 MW

Clearing Prices	
SR	$0/MW
30-Min	$5/MW

Constraint Formulation:

Cleared SR >= SR Requirement

Cleared 30-Min >= 30-Min Requirement

Observations:

- Because the 10 MW of SR no longer contributes to meeting the 30-Min Requirement, the 30-Min Requirement is now reduced by 10 MW.
- R1 has sufficient no-cost reserves to meet both the SR requirement.
- R1 does not meet the eligibility requirement to supply 30-Min Reserves.
- R2 is now cleared to meet the 30-Min Requirement because its Max Run meets the eligibility requirement for providing this service.
- Unlike under status quo, the 30-Min Market Clearing Price could be higher than the SR Market Clearing Price

Day-Ahead-Only Reserves Performance Evaluation and Consequence for Non-Performance

Motivation

- Any new reserve products introduced will require clearly defined performance obligations, performance evaluations and consequences for non-performance.
- Performance evaluation methodologies should align with how reserve services will be used.
- A reserve assignment obligates a resource both to make itself *available* to provide energy when called upon to do so and to *follow PJM's dispatch instructions* when procured reserves are converted to energy.
- Under a market construct where reserves are procured day-ahead but not cleared in real-time, new methodologies may be needed to evaluate whether reserve resources are fulfilling their obligation to make themselves available in real-time.

Day-Ahead-Only Reserves Example: Set-Up

Day-Ahead						
	Resource Bid Parameters				Assignments	
	Available	EcoMin	EcoMax	Time to Start	Energy	Day-Ahead-Only Reserves
R1	Yes	20 MW	50 MW	10 min	0 MW	50 MW
R2	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R3	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R4	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R5	Yes	100 MW	150 MW	N/A	100 MW	20 MW
R6	Yes	100 MW	120 MW	N/A	100 MW	20 MW

- Assume that providing Day-Ahead-Only Reserves requires a time to start of <= 30 min.
- R1, R2, R3 and R4 do not get day-ahead energy commitments, so they are each cleared for offline day-ahead-only reserves.
- R5 and R6 have both an energy commitment and an online day-ahead-only reserve assignment.
- R5 is marginal for reserves and only 20 MW of its total 50 MW of reserve capability is needed.

Day-Ahead-Only Reserves Example

Day-Ahead

	Resource Bid Parameters				Assignments	
	Available	EcoMin	EcoMax	Time to Start	Energy	Day-Ahead-Only Reserves
R1	Yes	20 MW	50 MW	10 min	0 MW	50 MW
R2	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R3	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R4	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R5	Yes	100 MW	150 MW	N/A	100 MW	20 MW
R6	Yes	100 MW	120 MW	N/A	100 MW	20 MW

Real-Time

	Resource Bid Parameters				Energy Instruction	Resource Output
	Available	EcoMin	EcoMax	Time to Start		
R1	Yes	20 MW	50 MW	6 hours	0 MW	0 MW
R2	No	20 MW	50 MW	30 min	0 MW	0 MW
R3	Yes	20 MW	50 MW	30 min	20 MW	0 MW
R4	Yes	20 MW	50 MW	30 min	0 MW	0 MW
R5	Yes	100 MW	110 MW	N/A	100 MW	100 MW
R6	Yes	100 MW	120 MW	N/A	120 MW	120 MW

- R1 extends its time to start from 10 minutes to 6 hours in real-time, which would disqualify it from clearing for Day-Ahead-Only reserves.
- R2 becomes unavailable in real-time.
- R3 is called by PJM but fails to come online.
- R4 bids in the same parameters to the Real-Time Market as it bid into the Day-Ahead Market and follows PJM's energy dispatch instructions.
- R5 reduces its EcoMax from 150 MW to 110 MW.
- R6 bids in the same parameters to the Real-Time Market as it bid into the Day-Ahead Market and follow PJM's energy dispatch instructions.

Day-Ahead-Only Reserves Example: Availability Check

Day-Ahead

	Resource Bid Parameters				Assignments	
	Available	EcoMin	EcoMax	Time to Start	Energy	Day-Ahead-Only Reserves
R1	Yes	20 MW	50 MW	10 min	0 MW	50 MW
R2	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R3	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R4	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R5	Yes	100 MW	150 MW	N/A	100 MW	20 MW
R6	Yes	100 MW	120 MW	N/A	100 MW	20 MW

Conceptual Basis:

- Does the resource bid into the Real-Time Market such that it has sufficient flexibility and capacity to meet both its day-ahead energy assignment and its day-ahead-only reserve assignment?
- Meeting its day-ahead only reserve assignment from the perspective of availability requires that a resource's bid parameters would qualify it to meet the day-ahead only reserve eligibility requirements.

Real-Time

	Resource Bid Parameters				Energy Instruction	Resource Output	Availability Check
	Available	EcoMin	EcoMax	Time to Start			
R1	Yes	20 MW	50 MW	6 hours	0 MW	0 MW	**Failed:** R1 extended its time to start beyond the day-ahead-only reserve eligibility criteria
R2	No	20 MW	50 MW	30 min	0 MW	0 MW	**Failed:** R2 is no longer available
R3	Yes	20 MW	50 MW	30 min	20 MW	0 MW	**Passed:** R3's bid in parameters meet its availability obligation
R4	Yes	20 MW	50 MW	30 min	0 MW	0 MW	**Passed:** R4's bid in parameters meet its availability obligation
R5	Yes	100 MW	110 MW	N/A	100 MW	100 MW	**Failed:** R5 reduced its EcoMax to below its energy + reserve assignments
R6	Yes	100 MW	120 MW	N/A	120 MW	120 MW	**Passed:** R6's bid in parameters meet its availability obligation

Day-Ahead-Only Reserves Example: Availability Check

Day-Ahead

	Resource Bid Parameters				Assignments	
	Available	**EcoMin**	**EcoMax**	**Time to Start**	**Energy**	**Day-Ahead-Only Reserves**
R1	Yes	20 MW	50 MW	10 min	0 MW	50 MW

Real-Time

	Resource Bid Parameters				Energy Instruction	Resource Output
	Available	**EcoMin**	**EcoMax**	**Time to Start**		
R1	Yes	20 MW	50 MW	6 hours	0 MW	0 MW

Notes:

- In this example, R1 has extended its time to start from 10 minutes to 6 hours, making it ineligible to meet the 30-minute time to start requirement to provide Day-Ahead-Only reserves.
- By contrast, if the resource had extended its time to start to 30 minutes in real-time rather than to 6 hours, it would still be eligible and have passed the availability check.
- The resource would be assessed an availability shortfall of 50 MW.

Day-Ahead-Only Reserves Example: Availability Check

Day-Ahead

	Resource Bid Parameters				Assignments	
	Available	EcoMin	EcoMax	Time to Start	Energy	Day-Ahead-Only Reserves
R2	Yes	20 MW	50 MW	30 min	0 MW	50 MW

Real-Time

	Resource Bid Parameters				Energy Instruction	Resource Output
	Available	EcoMin	EcoMax	Time to Start		
R2	No	20 MW	50 MW	30 min	0 MW	0 MW

Notes:

- In this example, R2 is no longer available
- The resource would be assessed an availability shortfall of 50 MW.

Day-Ahead-Only Reserves Example: Availability Check

Day-Ahead

	Resource Bid Parameters				Assignments	
	Available	EcoMin	EcoMax	Time to Start	Energy	Day-Ahead-Only Reserves
R5	Yes	100 MW	150 MW	N/A	100 MW	20 MW

Real-Time

	Resource Bid Parameters				Energy Instruction	Resource Output
	Available	EcoMin	EcoMax	Time to Start		
R5	Yes	100 MW	110 MW	N/A	100 MW	100 MW

Notes:

- In this example, R5 has decreased its EcoMax to 110 MW, which is lower than the its 100 MW day-ahead energy commitment + its 20 MW day-ahead only reserve assignment.
- By contrast, if the resource had decreased its EcoMax to 120 MW, it would still have met its reserve obligation.
- The resource would be assessed an availability shortfall of 10 MW.

Day-Ahead-Only Reserves Example: Performance Evaluation

Day-Ahead

	Resource Bid Parameters				Assignments	
	Available	EcoMin	EcoMax	Time to Start	Energy	Day-Ahead-Only Reserves
R1	Yes	20 MW	50 MW	10 min	0 MW	50 MW
R2	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R3	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R4	Yes	20 MW	50 MW	30 min	0 MW	50 MW
R5	Yes	100 MW	150 MW	N/A	100 MW	20 MW
R6	Yes	100 MW	120 MW	N/A	100 MW	20 MW

Conceptual Basis:

- Does the resource successfully convert its assigned day-ahead-only reserves to energy if instructed to do so by PJM in real-time?

Real-Time

	Resource Bid Parameters				Energy Instruction	Resource Output	Performance Evaluation
	Available	EcoMin	EcoMax	Time to Start			
R1	Yes	20 MW	50 MW	6 hours	0 MW	0 MW	N/A
R2	No	20 MW	50 MW	30 min	0 MW	0 MW	N/A
R3	Yes	20 MW	50 MW	30 min	20 MW	0 MW	**Failed:** R3 failed to come online and reach EcoMin within 30 minutes when called online by PJM.
R4	Yes	20 MW	50 MW	30 min	0 MW	0 MW	**Passed:** R4 was not called online by PJM.
R5	Yes	100 MW	110 MW	N/A	100 MW	100 MW	**Passed:** R5 followed PJM's energy dispatch instructions.
R6	Yes	100 MW	120 MW	N/A	120 MW	120 MW	**Passed:** R6 followed PJM's energy dispatch instructions.

Day-Ahead-Only Reserves Example: Performance Evaluation

Day-Ahead

	Resource Bid Parameters				Assignments	
	Available	**EcoMin**	**EcoMax**	**Time to Start**	**Energy**	**Day-Ahead-Only Reserves**
R3	Yes	20 MW	50 MW	30 min	0 MW	50 MW

Real-Time

	Resource Bid Parameters				Energy Instruction	Resource Output
	Available	**EcoMin**	**EcoMax**	**Time to Start**		
R3	Yes	20 MW	50 MW	30 min	20 MW	0 MW

Notes:

- In this example, R3 is called online by PJM.
- The resource is evaluated based on whether it reaches EcoMin within the allotted time. In this case, it fails to come online.
- The resource would be assessed a 50 MW performance shortfall.

Consequences for Failing the Availability Check

- In the May RCSTF, PJM put forward an initial solution option that the consequences for non-performance for the availability check could be a claw back of the day-ahead-only reserve revenue times some multiplier.

- Upon further reflect, PJM recognizes that while this may be a reasonable and appropriate consequence for non-performance in some circumstances, it may not appropriately represent the impact to the system when conditions change between day-ahead and real-time.

- For example, if reserves are abundant and low-cost day-ahead and then conditions become tight in real-time, it may be more appropriate to settle the day-ahead-only reserve assignment based on a penalty structure that better reflects real-time conditions when the resource fails to perform.

- Given that impact of resources failing to make themselves available to provide reserves results in tightening reserve margins, one approach might be to consider the real-time reserve market clearing price.

Day-Ahead-Only Reserves Initial Solution Options: Consequences for Failing the Availability Check

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 plus its day-ahead energy commitment it would be assessed a charge at the greater of its day-ahead revenue times some multiplier (e.g., 1.25) or the 30-Min Reserve Market Clearing Price.

Day-Ahead Only Reserves: Consequences for Failing the Performance Evaluation

- In the May RCSTF, PJM put forward an initial solution option that the consequences for non-performance when assigned reserves are converted into energy could be a claw back of the day-ahead-only reserve revenue times some multiplier at a higher rate than the penalty structure for the availability check.
- Like the availability check, PJM recognizes that this may not appropriately represent the impact to the system when conditions change between day-ahead and real-time.
- The impact of resources failing to perform when reserves are converted to energy is ultimately that PJM must dispatch other resources to provide that energy. This can lead to tightening reserve margins as well as increased energy costs.
- The penalty structure for resources that fail to convert assigned reserves to energy could therefore be based on the real-time reserve clearing prices or on the locational marginal price.

Day-Ahead Only Reserves: Consequences for Failing the Performance Evaluation

PJM's current thinking is that the consequences for failing to convert procured reserves into energy when instructed by PJM should be higher than failing the availability check, both because the impact to the system is likely to be greater and because PJM wants to incentivize resources to provide the most accurate information possible.
Some possible solution options include assessing a charge of:

- The greater of its day-ahead-only reserve revenue times some multiplier (e.g., 1.5) or the 30-Min Reserve Real-Time Market Clearing Price times some multiplier (e.g., 1.25).
- The Locational Marginal Price.
- The difference between the Locational Marginal Price and the resource's marginal cost.

Consideration of Resource Ramp Rate in Reserve Market Clearing

Motivation

- Some questions have arisen on how reserve clearing would occur across different reserve products in the co-optimization based on a resource’s available capability.

- One design decision that will need to be made is whether the same *ramping capability* or *ramp rate* can be assigned to multiple reserve services in the same interval.

- PJM’s position is that a resource’s reserve ramp should be “assigned” to reserves in a way that is consistent with how each reserve service would be used to avoid either over- or under-representing resources’ ability to provide reserve services.

Clearing Example: 10-Min Ramping/Uncertainty Reserves and Synchronized Reserves

Inputs

Resource Information			
	Ramp (MW/min)	**Headroom (MW)**	**Reserve Cost ($/MW)**
R1	1	30	0
R2	1	20	5

Reserve Product Information	
	Procured Quantity
SR	10 MW
10-Min RUR	5 MW

Set-Up and Assumptions:

- These examples only include two reserve products:
    - Synchronized Reserve (SR), and
    - 10-Minute Ramping/Uncertainty Reserves (10-Min RUR)
- The reserve costs for both services are assumed to be the same.
- In all cases, even where the same ramp rate can be assigned to multiple services, sufficient *headroom* must be available for each service individually.

Clearing Example: 10-Min Ramping/Uncertainty Reserves and Synchronized Reserves

Inputs

Resource Information	Ramp (MW/min)	Headroom (MW)	Reserve Cost ($/MW)
R1	1	30	0
R2	1	20	5

Reserve Product Information	Procured Quantity
SR	10 MW
10-Min RUR	5 MW

- R1 and R2 each have a ramp rate of 1 MW/min
- The 10-minute ramp capability for each resource is therefore:
  1 MW/min * 10 minutes = 10 MW
- If the same ramp rate **can** be used to meet both requirements, then both the 10 MW of SR and the 5 MW of 10-Min RUR could both be cleared on R1
- R1 is fully subscribed for SR, meaning that the **next** MW of SR would need to come from R2, making that resource marginal
- R1 has additional ramping capability to provide the next MW of 10-Min RUR, making it marginal

Results

Cleared Reserves	SR	10-Min RUR
R1	10 MW	5 MW
R2	0 MW	0 MW

Clearing Prices	
SR	$5/MW
10-Min RUR	$0/MW

Clearing Example: 10-Min Ramping/Uncertainty Reserves and Synchronized Reserves

Inputs

Resource Information			
	Ramp (MW/min)	**Headroom (MW)**	**Reserve Cost ($/MW)**
R1	1	30	0
R2	1	20	5

Reserve Product Information	
	Procured Quantity
SR	10 MW
10-Min RUR	5 MW

- R1 and R2 each have a ramp rate of 1 MW/min
- The 10-minute ramp capability for each resource is therefore:
  1 MW/min * 10 minutes = 10 MW
- If the same ramp rate **cannot** be used to meet both requirements, then only 10 MW of SR can be cleared on R1 at $0/MW, which fully subscribes its available 10-minute ramp
- The 5 MW of 10-Min RUR must therefore be cleared on R2
- Because R1 is fully subscribed, the marginal cost of both reserve services becomes $5/MW

Results

Cleared Reserves		
	SR	**10-Min RUR**
R1	10 MW	0 MW
R2	0 MW	5 MW

Clearing Prices	
SR	$5/MW
10-Min RUR	$5/MW

Clearing Example: 10-Min Ramping/Uncertainty Reserves and Synchronized Reserves

Inputs

Resource Information	Ramp (MW/min)	Headroom (MW)	Reserve Cost ($/MW)
R1	1	30	0
R2	1	20	5

Reserve Product Information	Procured Quantity
SR	10 MW
10-Min RUR	5 MW

Results

If the same ramp rate ***can*** be used to meet both the SR and 10-Min RUR requirements

Cleared Reserves	SR	10-Min RUR
R1	10 MW	5 MW
R2	0 MW	0 MW

Clearing Prices	
SR	$5/MW
10-Min RUR	$0/MW

If the same ramp rate ***cannot*** be used to meet both the SR and 10-Min RUR requirements

Cleared Reserves	SR	10-Min RUR
R1	10 MW	0 MW
R2	0 MW	5 MW

Clearing Prices	
SR	$5/MW
10-Min RUR	$5/MW

Observations:

- R1 has sufficient ***headroom*** to meet both reserve requirements.
- R1 only has 1 MW/min of ramping capability, meaning that it does not have sufficient ramp to be ***deployed*** for both services simultaneously.
- If the ramping capability of R1 can be assigned to both reserve services, it can clear for all 15 MW of reserve needs.
- However, if the same ramping capability cannot be assigned to both reserve services then the 5 MW of 10-Min RUR would be cleared on R2.
- In both cases R2 is marginal for SR.
- In the case where the ramp cannot be assigned to both services, it is also marginal for 10-Min RUR.

Clearing Example: 10-Min Ramping/Uncertainty Reserves and 30-Min Reserves

Inputs

Resource Information			
	Ramp (MW/min)	**Headroom (MW)**	**Reserve Cost ($/MW)**
R1	1	40	0
R2	1	20	5

Reserve Product Information	
	Procured Quantity
10-Min RUR	10 MW
30-Min	25 MW

Set-Up and Assumptions:

- These examples only include two reserve products:
  - 10-Minute Ramping/Uncertainty Reserves (10-Min RUR)
  - 30-Minute Reserves (30-Min)
- In this example, the 10-Min RUR and 30-Min requirements are not nested and must be fulfilled separately. (Note that this is different than the status quo for SR, PR and 30-Min.)
- The reserve costs for both services are assumed to be the same.
- In all cases, even where the same ramp rate can be assigned to multiple services, sufficient *headroom* must be available for each service individually.

Clearing Example: 10-Min Ramping/Uncertainty Reserves and 30-Min Reserves

Inputs

Resource Information			
	Ramp (MW/min)	Headroom (MW)	Reserve Cost ($/MW)
R1	1	40	0
R2	1	20	5

Reserve Product Information	
	Procured Quantity
10-Min RUR	10 MW
30-Min	25 MW

- R1 and R2 each have a ramp rate of 1 MW/min
- The 10-minute ramp capability for each resource is therefore:
  1 MW/min * 10 minutes = 10 MW
- The 30-minute ramp capability for each resource is therefore:
  1 MW/min * 30 minutes = 30 MW
- If the same ramp rate **can** be used to meet both requirements, then the 10 MW of 10-Min RUR and the 25 MW of 30-Min can both be cleared on R1
- The 10-minute ramping capability of R1 is fully subscribed, meaning that the next MW of 10-Min RUR would come from R2, making R2 marginal for 10-Min RUR
- R1 has 5 additional MW of 30-minute ramping capability, making it marginal for 30-Min Reserves

Results

Cleared Reserves		
	10-Min RUR	30-Min
R1	10 MW	25 MW
R2	0 MW	0 MW

Clearing Prices	
10-Min RUR	$5/MW
30-Min	$0/MW

Clearing Example: 10-Min Ramping/Uncertainty Reserves and 30-Min Reserves

Inputs

Resource Information			
	Ramp (MW/min)	Headroom (MW)	Reserve Cost ($/MW)
R1	1	40	0
R2	1	20	5

Reserve Product Information	
	Procured Quantity
10-Min RUR	10 MW
30-Min	25 MW

- R1 and R2 each have a ramp rate of 1 MW/min
- The 10-minute ramp capability for each resource is therefore:
  1 MW/min * 10 minutes = 10 MW
- The 30-minute ramp capability for each resource is therefore:
  1 MW/min * 30 minutes = 30 MW
- If the same ramp rate **cannot** be used to meet both requirements, then if 10 MW of 10-Min RUR are cleared on R1, only 20 MW of 30-Min can be cleared on that resource
- The remaining 5 MW of 30-Min would therefore be cleared on R2
- The next MW of both the 10-Min RUR and 30-Min would therefore come from R2 making it marginal for both services

Results

Cleared Reserves		
	10-Min RUR	30-Min
R1	10 MW	20 MW
R2	0 MW	5 MW

Clearing Prices	
10-Min RUR	$5/MW
30-Min	$5/MW

Clearing Example: 10-Min Ramping/Uncertainty Reserves and 30-Min Reserves

Inputs

Resource Information			
	Ramp (MW/min)	Headroom (MW)	Reserve Cost ($/MW)
R1	1	40	0
R2	1	20	5

Reserve Product Information	
	Procured Quantity
10-Min RUR	10 MW
30-Min RUR	25 MW

Results

If the same ramp rate ***can*** be used to meet both the 10-Min RUR and 30-Min requirements

Cleared Reserves		
	10-Min RUR	30-Min
R1	10 MW	25 MW
R2	0 MW	0 MW

Clearing Prices	
10-Min RUR	$5/MW
30-Min	$0/MW

If the same ramp rate ***cannot*** be used to meet both the 10-Min RUR and 30-Min requirements

Cleared Reserves		
	10-Min RUR	30-Min
R1	10 MW	20 MW
R2	0 MW	5 MW

Clearing Prices	
10-Min RUR	$5/MW
30-Min	$5/MW

Observations:

- R1 has sufficient headroom to meet both the 10-Min RUR and 30-Min requirements.
- R1 only has 1 MW/min of ramping capability, meaning that it does not have sufficient ramp to be ***deployed*** for both services simultaneously.
- If the ramping capability of R1 can be assigned to both reserve services, it can clear for all 35 MW of reserve needs.
- However, if the ramping capability cannot be assigned to both reserve services, then only 20 MW of 30-Min can clear on R1.
- In both cases R2 is marginal for 10-Min RUR. In the case where the ramp cannot be assigned to both services, it is also marginal for 30-Min.

Design Considerations

- How a resource's ramping capability or ramp rate is subscribed by or assigned to reserve services will dictate whether these reserve services can be converted into energy simultaneously.
- In instances where reserve services are deployed or converted into energy discretely (i.e., at different times and using different mechanisms) there may be instances where some amount of the same ramping capability could be used to meet two different reserve requirements.
- If the sharing or double-counting of a resource's ramping capability between reserve services could compromise the ability of reserves to perform, that could create a paradigm where we are procuring reserves that don't provide their intended reliability value.
- Given that reserves are essential reliability services, decisions around how reserve ramping capability is assigned to these services should align with system reliability needs.

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Additional Discussion and Examples on PJM's Initial Solution Options.

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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.
RUR	**Ramping/Uncertainty Reserves** are reserves that would be procured to manage forecasted ramp and uncertainty operational flexibility needs.
MW	A **Megawatt** is a unit of power equaling one million watts (1 MW = 1,000,000 watts) or one thousand kilowatts (1 MW = 1,000 KW).


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