Operating Reserve Clarification for Resources Operating as Requested by PJM:

Operating Reserve Make Whole Credit Education

Brian Weathers

Sr. Lead Consultant, Market Settlements Development

Market Implementation Committee

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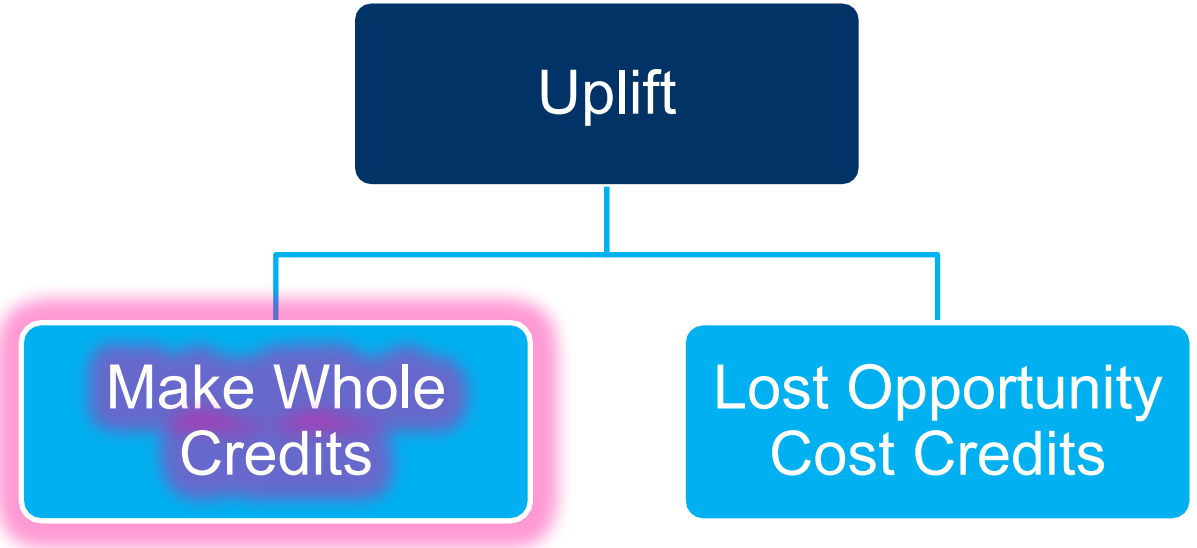
Uplift

Uplift is a general term that refers to additional credits paid to units to ensure resources operating at PJM's direction do not operate at a loss. Uplift in the energy market is paid through several sets of credits.



Balancing Operating Reserve make whole credits are the main focus of this issue charge.

Other types of uplift credits that have parallel logic, such as reactive services credits, may also require revision.

Line Items

- Day Ahead Operating Reserve
- Balancing Operating Reserve
- Reactive Services
- Synchronous Condensing

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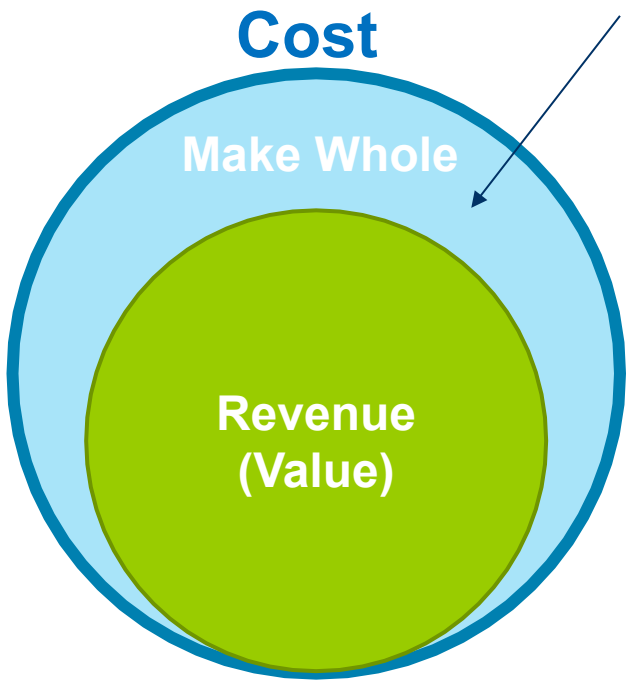
Operating Reserve Make Whole Credits: General Formula

Make whole credits are paid for pool scheduled resources when their revenues do not cover the costs represented in their offers.

Make Whole Credit = Cost minus Value (floored at zero)



Cost = Total resource offer amount for generation, including startup and no-load costs as applicable

Value = Amounts credited in the energy markets and net profit from the ancillary services markets

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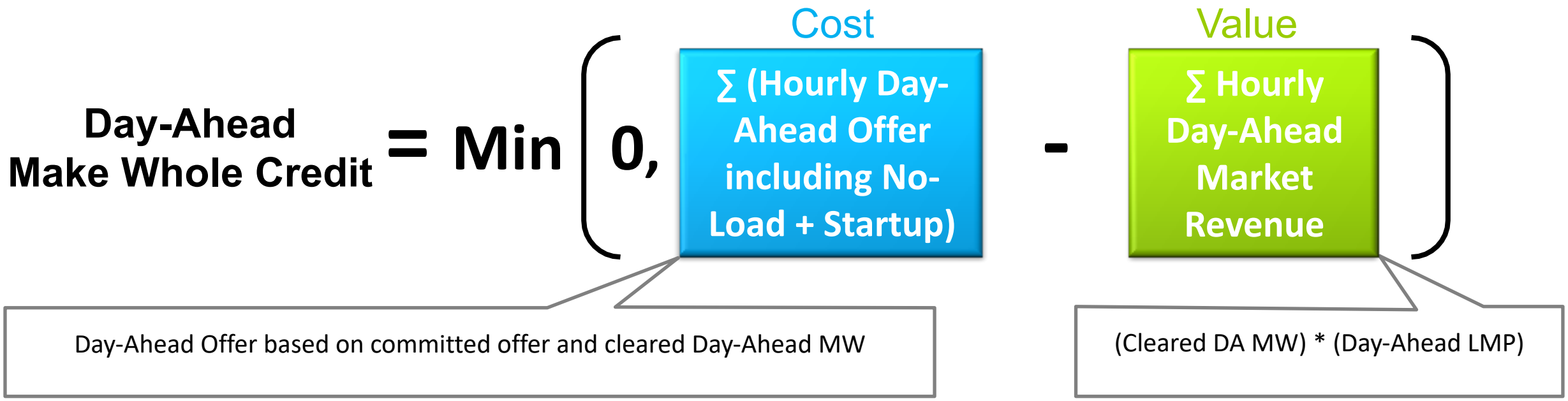
Day-Ahead Operating Reserve Make Whole Credit

Resources scheduled by PJM in the day-ahead market are eligible to receive day ahead operating reserve credits provided that resource is available for entire time specified in its offer data in the balancing market



Day-ahead Operating Reserve credits can be further adjusted by the Day-ahead Operating Reserve Offset to remove any commitment costs, including start-up and no-load costs that are credited through balancing market revenues.

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Balancing Operating Reserve (BOR) Segmented Make Whole Credit

- Day-Ahead Operating Reserve credits are calculated by Operating Day
- In contrast, Balancing Operating Reserve make whole credits are calculated by operating segment within an Operating Day
- A resource is made-whole for up to two segments for each synchronized start
  - Segment 1: Greater of day ahead commitment and Min Run time at time of commitment
    - Startup costs are included in this segment
  - Segment 2: 5-minute intervals in excess of Segment 1
- With 5-minute settlements, segments can start/stop during intervals within hour
- Segments do not “carry over” to the next day

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Segmented Make Whole Credits
Example 1: Unit Extended Beyond Min Run Time

Balancing Operating Reserve make whole credits are calculated for each segment using the 5-minute interval MWs and prices within each segment

Unit called on and on-line at 7:30

MIN RUN TIME – 4 HOURS (7:30 – 11:30)

REAL TIME DISPATCH (11:30 – 13:30) (beyond min run)

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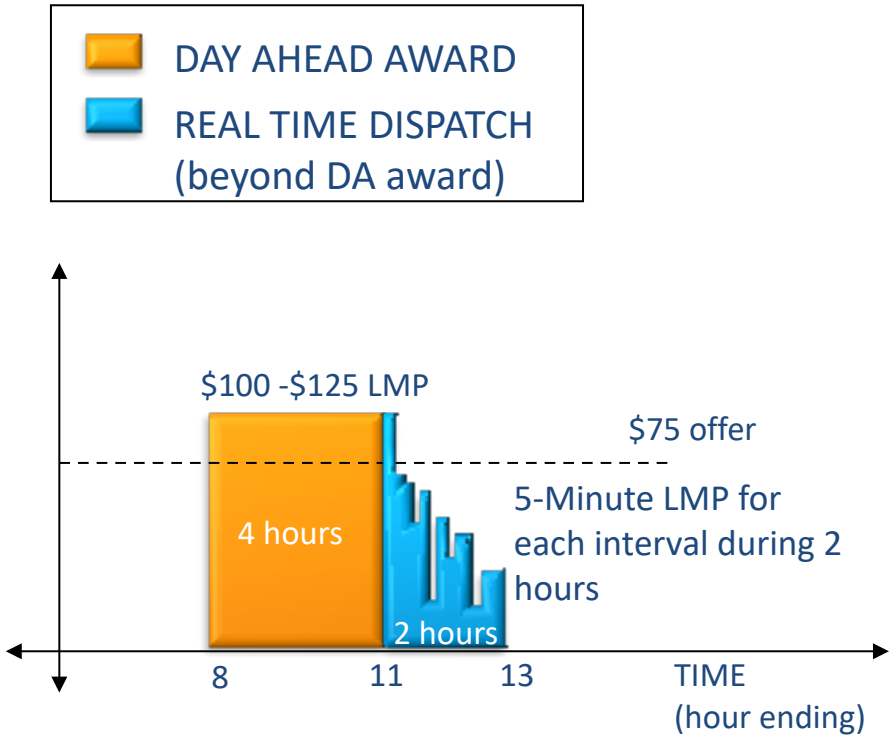
Segmented Make Whole Payments
Example 2: Unit Extended Beyond Day Ahead Schedule

Costs and revenues in one segment do not impact the make whole credit calculated for the other segment.



- LMP is above unit's offer in DA and RT for hours of DA award and covers startup and no load costs – no make whole needed
- Unit extended in real-time for 2 hours beyond DA schedule
- LMP is less than offer during extended period
- Additional revenue in Segment 1 does not offset the unrecovered costs in Segment 2

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Balancing Operating Reserve Make Whole Credit

For each segment…

$$\text{Balancing Make Whole Credit} = \text{Min}\left(0,\ \sum \text{Cost}\ \text{over 5-min intervals in segment} - \sum \text{Value}\ \text{over 5-min intervals in segment}\right)$$

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Balancing Make Whole Credit: Cost Components

Balancing Make Whole Credit = Min (0, ∑ Cost - ∑ Value)

∑ (5-Minute Real-Time Energy Offer including No-Load) + Startup Cost (only if calculating the first segment make whole credit)

RT Energy Offer is determined using:

- The incremental offer and no load from the lesser of the Committed Offer and the Final Offer for the hour
- Real-time MW Used for that five minute interval

If RT Output is:	<= Operating Reserve Desired MW	> Operating Reserve Desired MW and <= 110% Operating Reserve Desired MW	> 110% Operating Reserve Desired MW
Then RT MW Used =	RT MW	RT MW	Operating Reserve Desired MW
And incremental offer is associated with these MW:	RT MW	Operating Reserve Desired MW	Operating Reserve Desired MW

* Operating Reserve Desired MW calculation is covered in detail later in this presentation.

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Balancing Make Whole Credit: Value Components

Balancing Make Whole Credit = Min (0, ∑ Cost - ∑ Value)

∑ (5-Minute Balancing Value) + ∑ (5-Minute Synchronized + Non Synchronized Reserves + Reactive + DASR Excess Revenues) + Daily Day-Ahead Value + Daily Day-Ahead Operating Reserve Credit

*Revenues beyond offer plus opportunity cost

Only if calculating segment 1 make whole credit

Balancing Value = (**Balancing Value MW Used** – Day-Ahead MW) * (Real-time LMP / 12)

Balancing Value MW Used is Greater of …

- Real-Time MW
- *Lessor of …*
  - DA Scheduled MW
  - *Greater of …*
    - Operating Reserve Desired MW
    - Committed Offer Desired MW

* Operating Reserve Desired MW is covered in detail later in this presentation

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Eligibility for Balancing Make Whole Credits

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Eligibility for Balancing Operating Reserve Credits

- Operating Agreement, Schedule 1, Section 3.2.3(e)

…synchronized pool-scheduled resources…that operate as requested by the Office of the Interconnection…shall be made whole.

(e) At the end of each Operating Day, the following determination shall be made for each synchronized pool-scheduled resource of each Market Seller that operates as requested by the Office of the Interconnection. For each calendar day, pool-scheduled resources in the Real-time Energy Market shall be made whole for each of the following Segments: 1) the greater of their day-ahead schedules and minimum run time specified at the time of commitment (minimum down time specified at the time of commitment for Demand Resources); and 2) any block of Real-time Settlement Intervals the resource operates at PJM's direction in excess of the greater of its day-ahead schedule and minimum run time specified at the time of commitment (minimum down time specified at the time of commitment for Demand Resources). For each calendar day, and for each synchronized start of a generation resource or PJM-dispatched economic load reduction, there will be a maximum of two Segments for each resource. Segment 1 will be the greater of the day-ahead schedule and minimum run time specified at the time of commitment (minimum down time specified at the time of commitment for Demand Resources) and Segment 2 will include the remainder of the contiguous Real-time Settlement Intervals when the resource is operating at the direction of the Office of the Interconnection, provided that a segment is limited to the Operating Day in which it commenced and cannot include any part of the following Operating Day.

Nuclear resources are generally not eligible for operating reserve credits, unless directed to reduce output by PJM (in which case lost opportunity cost credits apply).

Nuclear generation resources shall not be eligible for Operating Reserve payments unless: 1) the Office of the Interconnection directs such resources to reduce output, in which case, such units shall be compensated in accordance with Tariff, Attachment K-Appendix, section 3.2.3(f) and the parallel provision of Operating Agreement, Schedule 1, section 3.2.3(f); or 2) the resource submits a request for a risk premium to the Market Monitoring Unit under the procedures specified in Tariff, Attachment M - Appendix, section II.B. A nuclear generation resource (i) must submit a risk premium consistent with its agreement under such process, or, (ii) if it has not agreed with the Market Monitoring Unit on an appropriate risk premium, may submit its own determination of an appropriate risk premium to the Office of the Interconnection, subject to acceptance by the Office of the Interconnection, with or without prior approval from the Commission.

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Operating as Requested by PJM

The term “operating as requested by PJM” is not well defined in the Tariff. Clarifying this definition would be beneficial.

INTERPRETATION

- The Tariff references payment of balancing operating reserve credits to units “operating as requested by PJM.”
  - Operating as requested by PJM has been historically interpreted as coming online and offline consistent with PJM’s request
  - Manual 28, Section 5.2.1 provides guidance on this interpretation (see next slide)
- The Tariff does not use the term “following dispatch” in reference to operating reserve eligibility. Instead, the term “following dispatch” is only referenced in the assessment of balancing operating reserve ***charges*** to units that deviate from PJM’s dispatch instructions.
- The concept of following dispatch is embedded throughout the Balancing Operating Reserve Make Whole Credit calculations though, as cost recovery is maximized when a resource is following dispatch

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Manual 28 Eligibility Rules (Section 5.2.1)

"PJM determines eligibility for Balancing Operating Reserve credits for each generating resource from dispatcher logs. The following operating guidelines are used in the determination of Operating Reserve credits:

- Resource **must operate according to the on and off times requested by PJM**, and units tripping during pool-scheduled periods of operation will retain their eligibility up through the five minute interval in which the unit trips.
- Resources that trip or fail to start are required to notify PJM per the Synchronization and Disconnection procedures in PJM Manual 14D: Generator Operational Requirements.
- Resources that trip, are requested to restart by PJM, and return to operate as requested, **are eligible to receive credits for the latter period of operation**. Resources that trip or failed to start, are requested to restart by PJM for reliability, and operate as requested, are eligible for additional startup costs."

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Dispatcher Logging & Eligibility

- PJM's commitment tools and dispatchers log the time when units are called on and off as well as the reason for committing or releasing the unit
- The status of pool scheduled or self-scheduled is derived from the log reason.
  - Log reasons therefore feed the determination of eligibility for operating reserve credits.
- PJM Settlements provides secondary review of dispatcher logs and recordings for consistency and verification of operating reserve eligibility as needed.

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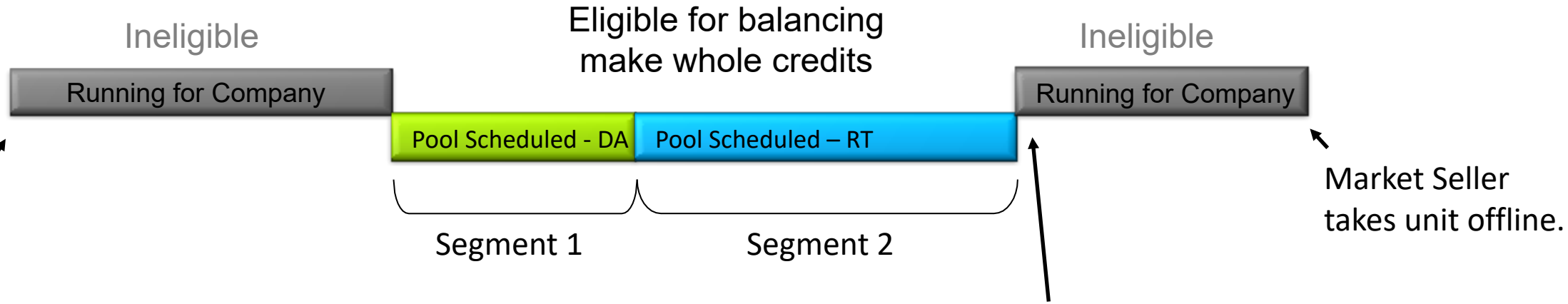
Example 1: Log Reasons and Make Whole Eligibility



Market Seller brings unit online several hours prior to DA commitment (earlier than necessary for ramping) and are ready to follow the dispatch signal.
Unit is treated as self-scheduled prior to DA commitment.

PJM releases the unit. Market Seller continues running the resource for their own reasons. Unit is treated as self-scheduled starting at this time.

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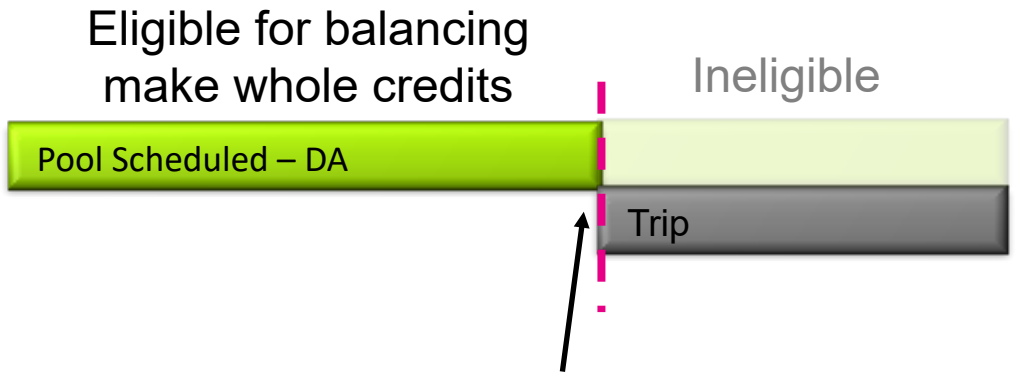
Example 2: Log Reasons and Make Whole Eligibility

- Day Ahead Award
- Extended by PJM
- Running for Company



PJM schedules the unit and it comes online at the desired start time.

The unit trips offline and does not return. Will be responsible for buying out of their DA commitment.

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Fixed Gen Flag

- Market Sellers use the Fixed Gen flag in Markets Gateway to communicate when a resource has a fixed operating schedule.
  - Used to reflect operational limitations among other reasons
- The use of the Fixed Gen flag doesn't directly impact eligibility.
  - If a unit offers itself to be committed by PJM and PJM decides to commit the unit, then it is considered pool-scheduled and eligible for operating reserve regardless of the fixed gen flag

If the use of the Fixed Gen flag is not the result of operational limitations and the unit has flexibility that is not being offered to PJM, should it impact eligibility for make whole credits and/or the level to which they are made whole?

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Real-Time Values & Operating Reserve Credit Eligibility

OA Schedule 1, Section 3.2.3(e)

"A Generation Capacity Resource that operates outside of its unit-specific parameters will not receive Operating Reserve Credits nor be made whole for such operation when not dispatched by the Office of the Interconnection, **unless the Market Seller of the Generation Capacity Resource can justify to the Office of the Interconnection that operation outside of such unit–specific parameters was the result of an actual constraint.** Such Market Seller shall provide to the Market Monitoring Unit and the Office of the Interconnection its request to receive Operating Reserve Credits and/or to be made whole for such operation, along with documentation explaining in detail the reasons for operating its resource outside of its unit-specific parameters, within thirty calendar days following the issuance of billing statement for the Operating Day."

OA Schedule 1, Section 6.6 dictates that cost-based and price-based PLS schedules are parameter limited. As such, PJM interprets this language to apply only when a resource is committed on a cost-based or price-based PLS schedule.

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Real-Time Values

- Market Sellers have ability to communicate actual operational parameters to PJM before and after day-ahead market closes using ‘Real-time Value’ functions in Markets Gateway
- Real-time Values are utilized when resource cannot operate according to unit-specific parameters, default Parameter Limit Schedule, or pre-approved parameter exceptions.
- Real-Time Values used in calculation of Operating Reserve make-whole credits, except in cases where unit-specific parameters apply
- Unit-specific parameters do not apply to price-based (non-PLS) schedules

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Real-Time Values & Operating Reserve Credits

- If a Capacity Performance generator is committed or running on its cost-based or price-based parameter limited schedule, the generator is NOT made-whole for intervals during which unapproved real-time values are less flexible than unit-specific parameters
  - Positive net revenues (revenues > offer) for less flexible intervals are used in Operating Reserve credit calculation
  - Unit is not eligible for Operating Reserve Lost Opportunity Cost Credits for applicable interval

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Make Whole Credit Calculation Examples

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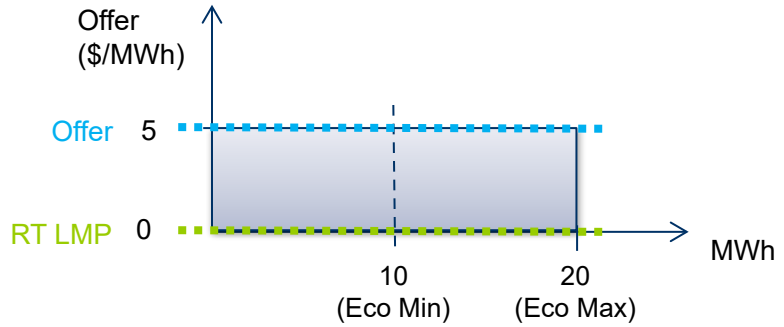
Make-Whole Examples: Set 1
No DA Commitment

Facts for each example:

- Resource is operating in Real-time only
- No ancillary service market participation
- Committed Offer = Final Offer
- Incremental Energy Offer: $5/MWh
- Startup & No Load Costs = $0
- Economic Min = 10 MW, Economic Max = 20 MW
- RT LMP = $0/MWh



Simplified Balancing Make Whole Credit Calculation

(assumes all DA values are 0 and no need to compare to committed offer given final offer has not changed. Several equation terms have been dropped for simplicity.)

Make Whole Credit	=	Cost			-	Value		
	=	RT MW Used	*	$/MWh Offer	-	Balancing Value MW Used	*	RT LMP
	=	Min(Operating Reserve Desired MW, RT MW)	*	$/MWh Offer	-	RT MW	*	RT LMP

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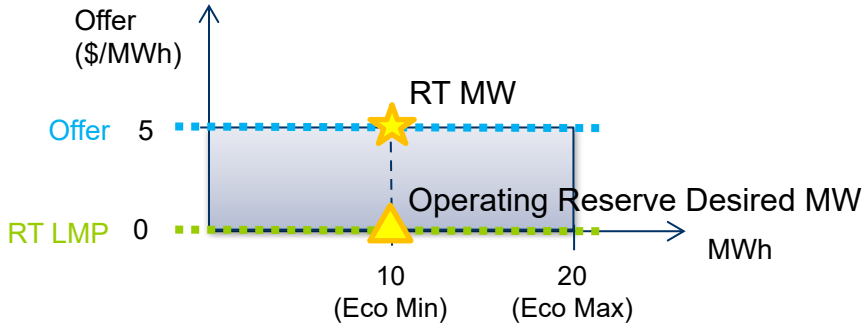
Example 1A: Operating at Desired MW

Example 1A:
RT MWh = 10
Offer = $5/MWh
RT LMP = $0/MWh
Operating Reserve Desired MWh = 10



Make Whole Credit	=	Cost			-	Value		
	=	RT MW Used	*	$/MWh Offer	-	Balancing Value MW Used	*	RT LMP
	=	Min(Operating Reserve Desired MW, RT MW)	*	$/MWh Offer	-	RT MW	*	RT LMP
	=	Min (10,10)	*	$5/MWh		10	*	$0/MWh
$50	=	10	*	$5/MWh	-	10	*	0/MWh

When a unit provides the Operating Reserve Desired MW, the full cost of those RT MW and the full revenue from those MW are included in the make whole credit calculation. Opportunity for cost recovery is maximized.

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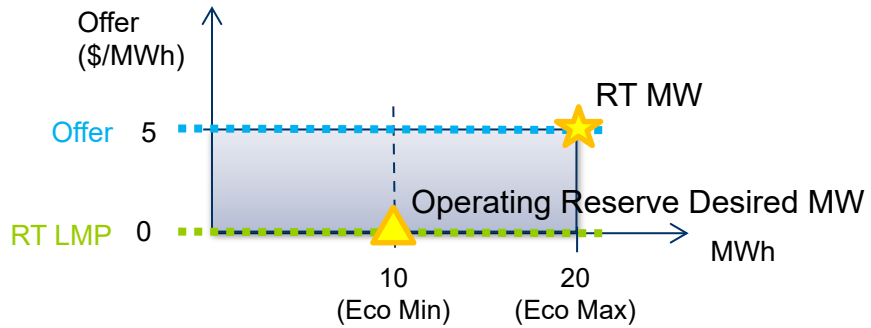
Example 1B: Operating Above Desired MW

Example 1B:
RT MWh = 20
Offer = $5/MWh
RT LMP = $0/MWh
Operating Reserve Desired MWh = 10



Make Whole Credit	=	Cost			-	Value		
	=	RT MW Used	*	$/MWh Offer	-	Balancing Value MW Used	*	RT LMP
	=	Min(Operating Reserve Desired MW, RT MW)	*	$/MWh Offer	-	RT MW	*	RT LMP
	=	Min (10,20)	*	$5/MWh		20	*	$0/MWh
$50	=	10	*	$5/MWh	-	20	*	0/MWh

In this scenario, the resource is only made whole for the MW PJM desired. It is providing the excess MW at the risk of not recovering the costs for those MW. Further, each dollar of revenue earned for the excess MW reduces the make whole credit by a dollar given the corresponding cost of those MW are not included in the cost side of the equation.

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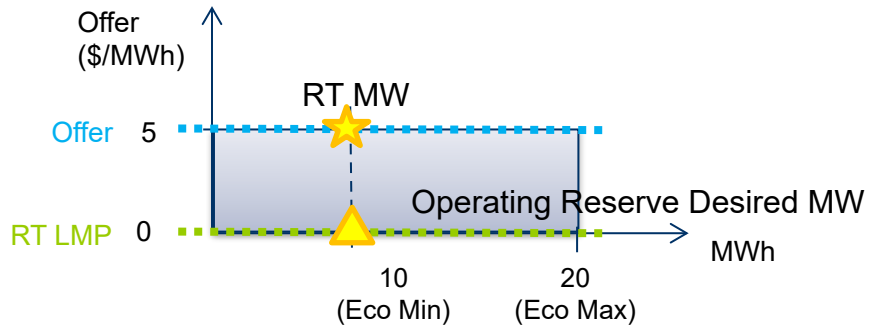
Example 1C: Operating Below Desired MW

Example 1C:
RT MW = 8
Offer = $5/MWh
RT LMP = $0/MWh
Operating Reserve Desired MW = 10



Make Whole Credit	=	Cost			-	Value		
	=	RT MW Used	*	$/MWh Offer	-	Balancing Value MW Used	*	RT LMP
	=	Min(Operating Reserve Desired MW, RT MW)	*	$/MWh Offer	-	RT MW	*	RT LMP
	=	Min (10,8)	*	$5/MWh		8	*	$0/MWh
$40	=	8	*	$5/MWh	-	8	*	0/MWh

In this scenario, the resource is only made whole to the cost of the MW provided. The value side of the equation captures the value of the RT MW provided.

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Set 1: Example Comparison

Scenario	Desired MW	Actual MW	Cost	Value	Make Whole Credit
1A: Operating At Desired MW	10	10	$50	$0	$50
1B: Operating Above Desired MW	10	20	$50	$0	$50
1C: Operating Below Desired MW	10	8	$40	$0	$40

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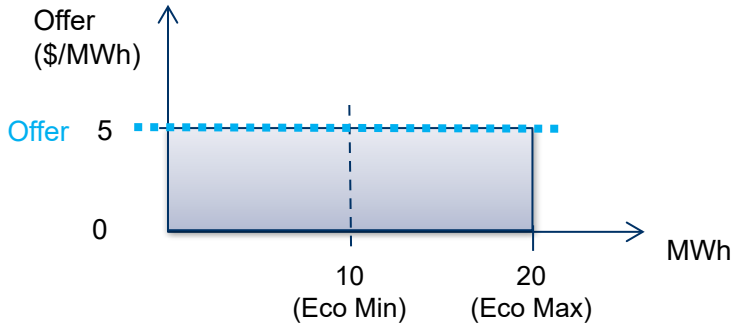
Make-Whole Examples: Set 2
RT Operation with DA Commitment

Facts for each example:

- Resource cleared day-ahead and operated in real-time
  - Day-ahead values needed for balancing calculation:
    DA MW = 15, DA Revenue = $75,
    DA Operating Reserve Credit = 0
- No ancillary service market participation
- Committed Offer = Final Offer
- Incremental Energy Offer: $5/MWh
- Startup & No Load Costs = $0
- Economic Min = 10 MW, Economic Max = 20 MW



Simplified Balancing Make Whole Credit Calculation

(Assumes no need to compare to committed offer given final offer has not changed)

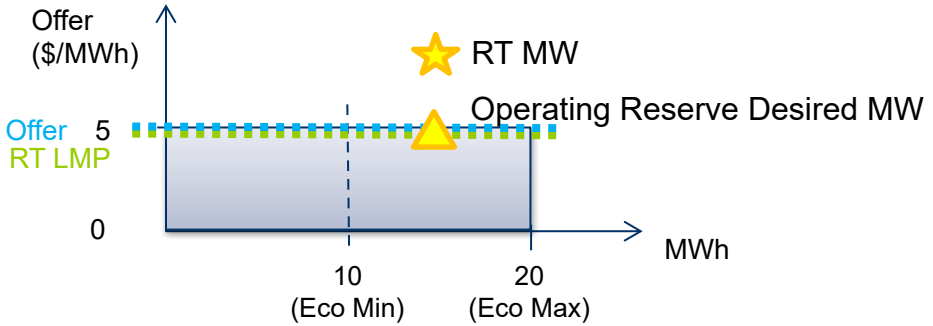
Make Whole Credit	=	Cost			-	Value								
	=	RT MW Used	*	$/MWh Offer	-	(Balancing Value MW Used	-	DA MW)	*	RT LMP	+	DA Revenue	+	DA Operating Reserve Credit
	=	Min(Operating Reserve Desired MW, RT MW)	*	$/MWh Offer	-	(Max (Min(DA MW, Op Res Desired MW), RT MW)	-	DA MW)	*	RT LMP	+	DA MW * DA LMP	+	DA Operating Reserve Credit

Example 2A: Operating at Desired MW

Example 2A:

RT MW = 15
Offer = $5/MWh
RT LMP = $5/MWh
Operating Reserve Desired MWh = 15

DA MW = 15
DA Revenue = $75
DA Op Res Credit = $0



Credit	=	Cost			-	Value								
	=	RT MW Used	*	$/MWh Offer	-	(Balancing Value MW Used	-	DA MW)	*	RT LMP	+	DA Revenue	+	DA Op Res Credit
	=	Min(Op Res Desired MW, RT MW)	*	$/MWh Offer	-	(Max (Min(DA MW, Op Res Desired MW), RT MW)	-	DA MW)	*	RT LMP	+	DA MW * DA LMP	+	DA Op Res Credit
	=	Min (15,15)	*	$5/MWh	-	(Max (Min(15, 15), 15)	-	15)	*	$5/MWh	+	$75	+	$0
	=	15	*	$5/MWh	-	(15	-	15)	*	$5/MWh	+	$75	+	$0
$0	=	$75			-	$75								

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Example 2A: Takeaway

When a unit provides the Operating Reserve Desired MW, the full cost of those RT MW and the full revenue from those MW are included in the make whole credit calculation. Opportunity for cost recovery is maximized.

Resource Profit/Loss for RT MW produced:

This P/L uses costs seen by PJM. It does not acknowledge other costs outside of PJM market.

DA Revenue	+	Balancing Revenue	-	Cost of RT MW	=	Profit / (Loss)
(DA MW * DA LMP)	+	(Bal MW * RT LMP)	-	(RT MW * Offer)		
$75	+	(0 MW * $5/MWh)	-	(15 MW * $5/MWh)		
$75	+	$0	-	$75	=	$0 Even

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Example 2B: Operating Above Desired MW

Example 2B:

RT MW = 20

Offer = $5/MWh

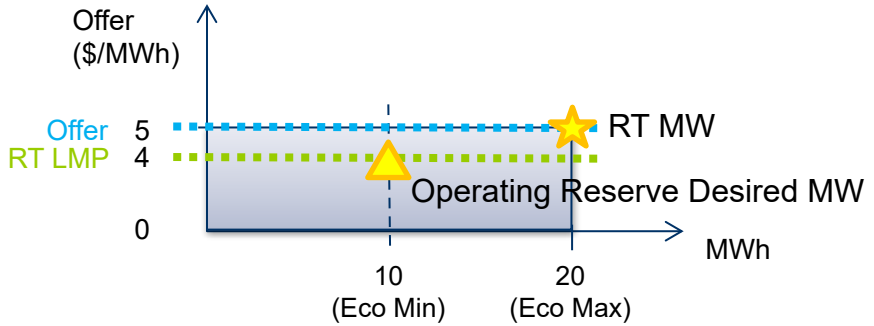
RT LMP = $4/MWh

Operating Reserve Desired MWh = 10

DA MW = 15

DA Revenue = $75

DA Op Res Credit = $0



Credit	=	Cost			-	Value								
	=	RT MW Used	*	$/MWh Offer	-	(Balancing Value MW Used	-	DA MW)	*	RT LMP	+	DA Revenue	+	DA Op Res Credit
	=	Min(Op Res Desired MW, RT MW)	*	$/MWh Offer	-	(Max (Min(DA MW, Op Res Desired MW), RT MW)	-	DA MW)	*	RT LMP	+	DA MW * DA LMP	+	DA Op Res Credit
	=	Min (10,20)	*	$5/MWh	-	(Max (Min(15, 10), 20)	-	15)	*	$5/MWh	+	$75	+	$0
	=	10	*	$5/MWh	-	(20	-	15)	*	$4/MWh	+	$75	+	$0
cannot be negative														
$0	=	$50			-	$95								

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Example 2B: Takeaway

In this scenario, the resource is only made whole for the MW PJM desired. It is providing the excess MW at the risk of not recovering the costs for those MW. Further, each dollar of revenue earned for the excess MW reduces the make whole credit by a dollar given the corresponding cost of those MW are not included in the cost side of the equation.

Resource Profit/Loss for RT MW produced:

This P/L uses costs seen by PJM. It does not acknowledge other costs outside of PJM market.

DA Revenue	+	Balancing Revenue	-	Cost of RT MW	=	Profit / Loss
(DA MW * DA LMP)	+	(Bal MW * RT LMP)	-	(RT MW * Offer)		
$75	+	(5 MW * $4/MWh)	-	(20 MW * $5/MWh)		
$75	+	$20	-	$100	=	$5 Loss

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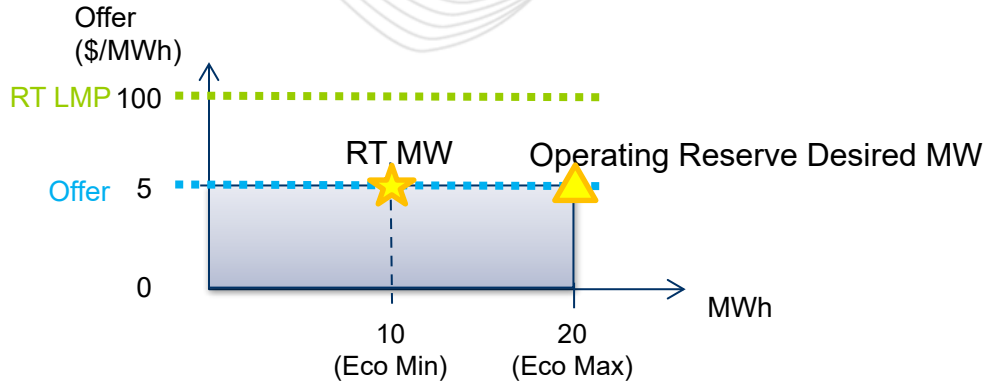
Example 2C: Operating Below Desired MW

Example 2C:

RT MW = 10
Offer = $5/MWh
RT LMP = $100/MWh
Operating Reserve Desired MWh = 20

DA MW = 15
DA Revenue = $75
DA Op Res Credit = $0



Credit	=	Cost			-	Value								
	=	RT MW Used	*	$/MWh Offer	-	(Balancing Value MW Used	-	DA MW)	*	RT LMP	+	DA Revenue	+	DA Op Res Credit
	=	Min(Op Res Desired MW, RT MW)	*	$/MWh Offer	-	(Max (Min(DA MW, Op Res Desired MW), RT MW)	-	DA MW)	*	RT LMP	+	DA MW * DA LMP	+	DA Op Res Credit
	=	Min (20,10)	*	$5/MWh	-	(Max (Min(15, 20), 10)	-	15)	*	$5/MWh	+	$75	+	$0
	=	10	*	$5/MWh	-	(15	-	15)	*	$4/MWh	+	$75	+	$0
cannot be negative $0	=	$50			-	$75								

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Example 2C: Takeaway

In this scenario, the resource is only made whole to the cost of the MW provided. However, the Balancing Revenue is zero because the MW used was set to the day-ahead MW, since the resource generated less than day-ahead and the desired MW was greater than day-ahead. This ensures that the make whole credit will only include any buyback for generation that is less than the day-ahead MW that was desired by PJM.

Resource Profit/Loss for RT MW produced:

This P/L uses costs seen by PJM. It does not acknowledge other costs outside of PJM market.

DA Revenue	+	Balancing Revenue	-	Cost of RT MW	=	Profit / Loss
(DA MW * DA LMP)	+	(Bal MW * RT LMP)	-	(RT MW * Offer)		
$75	+	(-5 MW * $100/MWh)	-	(10 MW * $5/MWh)		
$75	+	($500)	-	$50	=	$475 Loss

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Set 2: Example Comparison

Scenario	Desired MW	Actual MW	Cost	Value	Make Whole Credit	Profit / (Loss)
2A: Operating At Desired MW	15	15	$75	$75	$0	$0
2B: Operating Above Desired MW	10	20	$50	$95	$0	($5)
2C: Operating Below Desired MW	20	10	$50	$75	$0	($475)

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Desired MW

There are several variations of the Desired MW value that can be used in the operating reserve calculations.

Desired MW Type	Explanation
Ramp-limited Desired (RLD)	Output level that a resource should have achieved between dispatch signals.
Dispatch signal MW or UDS Basepoint MW	Output level requested via the dispatch basepoint issued by PJM's real-time dispatch tools
Dispatch LMP Desired	Output level based on the dispatch LMP and the incremental offer curve. This value is not ramp limited.
Real-time MW	Revenue Meter Value as defined in M28 section 1A.1 Business Rules for Revenue Data for Settlements.

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Determination of Operating Reserve Desired MW

Operating Reserve Desired MW is the umbrella term used for the desired MW value used in the Operating Reserve make whole credit calculation (as well as in the deviation charge calculation).

It is equal to one of Desired MW types referenced on the prior slide and is determined as follows:

- If the resource is a Combustion Turbine, then it equals Real-time MW;
- Otherwise, if any of the following are true, then it equals Dispatch LMP Desired;
  - Ramp-limited desired MW and Dispatch Signal are not available
    - This means they are unavailable due to technical reasons or Economic minimum and Economic maximum are not at least as far apart in real-time as they are in day-ahead as determined by:
      - RT eco min > 105% DA eco min or DA eco min plus 5 MW, whichever is greater
      - RT eco max < 95% DA eco max or DA eco max minus 5 MW, which ever is lower
  - Percent off dispatch is greater than 20%
  - Resource's Fixed Gen Flag is set in Real-time but not Day-ahead

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Determination of Operating Reserve Desired MW Continued

- Otherwise, if any of the following are true, then it equals Dispatch Signal MW
  - Dispatch Signal MW is less than or equal to the ramp-limited desired MW
  - Dispatch Signal MW is greater than the ramp-limited desired MW and the resource's Real-time MW is greater than the ramp-limited desired MW
- Otherwise it equals Ramp-Limited Desired MW
  - That is, all of the above conditions must be false for Ramp-Limited Desired MW to be used as Operating Reserve Desired MW

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Ramp Limited Desired: Opportunity for Improvement

- PJM recognizes the opportunity to improve the operating reserve make whole credit rules to provide stronger incentives for resources to follow PJM's dispatch signal
- Possible areas of improvement include:
  - Ramp Limited Desired
    - An important component in determining make-whole credits
    - The degree to which a unit follows PJM's signals can influence the Ramp Limited Desired MW
      - The unit's SE MW can limit the degree to which the dispatch software can move the unit
  - The use of actual MW for combustion turbines
    - At the time the rule was implemented, combustion turbines were incapable of following PJM's dispatch signal
    - Provide a better incentive for current technology to follow PJM's dispatch signal

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Contact

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

Secretary:
Nick Disciullo,
Nick.Disciullo@pjm.com

SME/Presenter:
Brian Weathers,
Brian.Weathers@pjm.com

Operating Reserve Make Whole Credit Education

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

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