

IMM Alternative/Supplemental Language to PJM's Manual 11 Reserve Price Formation Revisions

Section 4.2 PJM Reserve Market Offer Business Rules

Section 4.2.1 Reserve Market Resource Eligibility

In general, Generation, Energy Storage Resources, and Economic Load Response resources are eligible to provide Synchronized Reserves, Non-Synchronized Reserves, and Secondary Reserves except if:

- The resource is not within the metered boundaries of PJM
- The entire output is offered as Emergency Only
- The resource type includes: Nuclear, Wind, or Solar, unless an exception is requested and approved
- The resource is not available to provide energy or reduce load

In addition, the following resources are not eligible to provide Non-Synchronized Reserves:

- Economic Load Response
- ~~Energy Storage Resources enrolled in the ESR participation model~~
- ~~Pumped hydro resources that are not participating in the PJM optimized pumped storage model~~

Generation resources, including ESRs enrolled in the ESR participation model, must be able to provide 0.1 MW of Reserve Capability in order to participate in the Reserve Markets.

In the event PJM forecasts a credible natural gas pipeline contingency(s), as described in PJM Manual 13: Emergency Operations, Section 3.9, PJM Dispatch will determine the eligibility of resources to provide Reserves depending on the severity of the contingency and other system conditions in order to ensure system reliability is maintained .

Section 4.2.1.1 Requests for Eligibility for Nuclear, Wind, Solar Resources

The Market Seller of a nuclear, wind, or solar resource may obtain approval for the resource to be considered eligible to provide reserves by submitting to the Office of the Interconnection and the Market Monitoring Unit a written request for exemption and provide documentation to support the resource's ability to follow dispatch at the direction of PJM, such as historical operating data showing voluntary response to reserve events and/or technical information about the physical operation of the resource. Requests and questions may be submitted by Market Sellers to Reserves@pjm.com.

The Office of the Interconnection and the Market Monitoring Unit will review, in an open and transparent manner as between the Market Seller, the Market Monitoring Unit, and the Office of the Interconnection, the information and documentation in support of the request for approval to provide reserves.

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PJM will determine, with the advice and input of the Marketing Monitoring Unit, whether the resource will be permitted to provide reserves and provide written notification to the Market Seller of such determination no later than 30 business days from the date of data submittal supporting the request. If the request is denied, PJM will include in the notice a written explanation for the denial.

Section 4.2.1.2 Economic Load Response Reserve Eligibility

- Economic Load Response must successfully complete Ancillary Services certification in PJM DR Hub system for Reserve Market participation.
- Economic Load Response must be able to provide 0.1 MW of Reserve Capability in order to participate in the Reserve Markets.
 - See section 10.5 in this Manual for Economic Load Response aggregation rules to meet the 0.1 MW threshold for locations that have capability less than 0.1 MW.
- Economic Load Response providing reserves are required to provide after-the-fact meter data at a one (1) minute interval for each location called on to respond in a reserve event.
- Residential locations without meters recording at a one (1) minute interval or shorter may participate using the statistical sampling method detailed in PJM Manual 19: Load Forecasting and Analysis, Attachment D and subject to PJM approval.
- After-the-fact one (1) minute meter data for locations called on to respond in a reserve event must be submitted into the PJM DR Hub system no later than two (2) business days following the event day.
- Economic Load Response Curtailment Service Providers not providing complete, accurate and timely meter data for locations called on to respond in a reserve event may be suspended from participating in the Reserve Markets until corrective measures are implemented and may be referred to the PJM Market Monitor and/or the FERC Office of Enforcement for further investigation as necessary.
- Economic Load Response Curtailment Service Providers must complete initial and continuing training on Regulation and Reserve Markets as documented in PJM Manual 40: Certification and Training Requirements, Section 2.6: Training Requirements for Demand Response Resources Supplying Regulation and Reserve.
- Whenever Economic Load Response assigned in the Reserve Markets is called on to respond to a mandatory Emergency or Pre-Emergency Load Management Event, it will be de-assigned from Reserves for any intervals that overlap with the Load Management Event, starting from the notice time of the Load Management Event, unless otherwise approved by PJM. PJM will not assign the resource to Reserves for the remainder of the mandatory portion of the Load Management Event.
- Economic Load Response that demonstrate the ability to receive reserve commitments via approved telemetry (e.g. Jetstream) qualify as a Flexible resource. Otherwise, Economic Load Response resources are regarded as Inflexible resources.

Section 4.2.2 Reserve Resource Offer Requirements

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- Any generator that is a PJM generation capacity resource that has a Reliability Pricing Model (RPM) or Fixed Resource Requirement (FRR) Resource commitment that is eligible to provide Reserves must offer their 10-minute and 30-min reserve capability, unless the unit is unavailable due to an approved planned outage, maintenance outage or forced outage.
 - If a resource that has a reserve must offer requirement chooses to not make its reserve capability available, for example through self-scheduling or offering a fixed output, when the resource is otherwise able to operate with a dispatchable range, the resource is defined to be violating the reserve must offer requirement.
- All other generation resources that are eligible to provide reserves that have submitted Energy offers are considered to have offered the unit's applicable capability into the reserve markets
 - Hydroelectric, Economic Load Response and Energy Storage Resources (ESR) are not considered available by default, and must submit specific reserve offers to be considered. Hydroelectric, Economic Load Response and Energy Storage Resources reserve offers must be based on their realistic achievable ramp rate and current operating conditions. Any hydroelectric or Energy Storage resource with a reserve must offer requirement that cannot provide reserves must communicate to PJM and the MMU the reasons why it cannot provide reserves to Reserves@pjm.com.
 - For multiple physical units that are modeled as an aggregated resource in the Market system, if at least one of the physical units are online, then the aggregate is considered online and may be considered for online synchronized and/or online secondary reserves, but not eligible for non-synchronized reserve.

Section 4.2.2.1 Communication for Reserve Capability Limitation

A generation resource owner may request a lesser synchronized reserve maximum or secondary reserve maximum than the economic maximum if a physical limitation exists that cannot be addressed using the multi-segmented hourly ramp rate or using the real-time reserve deselection exception process. Resource owners ~~must~~ may submit ~~such a~~ request ~~for this modification~~ to Reserves@pjm.com. A copy of this email will be made available to the Market Monitoring Unit. The request ~~must~~ should include the Markets Gateway unit name, unit id, reason, and documentation to support the request. Examples of the types of information and documentation PJM would request to support adjusted unit-specific parameter limits requests:

- Original Equipment Manufacturer (OEM) documentation
- Control room data
- Operational procedure listing the required steps along with the time required to perform each step during ramping.

PJM will determine, with the advice and input of the Marketing Monitoring Unit, whether the request is approved or denied and provide a written notification to the generation resource owner no later than 30 business days from the date of data submittal supporting the request. If the request is denied, PJM will include in the notice a written explanation for the denial.

Section 4.4 Reserve Market Clearing

PJM schedules resources as needed to meet the Reserve Requirements of each Reserve Zone and active subzone via joint optimization with energy in both the day-ahead and real-time markets. Resources are scheduled based on the resource-specific offer data submitted as defined in Section 4.2 of this Manual and the product substitution cost of providing energy or any other product the resource is capable of providing. The joint optimization seeks to procure and minimize the total production cost of energy and meeting the various reserve requirements as described in Section 4.3 of this Manual, and in the Real-time Market, the Regulation Requirement as described in Section 3.2.4 of this Manual.

Reserves and energy will be co-optimized the same way in the Day-ahead and Real-time Market.

- The same reserve zone configuration will be modeled in day-ahead and real-time unless there is an operational emergency requiring it to be changed in real-time

Section 4.4.1 Product and Locational Substitution

As described in Section 4.1, the Synchronized Reserve, Non-Synchronized Reserve and Secondary Reserve products have a priority sequence based on the level of reliability which each provides. Synchronized Reserve, being the most reliable as it is online and can respond in ten (10) minutes or less, can also meet the Primary and 30-Minute Reserve requirements. Likewise, Non-Synchronized Reserve can also meet the 30-Minute Reserve requirement.

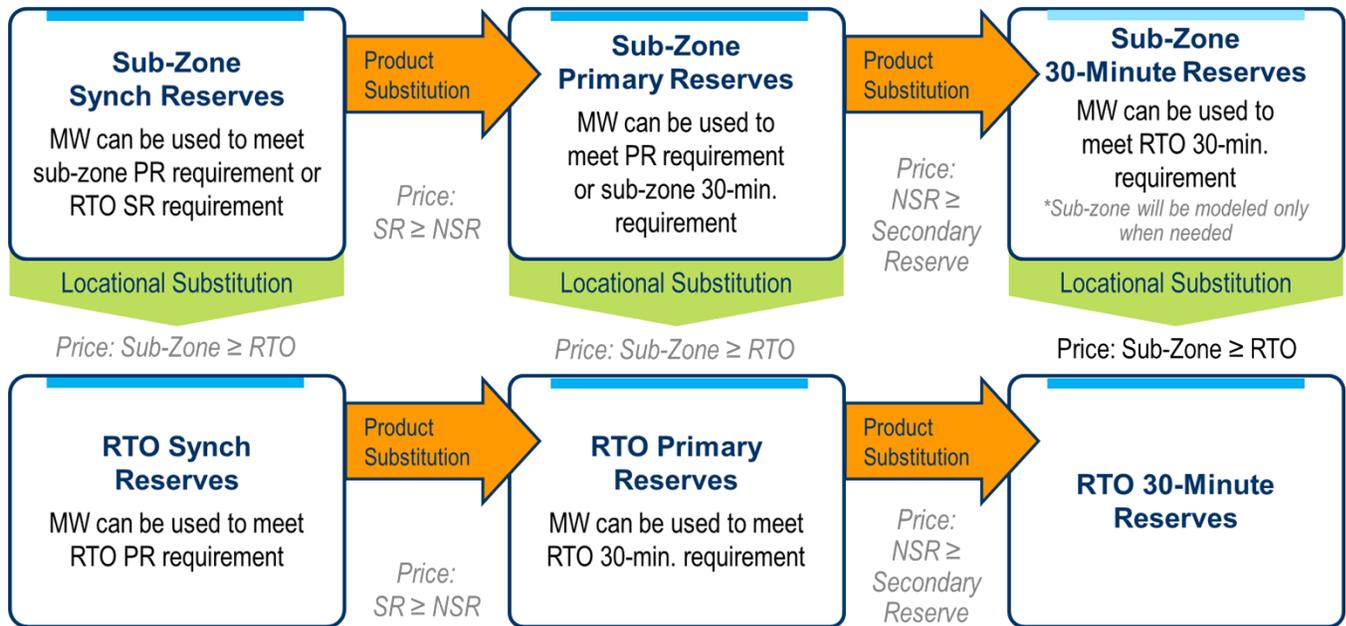
In addition, the location of the reserves procured also have a hierarchy. Reserves procured in a subzone can also meet the requirement of the RTO.

As a result, a megawatt cleared in a subzone for Synchronized Reserves can also be used to meet the RTO Synchronized Reserve Requirement, the subzone Primary Reserve Requirement, the RTO Primary Reserve Requirement, the subzone 30-minute Reserve Requirement (if modeled), and the RTO 30-minute Reserve Requirement.

PJM will commit the most economic combination of resources to simultaneously meet all energy and reserve requirements.

The graphic below illustrates the product and locational substitution.

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Section 4.4.2 Day-ahead Reserve Market Clearing

The Day-ahead Reserve Market clearing results in an hourly price for Synchronized Reserves, Non-Synchronized Reserves, and Secondary Reserves for the next day, and is posted along with the resource-specific reserve assignments from the dispatch run by 1330 EPT via the PJM Markets Gateway System.

The hourly Reserve Clearing Prices are fixed once calculated and posted by 1330 EPT the day before the Operating Day. The hourly Reserve clearing prices are based upon the offer prices submitted by the selected resources, together with any opportunity cost a resource incurs in the Day-ahead joint-optimization process, from the pricing run, in order to meet the Reserve Requirements.

The hourly Day-ahead Market Reserve clearing prices are set equal to the merit order price of the highest cost Reserve Resource necessary to meet the remaining requirement in the pricing run and may include Amortized Start-Up and/or Amortized No-Load costs for eligible Fast-Start Resources as part of the integer relaxation method.

- ~~For the purpose of determining the most economic set of resources with which to meet the Reserve Requirements, PJM will calculate a resource-specific merit order price for each resource using the following methodology:~~
 - ~~Resource merit order price (\$/MWh) = Resource Synchronized Reserve Offer + resource opportunity cost per MWh of capability + condense energy use per MWh of capability + condense startup cost~~
 - ~~**Note:** Condense startup cost is not included in the determination of the clearing price.~~

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Section 4.4.3 Real-Time Reserve Market Clearing

Sixty (60) minutes prior to the operating hour PJM executes the Ancillary Services Optimizer (ASO). The ASO jointly optimizes Energy, Synchronized Reserves, Non-Synchronized Reserves, Secondary Reserves, and Regulation based on forecast system conditions to determine an economic set of inflexible reserve resources to commit for the operating hour. Inflexible resources are defined as those resources that physically require an hourly commitment due to minimum run time constraints or staffing constraints. Inflexible resources include: ~~but are not limited to~~

- Synchronous condensers that are operating in condensing mode solely for the purpose of providing Synchronized Reserves ~~and~~
- Economic Load Response that are prepared to curtail in response to a PJM Reserve Event and that do not receive assignments via telemetry.

Any inflexible self-scheduled offers for Synchronized Reserves that are available at the time of the ASO execution are assumed valid and committed for the hour.

Any reserve commitments on inflexible resources that are made are locked for the operating hour and communicated via Markets Gateway.

- Condensers and Inflexible Economic Load Response resources that are cleared day-ahead will have their commitments carried to real-time
 - These resources need to have a min run time (min down time for ELR) no greater than one hour and ~~Condense n~~Notification ~~Time~~ no greater than ~~between ten and thirty minutes.~~
 - The reserve commitment is carried over unless in real-time the resource is committed to provide energy or another ancillary product

The following reserve information will be posted to Markets Gateway thirty (30) minutes prior to the operating hour from the approved ASO case:

- Preliminary Reserve Requirements for the RTO and active Sub-Zone.
- Total projected Reserve MW transferrable from the RTO into the active Sub-Zone.
- Total preliminary assigned reserve MWs for the RTO and active Sub-Zone.
- Total preliminary self-scheduled Reserves for the RTO and active Sub-Zone.
- Forecasted reserve deficit MW quantities for the RTO and active Sub-Zone.

The following resource specific reserve information will be posted to Markets Gateway thirty (30) minutes prior to the operating hour from the approved ASO case:

- Reserve Offer MW for the applicable product
- Inflexible Reserve Awarded MW for the applicable product
- Inflexible Synchronized Reserve Self-scheduled MW

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Additional Real-time Reserve commitments may be made on flexible reserve resources by the RT SCED application and additional inflexible reserves resources recommendations by the IT SCED application. Commitments on flexible reserves resources may change with each execution of the RT SCED application while commitments on inflexible reserve resources will respect the minimum run time of those resources. PJM Operator, if necessary, may manually request an inflexible resource previously committed for reserves to provide energy. Such reasons include but are not limited to constraint control. Such action will automatically terminate the resource's reserve assignment.

- Flexible reserve resource commitments will not be posted to Markets Gateway but will be telemetered via ICCP or other communication protocol to resource owners.
- Additional inflexible resource commitments will be communicated to the resource owners via ICCP or other communication protocol.

PJM utilizes resource specific offers together with energy offers and resource schedules from the Markets Gateway System, as input data to the Ancillary Service Optimizer (ASO). ASO then optimizes the RTO dispatch profile and forecasts LMPs to determine hourly commitments for inflexible resources.

Although the ASO considers all available resources during its commitment process, the hourly commitments for Reserves from the ASO are limited to inflexible resources only and may only represent a portion of PJM's Reserve needs for the hour.

IT SCED has the ability to project conditions further out into the future and make a recommendation to commit additional inflexible resources for reserves where they are economic.

The Real-time Security Constrained Economic Dispatch (RT SCED) program jointly optimizes the remaining RTO Reserve needs simultaneously with Energy while honoring effective regulation assignments. For more information on how RT SCED uses Reserve commitments in the joint optimization, please refer to Section 2.5 of this Manual. The Locational Pricing Calculator (LPC) calculates a clearing price for Reserve every five (5) minutes as described in Section 2.7 of this Manual. Five (5) minute, Real-time, Synchronized Reserve Market Clearing Prices (SRMCP), Non-Synchronized Reserve Market Clearing Prices (NSRMCP), and Secondary Reserve Market Clearing Prices (SecRMCP) are used for market settlement.

During each execution of RT SCED, additional Reserve MWs may be committed to meet the Reserve Requirements from flexible resources for all services based on forecasted system conditions by re-dispatching online generating resources. In addition, RT SCED will commit offline resources to meet the balance of the Primary Reserve Requirement and 30-minute Reserve Requirement.

PJM may call on resources not otherwise scheduled to run in order to provide Reserves, in accordance with PJM's obligation to maintain reliability. If a resource is called on by PJM for the purpose of providing Reserves, the resource is guaranteed recovery of applicable Reserve lost

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opportunity costs as well as start up, no-load and energy costs. Please refer to PJM Manual 28: Operating Agreement Accounting for additional settlements details.

The Real-time Market Reserve clearing prices are set equal to the merit order price of the highest cost Reserve Resource necessary to meet the remaining requirement in the pricing run and may include Amortized Start-Up and/or Amortized No-Load costs for eligible Fast-Start Resources as part of the integer relaxation method.

Resources cannot clear the Real-time Reserve and Regulation Markets for the same interval. The requirement for regulation is first met before reserves because regulation is a higher priority service.

- ~~● For the purpose of determining the most economic set of resources with which to meet the Reserve Requirements, PJM will calculate a resource-specific merit order price for each resource using the following methodology:
 - ~~○ Resource merit order price (\$/MWh) = Resource Synchronized Reserve Offer + estimated resource opportunity cost per MWh of capability + energy use per MWh of capability + condense startup cost~~
 - ~~▪ **Note:** Condense startup cost is not included in the determination of the clearing price. The opportunity cost for Economic Load Response is zero.~~~~

Section 4.4.3.1 Real-Time Reserve Assignment

Inflexible reserve assignments are initially determined by ASO. The inflexible reserve assignments are bridged from ASO to RT SCED. The assignments in RT SCED are modified during situations in which the inflexible reserve resource cannot provide synchronized reserves. These situations are captured by PJM in DMT.

Reserve MW assignments are derived from the latest approved Real-time Security Constraint Economic Dispatch (RT SCED) program solution for the target time at the end of the current five (5) minute interval. If there is not an approved RT SCED solution for the target time at the end of the current five (5) minute interval, the reserve MW assignments will use the most recent approved RT SCED solution prior to the target time as the reference case.

Section 4.4.3.2 PJM Reserve Deselection of Reserve Resources in Real-Time

To accurately account for reserves, PJM may temporarily deselect a resource from being eligible for reserves and if necessary deassign a current reserve commitment in certain market intervals. PJM Dispatchers are responsible for logging generating resources in the Dispatch Management Tool (DMT). Under certain operating conditions, resources cannot reliably provide reserves. These conditions are reflected in the DMT logs. Under the following operating conditions, resources will be deselected from clearing reserves synchronized, nonsynchronized and secondary reserves and exempt from the reserve must offer requirement::

- Cleared Regulation
- Testing
- Released / Tripped / Cancelled / Failed to Start

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• Startup

Resources that do not respond to PJM's dispatch signal and therefore cannot reliably be counted towards providing reserves can also be deselected by PJM. Resources deselected from providing reserves due to failure to respond to PJM's dispatch signals will be in violation of the reserve must offer requirement. Market Sellers should update their Offer Data as practical as possible to reflect any limitation in their capability to provide energy or reserves. This includes updating their economic minimum, economic maximum and ramp rates.

~~for reasons that include but are not limited to the following:~~

- ~~• Resource is not following its dispatch signal~~
- ~~• Resource owner has indicated via telemetry or phone call to PJM Dispatch that a resource is not available due to a physical limitation of the unit or at the plant~~
 - ~~○ Resource owner must submit a request for qualification to communicate reserve unavailability via telemetry by emailing Reserves@pjm.com. A copy of this email will be made available to the Market Monitoring Unit. The request should include the Markets Gateway unit name, unit id, and technical information about the operational modes, limits, or conditions to support the request. PJM will determine, with the advice and input of the Marketing Monitoring Unit, whether the request is approved or denied and provide a written notification to the generation resource owner no later than 60 business days from the date of data submittal supporting the request. If the request is denied, PJM will include in the notice a written explanation for the denial.~~

Section 4.4.3.3 Reserve Deselection in Real-Time Exception Process

Any Market Seller that believes its generating unit has operating modes, limits, or conditions where the unit would not be capable of providing Synchronized and/or Secondary Reserves in real time, can submit to PJM and the MMU a request for an exception from being assigned Synchronized and/or Secondary Reserves in the Real-time Reserve Markets during time periods in which the generating unit is in those operating modes, limits, or conditions. The request must be submitted to Reserves@pjm.com.

As part of the request, the Market Seller shall supply, for each generating unit, technical information about the operational modes, limits, or conditions to support the requested exception. Only actual physical operational limitations, environmental limitations and other actual constraints on a resource will be considered for an exception. The following list is not an exhaustive list, but provides examples of the types of information and documentation PJM would request to support adjusted unit-specific parameter limits requests:

- Original Equipment Manufacturer (OEM) documentation
- Control room data
- Operational procedure listing the required steps along with the time required to perform each step during ramping.

PJM shall consult with the MMU, and consider any input received from the MMU, in its determination of a request for such an exception. Within 60 days of the submission of the request, PJM shall notify the Market Seller in writing, with a copy to the MMU, whether the request is

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approved or denied. The effective date of any approved request will be provided in the written notification.

If a Market Seller has an approved exception, the Market Seller must communicate via telemetry primarily (or via phone calls when telemetry is not available) to PJM when the unit cannot provide reserves.

An approved exception will remain applicable to the unit until such time as PJM determines that a change is needed or the Market Seller notifies PJM, with a copy to the MMU, that a change is needed based on changed operational capabilities of the unit. Market Sellers must notify PJM, with a copy to the MMU, within 30 days of any changed operational capabilities that necessitate a change in an approved exception.

Section 4.4.4 Opportunity Costs for Condensers

~~Estimated resource opportunity cost for condensing CTs is calculated, based on the dispatch run, as follows:~~

$$O.C. = \text{[positive (forecast LMP - energy offer price)]} \times \text{MW capability} / \text{synchronized reserve capability}$$

~~Estimated resource opportunity cost for non-condensing resources is calculated, based on the dispatch run, as follows:~~

$$O.C. = \text{[LMP - ED]} \times \text{GENOFF}$$

Where:

LMP	is the forecasted hourly LMP at the generator bus,
ED	is the price associated with the set point the resource must maintain to provide its assigned amount of Synchronized Reserve, and
GENOFF	is the MW amount of Synchronized Reserve provided.

~~This formula is somewhat simplistic. The actual calculation is an integration that may be visualized as the area on a graph enclosed by the resource's energy offer curve. The points on that curve correspond to the resource's desired economic dispatch and the set point necessary to provide the assigned amount of Reserve and the LMP.~~

~~Energy use for each condensing resource is entered in MW by the owner via the Markets Gateway system as part of the Reserve Offer. Estimated energy use is calculated as part of the merit order price as follows:~~

$$E.U. = \text{forecast LMP} \times \text{energy use MW} / \text{synchronized reserve capability}$$

~~For each of these calculations, forecast LMP is the result of the 1-hour look-ahead calculated in the ASO. Energy resources for which an energy offer is not submitted will be ineligible for opportunity cost credit.~~

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~~When calculating the reserve MCP in Real-time, the actual LMP is used instead of the forecast LMP in the previous equations and calculated in the LPC engine. The actual five minute reserve MCP, calculated using the LPC pricing run, is used for settlements.~~

~~Hydropower units condensing to provide Reserves during times when they were not scheduled to operate incur no opportunity cost. There may or may not be an energy use component, as indicated by the owner as part of the Reserve Offer. Only hydropower units not enrolled in the ESR participation model are considered in the rules below.~~

- ~~• If a hydropower unit is held to condense for reserves or reduced to provide reserves during a time when it is scheduled to generate, it will incur opportunity cost. Since hydropower units operate on a schedule and do not have an energy bid, opportunity cost for these units is calculated as follows:
 - ~~○ The formula is the same as that shown under 'Reserve Commitment', O.C. = $|LMP - ED| \times GENOFF$, except the ED value is the average value of the LMP at the hydropower unit bus for the appropriate on-peak (0700–2259) or off-peak (0000–0659, 2300–2359) period, excluding those hours during which all available units at the hydropower plant were operating. Day-ahead values are used for the purposes of committing reserve resources, and actual LMPs are used in the after-the-fact settlement. If the average LMP value is higher than the actual LMP at the generator bus, the opportunity cost is zero.~~~~
- ~~• During those hours when a hydropower unit is in spilling mode, the ED value is set to zero such that the opportunity cost is based on the full value of LMP. During the operating day, the operating company is responsible for communicating this condition on the Regulation Hourly Updates page in the Markets Gateway System.~~
- ~~• When determined to be economically beneficial, PJM maintains the authority to adjust hydropower unit schedules for those units scheduled by the owner if the owner has also submitted a Synchronized Reserve Offer for those units and made the units available for spin.~~
- ~~• An example of the reserve lost opportunity cost calculation is very similar to that of the regulation hydropower lost opportunity cost calculation detailed on the PJM website at <https://pjm.com/-/media/markets-ops/ancillary/regulation-uplift-andlost-opportunity-cost.ashx?la=en>.~~

Section 4.4.5 Determination of Reserve Clearing Prices

PJM clears the Reserve markets based on the locational Reserve Requirements and calculates clearing prices for the RTO and active subzone where applicable. Whenever the locational reserve constraint is not binding, the clearing prices are equal for each category of the reserve products. However, when more Reserves are required in a given location than would have been assigned without this requirement, the clearing prices will separate. Resources will be identified and receive the applicable clearing price based on their location with respect to the binding constraint(s). That is, resources for which reserve event response would help the constraint will receive the higher clearing price, whereas resources for which reserve event response would aggravate the constraint will receive the lower clearing price.

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Day-ahead prices for Synchronized Reserves, Non-Synchronized Reserves, and Secondary Reserves are calculated simultaneously with Energy every hour, in the pricing run of the Day-ahead joint-optimization process.

Real-Time prices for Synchronized Reserves, Non-Synchronized Reserves, and Secondary Reserves are calculated simultaneously with Energy, and Regulation, every five (5) minutes by LPC, in the pricing run, as described in Section 2.7 of this Manual.

The prices for Synchronized Reserves, Non-Synchronized Reserves, and Secondary Reserves will be calculated as the marginal cost to serve an additional MW of applicable reserve product in the RTO Reserve Zone and applicable active Reserve Sub-Zone while simultaneously satisfying energy requirements, regulation requirements, synchronized reserve requirement, primary reserve requirements, 30-minute reserve requirements, and transmission limitations.

The hourly Day-ahead Reserve clearing prices from the pricing run are fixed once calculated and posted in Markets Gateway and Data Miner with the Day-ahead results by 1330 EPT the day before the Operating Day.

Preliminary Real-time five (5) minute SRMCPs, NSRMCPs, and SecRMCPs from the pricing run will be published to Data Miner for public view. The procedure for finalizing the Real-time MCPs along with LMPs is described in section 2.10 of this manual.

During periods when there is no reserve shortage, prices for Reserves will be determined by the cost of the applicable marginal reserve resource of the product type.

- The cost of the marginal reserve resource is defined as its reserve offer plus any opportunity cost for this resource relative to forgone energy or other ancillary service payments. In the pricing run, the cost of the marginal reserve resource may also include amortized Start-Up and amortized No-Load Costs due to integer relaxation for eligible Fast-Start resources.

Cost of the Marginal Reserve Resource = Reserve Offer + Lost Opportunity Cost + (Amortized Start Up Cost + Amortized No Load Cost)*

*Amortized Start-Up and No-Load Cost may only be included in the pricing run due to integer relaxation for eligible Fast-Start resources.

Resource Opportunity Costs (\$) = LMP – Resource Energy Offer

When there is a Reserve shortage, the maximum Real-time prices are capped as follows:

- Synchronized Reserves capped at two times the penalty factor (\$1,700)
- Non-synchronized Reserves capped at one and a half times the penalty factor (\$1,275)
- Secondary Reserves capped at one times the penalty factor (\$850)

4.4.5.1 Determination of Synchronized Reserve Clearing Prices

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During periods when there is no Synchronized Reserve Shortage, the SRMCP is the cost of the Marginal Synchronized Reserve resource. During periods when there is a shortage of Synchronized Reserves, the SRMCP will be greater than or equal to the penalty factor of the location where the shortage occurred.

The ~~prices for~~ Synchronized Reserve Market Clearing Price (SRMCP) will always be greater than or equal to the Non-Synchronized Reserve Market Clearing Price (NSRMCP) in the same location because Synchronized Reserve is a higher quality product than Non-Synchronized Reserves and may be substituted for it. Similarly, the ~~Real-time prices for~~ Non-Synchronized Reserve Market Clearing Price (NSRMCP) will always be greater than or equal to the Secondary Reserve Market Clearing Price (SecRMCP) in the same location because Non-Synchronized Reserve is a higher quality product than Secondary Reserves and may be substituted for it as referenced in section 4.4.1.

The price for each reserve product will not exceed the greater of the price cap for the reserve product or the sum of the penalty factor and the prices for the lower quality reserve products for the same location.

The Day-ahead hourly SRMCPs and Real-time five (5) minute SRMCPs from the pricing run are used for market settlement purposes.

Resources that are assigned Synchronized Reserves will be paid the SRMCP corresponding to the location in which they provided the service.

4.4.5.2 Determination of Non-Synchronized Reserve Clearing Prices

During periods when there is no Primary Reserve Shortage, the NSRMCP is the cost of the Marginal Primary Reserve Resource. If the marginal resource is a Synchronized Reserve Resource, the cost of the Marginal Primary Reserve Resource is defined as its Synchronized Reserve Offer plus any opportunity cost for this resource relative to forgone energy or other ancillary service payments.

During periods when there is a shortage of Primary Reserves, the NSRMCP will be greater than or equal to the penalty factor of the location where the shortage occurred.

The NSRMCP will always be less than or equal to the SRMCP in the same location because Synchronized Reserve is a higher quality product than Non-Synchronized Reserve and may be substituted for it.

The Day-ahead hourly NSRMCPs and Real-time five (5) minute NSRMCPs from the pricing run are used for market settlement purposes.

Resources that are assigned Non-Synchronized Reserves will be paid the NSRMCP corresponding to the location in which they provided the service.

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4.4.5.3 Determination of Secondary Reserve Clearing Prices

During periods when there is no 30-minute Reserve Shortage, the SecRMCP is the cost of the Marginal 30-minute Reserve Resource. If the marginal resource is an online Reserve Resource, the cost of the Marginal 30-minute Reserve Resource is defined as its Reserve Offer plus any opportunity cost for this resource relative to forgone energy or other ancillary service payments.

During periods when there is a shortage of 30-minute Reserves, the SecRMCP will be equal to the penalty factor of the location where the shortage occurred.

The SecRMCP will always be less than or equal to the SRMCP and NSRMCP in the same location because Synchronized Reserve and Non-Synchronized Reserve are higher quality products than Secondary Reserve and may be substituted for it.

The hourly Day-ahead SecRMCPs and Real-time five (5) minute SecRMCPs from the pricing run are used for market settlement purposes.

Resources that are assigned 30-minute Reserves will be paid the SecRMCP corresponding to the location in which they provided the service.