PJM Manual 28:

Operating Agreement Accounting

Revision: 85

Effective Date: September 1, 2021

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Section 6: Synchronized Reserve Accounting

Welcome to the Synchronized Reserve Accounting section of the ***PJM Manual for Operating Agreement Accounting***. In this section, you will find the following information:

- A description of how Synchronized Reserve are provided and accounted for in the PJM Energy Markets (see "Synchronized Reserve Accounting Overview").
- How credits are calculated for providers of Synchronized Reserve (see "Credits for Synchronized Reserve").
- How the total cost of Synchronized Reserve is allocated (see "Charges for Synchronized Reserve").
- How Synchronized Reserve charge reconciliations are calculated (see "Reconciliation for Synchronized Reserve Charges").

6.1 Synchronized Reserve Accounting Overview

Synchronized Reserve shall be supplied from resources located within the metered boundaries of PJM Resources participating in the Synchronized Reserve market are divided into two tiers. Tier 1 is comprised of all those resources on-line following economic dispatch and able to ramp up from their current output in response to a synchronized reserve event. Tier 2 consists of the additional resources that are synchronized to the grid and operating at a point that deviates from economic dispatch (including condensing mode) to provide additional Synchronized Reserve not available from Tier 1 resources. Synchronized Reserve resources include generators and Demand Resources.

The total PJM Synchronized Reserve Requirement is defined as the amount of 10-minute reserve that must be synchronized to the grid in accordance with the applicable NERC Council standards.

Tier 1 Synchronized Reserve credits are awarded to all resource owners whose resources increased output or decreased consumption in response to a synchronized reserve event (with the exception of those resources that were assigned Tier 2 Synchronized Reserve). Tier 1 Synchronized Reserve resources are also compensated when the Non-Synchronized Reserve Market Clear Price is non-zero. Tier 2 Synchronized Reserve credits are awarded to all resource owners that have assigned self-scheduled or pool-scheduled Synchronized Reserve.

The Synchronized Reserve offer price for Tier 2 resources is capped at a maximum value of the unit's Operating and Maintenance cost (as determined by the Cost Development Task Force) plus $7.50/MWh.

Generator resources on-line and providing Tier 2 are made eligible for make-whole payments to recover applicable start-up, no-load and minimum energy costs in the Balancing Operating Reserve billing line item. Demand Resources that respond to a Synchronized Reserve event, and are eligible for make-whole payments to recover shutdown cost are made-whole in the Operating Reserve for Load Response billing line item.

Resources that are assigned regulation when a Synchronized Reserve event is initiated are compensated based on the amount of response provided beyond their regulation commitment,

as well as for any response in excess of their regulation high limit or economic maximum (whichever is lower). Additional details can be found in PJM Manual 11: Energy & Ancillary Services Market Operations, Section 4.2.1~~1~~0.

Each Market Participant that is a Load Serving Entity (LSE) or synchronized buyer that is not part of an agreement to share reserves with external entities subject to the requirements in NERC Reliability Standard BAL-002 incurs a synchronized reserve obligation based on their Load Ratio Share and applicable reserve zone's requirements during that hour. During hours when the Synchronized Reserve Market Clearing Price (SRMCP) is the same throughout the reserve zone, an LSE's Synchronized Reserve obligation is equal to its Load Ratio Share times the amount of synchronized reserve assigned for all five minute intervals for the entire reserve zone. During hours when congestion causes the SRMCP to separate, each LSE's Synchronized Reserve obligation is equal to its Load Ratio Share within its reserve zone or sub-zone and the amount of Synchronized Reserve assigned in that reserve zone or sub-zone.

Participants may fulfill their Synchronized Reserve obligations by owning Tier 1 resources from which PJM obtains Synchronized Reserve, entering bilateral arrangements with other PJM Market Participants, or purchasing Synchronized Reserve from the PJM Synchronized Reserve Market.

6.2 Credits for Synchronized Reserve

Synchronized Reserve credits are paid to Market Participants that supply their resource to PJM. PJM sums the Synchronized Reserve credits (both Synchronized Reserve Clearing Price credits and Synchronized Reserve Lost Opportunity Cost credits) to determine the total hourly credit for each Synchronized Reserve market participant. Synchronized Reserve credits for joint-owned generators supplying Synchronized Reserves are allocated to the owners based on their ownership share.

6.2.1 Synchronized Reserve Clearing Price Credit

Synchronized Reserve credits are paid to Tier 1 resources and Tier 2 resources. Since Tier 1 resources are online units following economic dispatch and Tier 2 resources offer and must be cleared through the Synchronized Reserve Market, there are different compensation methodologies. The response MW value is determined in accordance with the PJM Manual 11: Energy & Ancillary Services Market operations, Section 4.2.11. Lost opportunity cost credits are descried in Section 6.2.2 of this PJM Manual.

PJM Actions

- PJM retrieves the following information for the Tier 1 Synchronized Reserve Clearing Price credit:
  - Synchronized Reserve Ramp rate for Tier 1 resources
  - Synchronized Reserve maximum for Tier 1 resources
  - 5 minute MW response
  - Synchronized energy premium price

- Total PJM Synchronized Reserve requirement as determined in whole MW for each five minute interval of the operating day
- Synchronized Reserve Market Clearing Price (SRMCP) ($/MWh)
- Non-Synchronized Reserve Market Clearing Price (NSRMCP) ($/MWh)

- PJM calculates the five minute interval Synchronized Reserve credits for each Tier 1 resource for when the five minute intervals NSRMCP is zero for the same reserve zone or sub-zone that a Tier 1 resource is located, Tier 1 Synchronized Reserve credits are equal to the increase in MW generator output (or decrease in MW consumption for demand side response resources) from each resource for each five minute interval during the length of a Synchronized Reserve event multiplied by the synchronized energy premium divided by 12. The synchronized energy premium is $50/MWh.
  - *Tier 1 Synchronized Reserve Credit = Five Minute MW Response * $50/MWh / 12*

- PJM calculates the five minute interval Synchronized Reserve credit for each Tier 1 resource for when the five minute intervals NSRMCP is non-zero for the applicable reserve zone or subzone, Tier 1 synchronized reserve credits are equal to the applicable reserve zone or sub-zone Synchronized Reserve Market Clearing Price multiplied by the lesser of the increase in MW output or decrease in MW of consumption from each resource for each five minute interval during the length of a synchronized reserve event and the estimated Tier 1 the resource could have provided. During five minute intervals when no synchronized reserve event occurs in the applicable reserve zone or sub-zone, the Tier 1 resource will be compensated using the estimated Tier 1 amount for only those resources that can reliably provide Synchronized Reserve service per the rules in Manual 11: Energy & Ancillary Services Market Operations, Section 4.2.1.
  - *Tier 1 Synchronized Reserve Credit = (Lesser of Five Minute Actual Response OR Five Minute Estimated Tier 1 Response) * SRMCP / 12*

- PJM retrieves the following information for the Tier 2 Synchronized Reserve Clearing Price credit:
  - Synchronized Reserve availability
  - Synchronized Reserve assigned quantity (response) (MW)
  - Synchronized Reserve offer price
  - Synchronized Reserve bilateral transactions
  - Energy use for condensing resource
  - Condense startup cost
  - 5-minute interval LMP data
  - Total PJM Synchronized Reserve requirement
  - Synchronized Reserve Market Clearing Price (SRMCP) ($/MWh)

- PJM calculates the five minute interval Synchronized Reserve Clearing Price credits for both pool-scheduled and self-scheduled Tier 2 resource to equal the five minute SRMCP divided by 12 times the resource's five minute Synchronized Reserve capability less any shortfall for the five minute interval due to failure to provide assigned capability during a Synchronized Reserve event.
    - *Tier 2 Synchronized Reserve Credit = (SRMCP / 12) * (Assigned Synchronized Reserve MW – Synchronized Reserve MW Shortfall)*

6.2.2 Synchronized Reserve Lost Opportunity Cost Credit

PJM calculates a Synchronized Reserve Lost Opportunity Cost Credit for pool-scheduled Tier 2 resources if the Synchronized Reserve Lost Opportunity Cost is greater than the SRMCP Credit for the resource for the five minute interval. If the resulting amount is negative, then the credit is $0.

PJM Actions

- PJM retrieves the following information for the Synchronized Reserve Lost Opportunity Cost credit:
    - Real-time LMP
    - Energy use (only used for condensing units) o Applicable offer curves
    - Synchronized Reserve Market Clearing Price (SRMCP) credit
- PJM calculates a Synchronized Reserve Lost Opportunity Cost Credit if the lost opportunity cost is greater than the Synchronized Reserve Market Clearing Price credit for the resource for the five minute interval.
    - *Synchronized Reserve Lost Opportunity Cost Credit = (Synchronized Lost Opportunity Cost / 12) – SRMCP Credit*
    - *Synchronized Lost Opportunity Cost = (Energy Use * 5-minute real-time LMP) + (MW deviation * (5-minute real-time LMP – Offer Price))*
- Since hydro units operate on a schedule and do not have an energy bid, lost opportunity costs for these units are calculated using the average of the real-time LMP at the hydro 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 hydro plant were operating.
- If a hydro unit is in spill, the lost opportunity cost for each five minute interval is equal to (i) the Synchronized Reserve assigned MW multiplied by (ii) the real-time five minute LMP at the generator bus.
- If a hydro unit is committed day-ahead with MW greater than zero, the lost opportunity cost for each five minute interval is equal to (i) the Synchronized Reserve assigned MW multiplied by (ii) the difference between the real-time five minute LMP at the generator bus and the average real-time LMP (calculated as stated above). If this average realtime LMP value is higher than the real-time five minute LMP at the generator bus, the lost opportunity cost will be zero.

- If a hydro unit is not committed day-ahead, the lost opportunity cost is equal to zero.

6.3 Charges for Synchronized Reserve

The total cost of providing Synchronized Reserve for each hour is the sum of the five minute credits provided to PJM Members for supplying Synchronized Reserve in that hour. The cost of Tier 1 and Tier 2 Synchronized Reserve is allocated separately and charged to PJM Members.

6.3.1 Synchronized Reserve Clearing Price Charge

Each Market Participant that is a Load Serving Entity (LSE) or synchronized buyer that is not part of an agreement to share reserves with external entities subject to the requirements in NERC Reliability Standard BAL-002 incurs a Synchronized Reserve Obligation based on their Load Ratio Share and applicable reserve zone's requirements during that hour. A Load Serving Entity (LSE) whose reserve obligations are satisfied through an agreement to share reserves with external entities subject to the requirements in NERC Reliability Standard BAL-002 do not have a Synchronized Reserve Obligation. **PJM Actions**

- PJM retrieves the following information for the Synchronized Reserve Clearing Price Charge:
  - O Synchronized Reserve bilateral transactions
  - o Total PJM Synchronized Reserve assigned by reserve zone and sub-zone
  - o Total Synchronized Reserve shortfall (MWh) by reserve zone and sub-zone
- PJM calculates the Synchronized Reserve Tier 1 charges for each Market Participant for the applicable zone or subzone by multiply the total Tier 1 credits by the Tier 1 Allocation to Obligation ratio for that hour
  - o *Tier 1 Charges = Total Tier 1 Credit * (Tier 1 Allocation to Obligation / Total Tier 1 Allocation to Obligation)*
  - o *Tier 1 Allocation to Obligation = Lesser of (Remaining Bilateral Adjusted Obligation or Obligation Ratio Share of Excess Tier 1) + Lesser of (Adjusted Synchronized Reserve Obligation or Tier 1 Estimate MWh)*
  - o *Remaining Bilateral Adjusted Obligation = Adjusted Synchronized Reserve Obligation – Tier 1 Estimate MWh*
  - o *Obligation Ratio Share of Excess Tier 1 = Total Tier 1 Excess * (Remaining Bilateral Adjusted Obligation / Total Remaining Bilateral Adjusted Obligation)*
  - o *Adjusted Synchronized Reserve Obligation = Synchronized Reserve Obligation + Bilateral Synchronized Reserve Sales – Bilateral Synchronized Reserve Purchases*
  - o *Synchronized Reserve Obligation = (Total Tier 1 Estimated and Tier 2 Assigned) * Market Participant Load / Total Load)*
- PJM calculates the Synchronized Reserve Tier 2 charges for each Market Participant for the applicable zone or subzone by the appropriate hourly Tier 2 Synchronized Reserve

credits times the Market Participant's ratio share of Synchronized Reserve adjusted obligation MW, less any Tier 1 Synchronized Reserve applied to obligation.

- *Tier 2 Charges = (above Obligation Tier 1 Adjustment / Total PJM Above Obligation Tier 1 Adjustment) * Total PJM Synchronized reserve Tier 2 Credits*
- *Above Obligation Tier 1 Adjustment = Adjusted Synchronized Reserve Obligation – Tier 1 Allocation to Obligation*
- If the hourly-integrated SRMCP is equal for all the sub-zones within a reserve zone, the Total PJM Synchronized Reserve Tier 2 Credits in the reserve zone are allocated based on a Market Participant's above obligation ration share in the reserve zone.
- If the hourly-integrated SRMCP is different for the sub-zones within a reserve zone, the Total PJM Synchronized Reserve Tier 2 Credits in the sub-zone are allocated based on a Market Participant's above obligation ration share in the sub-zone.

6.3.2 Synchronized Reserve Lost Opportunity Cost Charge

- The amount of unrecovered costs allocated to each Market Participant is determined based on each Market Participant's ratio share of Tier 2 Synchronized Reserve purchased from the market. A Market Participant's purchases equals their Synchronized Reserve obligation MW less any Tier 1 Synchronized Reserve applied to obligation, less any self-scheduled Tier 2 MW.
  - *Synchronized Reserve Lost Opportunity Cost Charge Cleared = Total Lost Opportunity Cost Credits * (Synchronized Reserve Purchase / Total PJM Synchronized Reserve Purchases)*
  - *Synchronized Reserve Purchase = (Above Obligation Tier 1 Adjustment – Tier 2 Self Scheduled MWh)*
- The cost of Tier 2 resources assigned by PJM during the operating hour in addition to that which resulted from the Tier 2 clearing process due to reduced availability of Tier 1 Synchronized Reserve are allocated to those entities for which less Tier 1 was available during the hour that was estimated prior to the hour (Tier 1 Lost MW), in proportion to the reduction in Tier 1 availability. If there are no entities with a reduction in Tier 1 availability, the cost of these resources assigned during the hour is allocated based on a participant's purchases from the market.
  - *Synchronized Reserve Lost Opportunity Cost Charge Added = Total Lost Opportunity Cost Credit Added * (Tier 1 Lost MW / Total Tier 1 Lost MW)*
- A Market Participant is also charged a share of any unrecovered costs incurred by assigned Tier 2 pool-schedule resources, including those Tier 2 resources assigned in addition to that which was estimated prior to a given hour, over and above those Tier 2 resources clearing price credits.

6.3.3 Synchronized Reserve Tier 2 Retroactive Penalty Charge

Tier 2 resources that fail to provide assigned Tier 2 capability during a Synchronized Reserve Event incur a retroactive obligation to refund at SRMCP the amount of the shortfall for the five minute interval measured in MW for all of the five minute intervals the resource was assigned over the immediate past interval, the duration of which is equal to the lesser of the average number of days between events as determined by the annual review of the last 2 years, or the number of days since the resource last failed to respond with its assigned or self-scheduled Synchronized Reserve amount in response to a synchronized reserve event.

- Market Participants that own multiple Demand R~~r~~esources assigned or self-scheduled to provide Tier 2 Synchronized Reserve are permitted to demonstrate aggregate response, such that any resource that responds greater than their assignment or self-schedule can be used to offset any Demand R~~r~~esource that responds less than their assignment or self-schedule of Tier 2 Synchronized Reserve during a Synchronized Reserve Event.
- The Market Participant's aggregate response does not affect how an individual resource is credited for Tier 2 Synchronized Reserve it provides as described above, but is used to determine what the Market Participant owes in refund charges for each resource that was assigned or self-scheduled to provide Tier 2 Synchronized Reserve and responded less than their assignment or self-schedule of Tier 2 Synchronized Reserve.

  o *Tier 2 Retroactive Penalty Charge = Resource Retroactive Shortfall MW * SRMCP / 12*

  o *Resource Retroactive Shortfall MW (for Demand Resources) = Resource Shortfall MW – ((Resource Shortfall MW / Participant's Total Shortfall MW) * Participant's Total Over Response MW)*

  Resource Retroactive Shortfall MW (for Generators) = Resource Shortfall MW

- If the Retroactive Shortfall MW value per the above equation is less than 0 MW, the Retroactive Shortfall MW is equal to 0 MW.

Note:
If there are multiple Synchronized Reserve Events during a day, the maximum Resource Retroactive Shortfall MWh for the day is used to determine what the Market Participant owes in refund charges.

The retroactive penalty charges calculated above are allocated based on a Market Participant's ratio share of the Synchronized Reserve obligation MW less any Tier 1 Synchronized Reserve applied to obligation on the five minute intervals of the Synchronized Reserve event for the subzone or Reserve Zone for which the Synchronized Reserve event occurred. If the event spans multiple hours, the penalty charges are prorated hourly based on the duration of the event within each hour. Participants that incur a penalty charge and also have an applicable Synchronized Reserve obligation during the hours(s) of the Synchronized Reserve Event are not included in the allocation of such penalties. Additional details on verification and non-

performance can be found in PJM Manual 11: Energy & Ancillary Services Market Operations, Section 4.