Working to Perfect the Flow of Energy

PJM Manual 28:

Operating Agreement Accounting

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Market Strategy

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Section 4: Regulation Accounting

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

- A description of how Regulation is provided and accounted for in the PJM Regulation Markets (see *"Regulation Accounting Overview"*).

- How credits are calculated for providers of Regulation (see "*Regulation Credits*").

- How charges are calculated for users of Regulation (see "*Regulation Charges*").

- How regulation charge reconciliations are calculated (see *"Reconciliation for Regulation Charges"*).

4.1 Regulation Accounting Overview

Regulation is necessary to provide for the continuous balancing of resources (generation and interchange) with load and for maintaining scheduled Interconnection frequency at 60 cycles per second (60 Hz). PJM commits on-line resources whose output is raised or lowered as necessary to follow moment-to-moment changes in load. Regulation is predominantly achieved using automatic generation control equipment. Regulating resources include both generators and demand side response resources.

PJM operates the Regulation Market where the a Regulation Market Clearing Prices (RMCP) are is determined based on Regulation offers and estimated opportunity costs. PJM assigns the most economically efficient set of regulating resources available in real-time to separately meet the applicable NERC regions' regulation zone requirements. For more detailed information about how regulating requirements are developed and how Regulation is assigned, see the **PJM Manual for Balancing Operations (M-12)**. For an overview of the Regulation Market, see the **PJM Manual for Energy & Ancillary Services Market Operations (M-11)**.

Each PJM load serving entity has an hourly Regulation obligation equal to their regulation zone real-time load ratio share of the applicable Regulation requirement for the hour, prorated to reflect the total amount of Regulation actually assignedsupplied.

A market participant's Regulation obligation can be satisfied from their own resources capable of providing Regulation, by contractual arrangements with other Market Participants capable of providing Regulation, and/or by purchases of Regulation from the PJM Regulation Market.

Resource owners of supplying self-scheduled Regulation /orresource owners providing Regulation are credited at based on the hourly Regulation Market Capability Clearing Price (RMCCP) and Regulation Market Performance Clearing Prices (RMPCP) for each MW of Regulation supplied, with consideration of the resource's Regulation performance, requested movement, and benefits to system control. for each MW of Regulation supplied. Resource owners providing supplying pool-scheduled Regulation are credited for each Regulation MW MWh at the higher of based on the hourly Regulation Market Performance and Capability Clearing Prices, with consideration of the resource's Regulation performance, requested movement, and benefits to system control. RMCP or their Regulation offer price (plus real-time opportunity cost including shoulder hours' lost opportunity costs, for

generating resources). Regulation buyers are charged the hourly ~~Capability~~ Regulation Market Capability Clearing Price (RMCCP) and Regulation Market Performance Clearing Price (RMPCP) ~~plus the proportionate share of any performance credits paid to regulating resources and~~ plus their percentage share of any Regulation provider's unrecovered costs over and above their total Regulation ~~RMCP~~ Clearing Price credits~~payments~~.

4.2 Regulation Credits

Each resource supplying pool-scheduled Regulation is credited ~~based on of~~ at the higher of the hourly RMCCP and RMPCP ~~capability and performance RMCPs~~ with consideration of the resource's Regulation performance, ~~requested movement,~~ and benefits to system control. ~~hourly Regulation Market Clearing Price (RMCP)~~ or its Regulation offer price (plus real-time opportunity cost including shoulder hours' lost opportunity costs, for generating resources). A resource supplying self-scheduled Regulation is credited based on the hourly RMCCP and RMPCP ~~capability and performance RMCPs~~ with consideration of the resource's Regulation performance, ~~requested movement,~~ and benefits to system control. ~~at the hourly RMCP~~. Regulation credits for joint-owned generators ~~providing~~ supplying Regulation are allocated to the owners based on their ownership shares.

Any resource with an hourly performance score below the applicable threshold for minimum hourly performance in Manual 11 Section 3.2.10 will receive zero regulation credits for that market hour.

PJM Actions:

- From the Regulation log, PJM identifies each resource that supplied Regulation (both pool-scheduled and self-scheduled) with an hourly performance score greater than or equal to the applicable threshold for minimum hourly performance in Manual 11 Section 3.2.10 during an hour.

- PJM calculates the hourly Regulation RMCCP Credit ~~credit~~ for each ~~assigned~~ applicable regulating resource by multiplying each increment of such Regulation in megawatts during the hour by the Regulation Market Capability Clearing Price (RMCCP), the resource's actual performance score, and the applicable marginal benefits factor ~~-~~ for that hour.

Regulation RMCCP Credit = Hourly-integrated Regulation MW x Actual Performance Score x Marginal Benefits Factor x RMCCP

- PJM calculates the hourly Regulation RMPCP Credit for each applicable regulating resource by multiplying each increment of such Regulation in megawatts during the hour by the Regulation Market Performance Clearing Price (RMPCP) for that hour, ~~the applicable mileage ratio,~~ the applicable marginal benefits factor, and the resource's actual performance score for that hour.

Regulation RMPCP Credit = Hourly-integrated Regulation MW ~~x Mileage Ratio~~ x Actual Performance Score x Marginal Benefits Factor x RMPCP

- PJM calculates the total Regulation Clearing Price Credit as the Regulation RMCCP Credit plus the Regulation RMPCP Credit for that hour.

  Regulation Clearing Price Credit = Regulation RMCCP Credit + Regulation RMPCP Credit

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- The lost opportunity costs calculated as part of the real-time pricing algorithm as adjusted by the applicable performance score and benefits factor will be used in the settlement calculation for intra-hour lost opportunity costs.

- ~~PJM calculates the lost opportunity costs incurred by each generator providing pool-scheduled Regulation for the hour. Note that the energy offer referred to below is the generator's incremental energy offer curve that is associated with the price-based or cost-based schedule used in the real-time dispatch of the unit (the lesser of the available price-based energy schedule or most expensive available cost-based energy schedule. The "lost opportunity cost energy schedule").~~

- ~~If a generator must reduce its output to provide Regulation, its lost opportunity cost equals the amount of its energy offer at its economically desired level in excess of its energy offer at its Regulation setpoint (biased to reflect the actual Regulation signal) or actual output MWh, per applicable tolerance levels. The actual output of the resource will be used if the absolute value of the difference between the actual output and the Regulation setpoint (biased to reflect the actual Regulation signal) is within plus or minus the minimum of either 20% of the regulation supplied or 10 MW.~~

- ~~If a generator must increase its output to provide Regulation, its lost opportunity cost equals the amount of its energy offer at its Regulation setpoint (biased to reflect the actual Regulation signal) or actual output MWh, per applicable tolerance levels, in excess of its energy offer at its economically desired level. The actual output of the resource will be used if the absolute value of the difference between the actual output and the Regulation setpoint (biased to reflect the actual Regulation signal) is within plus or minus the minimum of either 20% of the regulation supplied or 10 MW.~~

- ~~If the LMP is less than the generator's energy offer at economic minimum, the lost opportunity cost will also include the lesser of: (i) the difference between its energy offer at economic minimum and the LMP at its generation bus times its economic minimum; or (ii) the difference between its Regulation setpoint and its economic minimum times the LMP at its generation bus.~~

- PJM calculates shoulder hours' lost opportunity costs incurred by each generator providing pool-scheduled Regulation for the preceding and following hour. Note that the energy offer referred to below is the generator`s incremental energy offer curve that is associated with the price-based or cost-based schedule used in the real-time dispatch of the unit.

- CT and hydro generators are not eligible for shoulder hour lost opportunity costs.

- A generator is eligible for preceding shoulder hour lost opportunity costs when: it is online the hour prior to regulating; the Regulation assignment starts at the top

of the hour; it is not regulating during the preceding hour; and the LMP Desired from the prior hour is not already within the regulation hour regulation limits.

- A generator is eligible for following shoulder hour lost opportunity costs when: it is online the hour following regulating; the Regulation assignment ends at the top of the following hour; it is not regulating during the following hour; and the LMP Desired from the following hour is not already within the regulation hour regulation limits.

- In the preceding or following hour of regulation, if a generator must reduce its output, its shoulder hour lost opportunity cost equals the amount of its energy offer at the preceding or following hour economically desired level in excess of its energy offer at its Regulation setpoint at the start or end of the regulating hour.

- In the preceding or following hour of regulation, if a generator must increase its output, its shoulder hour lost opportunity cost equals the amount of its energy offer at its Regulation setpoint at the start or end of the regulating hour in excess of its energy offer at the preceding or following hour economically desired level.

- 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.

  o During those hours when a hydro unit is in spill, the average of the real-time LMP value is set to zero such that the lost opportunity cost is equal to (i) the regulation setpoint (biased to reflect the actual regulation signal and adjusted by the applicable performance score and benefits factor) multiplied by (ii) the full value of the real-time LMP at the generator bus.

  o If a hydro unit is committed day-ahead with MW greater than zero, the lost opportunity cost is equal to (i) the regulation setpoint (biased to reflect the actual regulation signal and adjusted by the applicable performance score and benefits factor) multiplied by (ii) the difference between the real-time LMP at the generator bus and the average real-time LMP (calculated as stated above). If this average real-time LMP value is higher than the real-time LMP at the generator bus, the lost opportunity cost is zero.

  o If a hydro unit is not committed day-ahead with MW greater than zero, the lost opportunity cost is equal to (i) the regulation setpoint (biased to reflect the actual regulation signal and adjusted by the applicable performance score and benefits factor) multiplied by (ii) the difference between the average real-time LMP (calculated as stated above) minus the real-time LMP at the generator bus. If the actual real-time LMP is higher than the average real-time LMP, the lost opportunity cost is zero.

  o Additional details on hydro units in the Regulation Market can be found in Manual 11: Energy and Ancillary Services Market Operations.

- For each resource providing Regulation at the direction of PJM, the sum of its Regulation offer price (and lost opportunity costs, including shoulder hours' lost

opportunity costs, for generators) is compared to its hourly Regulation Clearing Price RMCP credits.

- If the resource's pool-scheduled Regulation offer price (plus lost opportunity costs, including shoulder hours' lost opportunity costs, for generators) is greater than its Regulation RMCP Clearing Price credit for that hour, then the resource receives an additional credit equal to the amount that its Regulation offer price (plus lost opportunity costs, including shoulder hours' lost opportunity costs, for generators) is in excess of its Regulation RMCP Clearing Price credit.

Lost Opportunity Cost Credit = (Regulation Offer + Lost Opportunity Cost, including Shoulder Hours' Lost Opportunity Cost, if applicable) – Regulation RMCP Clearing Price Credit, only if quantity is positive

- PJM sums the Regulation credits (both Regulation RMCP Clearing Price credits and Lost Opportunity Cost credits) to determine the total hourly credit for each Regulation market participant, taking into account joint-ownership of regulating generators.

4.3 Regulation Charges

Each PJM load serving entity, or other Regulation buyer, is charged at the hourly Regulation Capability Market Clearing Price (RMCCP) and the Regulation Performance Market Clearing Price (RMPCP) for the amount of Regulation purchased to meet their hourly obligation plus the proportionate share of any performance credits paid to regulating resources. Hourly Regulation obligations equal their real-time load ratio share of the total amount of Regulation assigned supplied by PJM that hour, adjusted for any bilateral Regulation transactions. In addition, net purchasers of Regulation in an hour are also charged a proportionate share of any lost opportunity credits paid to regulating generators for unrecovered costs over and above their RMCP Regulation Clearing Price creditspayments (including regulation lost opportunity costs incurred by generators operating for PJM solely for Regulation).

PJM Actions:

- From the Regulation log, PJM sums the total amount of Regulation supplied (both pool-scheduled and self-scheduled) during an hour.

- PJM determines each load serving entity's (LSE's) applicable regulation zone load ratio share based on their real-time load (excluding transmission losses).

$$Load\ Ratio\ Share = \frac{\left\{\begin{array}{c} Real\ Time\ Load + Retail\ or\ Wholesale\ Load\ Responsibility \\ eSchedule\ MW,\ if\ buyer \\ Retail\ or\ Wholesale\ Load\ Responsibility \\ eSchedule\ MW,\ if\ seller \end{array}\right.}{Total\ PJM\ Real\ Time\ Load}$$

- PJM calculates each LSE's hourly Regulation obligation by multiplying their applicable regulation zone load ratio share for that hour by the total amount of Regulation supplied in that hour for the applicable regulation zone's market.

*Regulation Obligation = Load Ratio Share * Total Regulation ~~Assigned~~Supplied*

- PJM adjusts obligations to reflect bilateral Regulation transactions among Regulation market participants.

Adjusted Obligation = Regulation Obligation - Regulation MW Purchased + Regulation MW Sold

- PJM calculates the hourly charge for each Regulation buyer by multiplying their adjusted regulation zone ~~Obligation~~ obligation in megawatts during the hour by the Regulation Market Capability Clearing Price (RMCCP) and the Regulation Market Performance Clearing Price (RMPCP) for that hour ~~plus the proportionate share of any performance credits paid to regulating resources~~.

————————— *Regulation ~~RMCP~~ Clearing Price Charge = Adjusted Obligation * [RMCCP +* *{RMPCP] ~~RM-PCP Credits / Total PJM Adjusted Obligation~~*

- PJM calculates amount of Regulation each market buyer purchased from the applicable market by subtracting the amount of self-scheduled regulation MW provided by that market buyer from their adjusted obligation for the hour.

Net Regulation Purchase = Adjusted Obligation – Self Scheduled Regulation MW

- If any lost opportunity or other unrecovered costs due to regulating were credited to Regulation providers, each Regulation market buyer is allocated a share of the hourly costs based on the amount of Regulation they purchased from the market that hour.

$$Lost\ Opportunity\ Charge = \frac{Total\ Lost\ Opportunity\ Costs * Net\ Regulation\ Purchase}{Total\ PJM\ Regulation\ Purchases}$$

- PJM sums the Regulation charges (both Regulation ~~RMCP~~ Clearing Price charges and Lost Opportunity charges) to determine the total hourly charge for each Regulation market participant.

4.4 Reconciliation for Regulation Charges

PJM will calculate reconciled Regulation charges for EDCs and Retail Load Aggregators (a.k.a. Electric Generation Suppliers) for past months' billings that were based on load ratio shares. The reconciliation kWh data must be supplied to PJM by the EDCs, and represents the difference between the scheduled Retail Load Responsibility eSchedules and the "actual" usage based on metered data. This hourly kWh data must be reported separately for each applicable eSchedules contract.

PJM calculates the Regulation charge reconciliations by multiplying the kWh data (de-rated for transmission losses) by the Regulation billing determinant for that hour. The hourly Regulation charge billing determinant (in $/MWh) is calculated by dividing the total hourly Regulation charges by the total real-time PJM load (de-rated for transmission losses) for in that hour. These charge reconciliations are then totaled for the month for each EDC or

Retail Load Aggregator. Note that the reconciliation for Regulation charges for a month may be either a positive or a negative value, and may even be such that the reconciled load responsibility MWh results in a negative load quantity.