LMP Calculation During Reserve Shortages

Real Time Market Operation

Market Implementation Committee

April 7, 2021

- FERC Order 825 (Docket No. RM 15-24-000) directed RTOs/ISOs to implement Shortage Pricing
  - Issued June 16, 2016
- Order 825 states: – Under this requirement, whenever a shortage of energy or operating reserves is indicated in an RTO's/ISO's pricing run software for a particular pricing interval, shortage pricing should be invoked
- Associated Tariff and Manual provisions shared with Stakeholders
- PJM implemented changes on May 11, 2017

- Shortage pricing is based on Real-time system conditions
  - Not limited to high load or unit loss conditions

- Shortage Pricing is declared based on the inability of RT SCED to procure sufficient reserves to meet the reserve requirement

- Resources need to respond to base-points to maintain reserves procured in RT SCED – Otherwise reserve amounts observed in real-time, in the PJM EMS, may not match RT SCED calculated reserves

- The PJM EMS provides operators with an available reserve calculation to help provide minute to minute reserve position details
    - The PJM Data Viewer application provides a status for RTO/MAD Synchronized and Primary reserves based on the PJM EMS calculation
- RT SCED determines reserve status based on it's calculations and co-optimization
    - This is based on a 10-minute look ahead respecting generation bid-in parameters, transmission constraints, system losses, etc.

- LMP calculations are consistent during intervals where reserves are adequate as well as intervals where reserves are short of requirements. The total LMP for a pricing node includes three components: Energy LMP, Congestion LMP and Loss LMP.

- When insufficient reserves are available and identified by RT SCED, the result is a reserve shortage condition.

- Reserve shortages are declared in the region(s) where reserve deficit(s) exists. Applicable reserve penalty factors are then included in the determination of LMPs.

- The maximum LMP solved by the MCE during periods of reserve shortages is limited by:

  1. $2000/MWh which is the maximum of allowable energy offer plus
  2. The first step of the penalty factor on the demand curve for the primary reserve requirement plus
  3. The first step of the penalty factor on the demand curve for the synchronized reserve requirement plus
  4. Congestion and loss impacts

- Currently, the first step of the penalty factor for primary and synchronized reserve is $850/MWh as defined from Operational Reserve Demand Curve (ORDC).

- The current Energy component of LMP cap as calculated by the MCE is defined as:
  1. Generation energy offer cap of $2000/MWh +
  2. Synchronized Reserve Penalty Factor from the first step on the demand curve of $850/MWh +
  3. Primary Reserve Penalty Factor from the first step on the demand curve of $850/MWh +
  4. An adder of $50/MWh (a buffer to account for congestion and losses contribution)

  With a total system Energy component of LMP cap of $3750/MWh.

- System Energy LMP is defined as the total cost increase resulting from increasing the output of the marginal resource while considering the impact of marginal losses to meet the next MW of load. Three contributing factors are considered when calculating the total cost increase of the marginal resource to meet this additional MW of load: Marginal cost (including impact of marginal loss), Congestion cost and Loss of Opportunity Cost (LOC).

- The <u>Marginal Cost</u> from the marginal resource to meet the next MW of load considering the impact of marginal losses is obtained from the incremental energy offer curve of the marginal resource.

- The <u>Congestion Cost</u> increase is the cost of controlling constraints when the marginal energy resource's output is increased to meet the next MW of load. It is the summation of congestion LMPs from all binding constraints:

    SUM (ABS ($\sum$ Dfax * constraint shadow price))

    Dfax – The distribution factor of resource on active constraint.

- <u>Loss of Opportunity Cost</u> (LOC) is the cost of meeting the reserve requirements that is incurred when the marginal energy resource's energy output is increased by 1 MW. This is non-zero when the additional MW of energy is produced by converting a MW of reserves into a MW of energy.

- When multiple reserve service shortages occur in a given MCE solution, the energy component of LMP could exceed the cap of $3750/MWh given the addition of multiple reserve penalty factors. When this occurs, the issue is resolved by rerunning the case with the Primary Reserve requirement for the MAD reserve subzone disabled. If the energy component of LMP remains above the $3750/MWh cap, the case is rerun with both the Primary Reserve and Synchronized Reserve requirements for the MAD reserve sub-zone disabled.

- PJM will post a generic example with additional details to help walk Market Participants through LMP formulation under Shortage conditions

- PJM will also provide a live presentation at the May MIC

Real time and historical data is available to provide transparency for system conditions

- Unverified RT data posted every 5 minutes in Data Miner 2:
  - https://dataminer2.pjm.com/feed/dispatched_reserves/definition
    - Dispatched Reserves – shows reserve positions and clearing prices for applicable reserve regions and includes shortage indicator
  - https://dataminer2.pjm.com/feed/rt_unverified_fivemin_lmps/definition
    - Real-Time Five Minute LMPs – shows RT LMPs for all bus locations
- Verified RT data posted daily on business days in Data Miner 2:
  - https://dataminer2.pjm.com/feed/rt_dispatch_reserves/definition
    - Real-time Dispatch Reserve – shows reserve positions for applicable reserve regions including deficit MWs
  - https://dataminer2.pjm.com/feed/rt_marginal_value
    - Real-time Marginal Value – shows constraint information including shadow prices
  - https://dataminer2.pjm.com/feed/ancillary_services_fivemin_hrl/definition
    - Ancillary Services Five Minute LMPs – shows verified Ancillary Services clearing prices
  - https://dataminer2.pjm.com/feed/rt_fivemin_hrl_lmps/definition
    - Real-Time Five Minute LMPs – shows verified RT LMPs for all bus locations

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