Resource Modeling Ramping Capability Calculation

RCSTF

November 27, 2023

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Resource Modeling

Ramping

- **OA Definition**
  - **Ramping Capability: "shall mean the sustained rate of change of generator output, in megawatts per minute."**
- **Section 1.7.19**
  - **Ramping: "A generator dispatched by the Office of the Interconnection pursuant to a control signal appropriate to increase or decrease the generator's megawatt output level shall be able to change output at the ramping rate specified in the Offer Data submitted to the Office of the Interconnection for that generator. Market Sellers must specify a ramping rate in the Offer Data that is an accurate representation of the resource's capabilities given the confines of the PJM software."**
- **Ramp rates, either daily values or hourly values, must accurately represent the unit's capability.**

Ramp Rate Use (Energy)

- PJM sends dispatch signals (basepoints) based on system conditions, offer data and operating parameters submitted by market sellers.
- One of those operating parameters is the ramp rate.
- PJM instructs resources, via the electronic dispatch signal, to ramp up or ramp down as fast as their submitted ramp rates allow.
- The expectation is that resources will follow the dispatch signals.
- Prices are set based on that expectation (ex ante pricing).

Ramp Rate Use (Reserves)

- **PJM assigns reserves based on system conditions, offer data and operating parameters submitted by market sellers.**
- **One of those operating parameters is the ramp rate.**
- **The reserve assignment cannot exceed:**
  - **For primary reserves, 10 minutes x Ramp Rate**
  - **For 30 minute reserves, 30 minutes x Ramp Rate**
  - **Secondary reserves is the difference between 30 minute and primary reserves.**

Modeling Plant Transitions

- **Some generation technologies' offer curves include transitions between operating modes.**
  - **CCs move from one CT/HRSG to two, or two to three, etc.**
  - **CCs use duct burners.**
  - **CCs/CTs use peak firing and other power augmentation.**
  - **Coal units have different operating modes (mills).**
- **Issue is how to accurately represent these transitions to the PJM market clearing software so that units are dispatched correctly and reserves are assigned correctly.**
- **This is essential for accurate pricing, essential for operations.**

Ramp Rates

- **PJM permits the use of ramp rates to reflect transitions.**
  - **Slow ramp rates are used to reflect delays in making transitions.**
- **Slow ramp rates are not an effective or appropriate way to reflect transitions between operating modes.**
- **The use of slow ramp rates in these cases can effectively result in physical withholding.**
- **Hourly ramp rates are an improvement over daily ramp rates but do not solve the problem associated with transitions between operating modes.**

Example

- **Example:**

MW	MW/minute
200	5.0
300	10.0
310	0.1
400	10.0

- **This unit ramp rate curve means that the unit can ramp at 5 MW/minute between eco min and 200 MW, at 10 MW/minute from 200 MW to 300 MW, at 0.1 MW/minute from 300 to 310 MW and at 10 MW/minute from 310 to 400 MW.**
- **The 0.1 MW/minute ramp rate is used to reflect a transition between operating modes.**

Example

- **The transition point implies that it takes the unit 100 minutes to operate above 300 MW by bringing additional equipment online.**
- **The 100 minutes is equal to (310 MW minus 300 MW) / 0.1 MW/minute.**
- **The transition is necessary to ensure that RTSCED does not dispatch the unit to a level it cannot achieve in the RTSCED look ahead window.**

Conclusion

- The IMM recognizes the limitations of PJM's current generator modeling.
  - Operating transitions are not modeled.
  - Peaking operation is not modeled.
  - Soak time is not modeled.
- PJM emphasized fast start pricing and ORDC over improvements to dispatch, modeling and transparent communications.
- nGEM is supposed to address the modeling issues.
- In the meantime, dispatch expectations and communications should be transparent when units reach inflection points.

Ramping Capability Calculation

Ramp Capability Calculation

- **PJM calculates reserves using the units' ramp rates.**
- **The reserves are also limited by the units' Eco Max, Synchronized Reserve Max or Secondary Reserve Max.**
- **Equations:**
  - SR MW Capability = max {0, min [min(EcoMax, Synch Max) – **Initial Energy Output**, RampRate*10 minutes]}
  - SecR MW Capability = max {0, min [min(EcoMax, SecR Max) – **Initial Energy Output**, RampRate* 30 minutes] – SR MW}

Ramp Rates

- Units can offer a single ramp rate or use a segmented ramp rate curve.
- For units that offer a single ramp rate, PJM uses that ramp rate.
- For units that offer a segmented ramp rate curve, PJM calculates a ramp rate equal to the units' 10 minute ramping capability (in MW) from the initial energy output by 10 minutes.
  - DA, the initial energy output is the output the hour before.
  - RT, the initial energy output is equal to the state estimator MW.

Example

- **A unit with the ramp rate curve below, synch max of 600 MW and initial MW of 450 MW will have a calculated ramp rate of 5.5 MW per minute to be used in the reserve capability calculation.**

Output Range (MW)	Ramp Rate (MW/min)
Eco Min to 500 MW	10
500 to 600 MW	1

Example

- **The 5.5 MW per minute is equal to 5 minutes at 10 MW per minute to go from 450 MW (initial MW) to the first segment of the ramp rate curve (500 MW). Next, 5 more minutes (to complete 10 minutes) at 1 MW. The ramp rate is equal to:**

$$\text{Average Ramp Rate} = \frac{[(5\text{ min} \times 10\text{ MW/min}) + (5\text{ min} \times 1\text{ MW/min})]}{(5\text{ min} + 5\text{ min})} = \frac{55\text{ MW}}{10\text{ min}} = 5.5\text{ MW/min}$$

Example

- **The 5.5 MW/min ramp rate is used in the synchronized reserve (SR) MW capability calculation. This unit SR MW will be limited by 5.5 MW/min times 10 minutes, or 55 MW. This is incorrect.**
- **The unit can provide 100 MW of SR reserves when operating between 300 MW and 400 MW.**
- **Beyond 400 MW, the unit's SR capability is reduced because the ramp rate goes down to 1 MW/minute after 500 MW.**

Example

- Because this calculation is done before the optimization and before the calculation of the dispatch signal, the result could be under or overstating the actual capability.
- In the example above, if the dispatch signal is 400 MW, the unit can provide 100 MW of SR. If the dispatch signal is 500 MW, the unit can provide 10 MW of SR.
- The calculation only results in the correct capability when the dispatch signal is equal to the initial MW or when the units are not crossing a discontinuity on the ramp rate curve.

Ideal Calculation

- **The ideal calculation of the ramping capability of the units should be a function of the energy signal. Equations:**
  - SR MW Capability = max {0, min [min(EcoMax, Synch Max) – **Energy Signal** , 10 Minutes Ramping Capability from Energy Signal]}
  - SecR MW Capability = max {0, min [min(EcoMax, SecR Max) – **Energy Signal**, 30 Minutes Ramping Capability from Energy Signal] – SR MW}
- **This is not possible without changes to the market engine. This will also affect the performance of the engine.**

Impact

- **Due to this modeling limitation, Market Sellers owners of units with discontinuities request the use of synchronized reserve max to reflect such discontinuities in the reserve MW capability calculation.**
- **Requests should be sent to PJM/MA at reserves@pjm.com**
- **Market Sellers should include supporting documentation in the requests. For example, operating level at which additional equipment needs to be deployed in order to reach higher outputs.**

Modeling Solution

- The ultimate and practical solution for this problem is to treat discontinuities as additional commitment instructions. This requires improved unit modeling (nGEM).
- For example, units will provide the time required to deploy additional equipment and/or operating modes along with minimum run times and minimum down times.

Modeling Solution

- **SCED would then provide commitment recommendations when the additional MW should be deployed.**
- **MW that can be deployed in 10 minutes would qualify as synchronized reserves.**
- **MW that can be deployed in 30 minutes would qualify as secondary reserves.**
- **There would be no need for synchronized reserve max or secondary reserve max parameters.**
- **Reserves and energy would be consistent.**

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