



RPSTF Implementation Proposal

Two-Phase Approach

PJM Interconnection
September 15, 2011

Phase 1 – Implementation in 1st Quarter of 2012

- Modified energy ramp rate for regulating resources to minimize the conflict when a unit is ramping for regulation and energy
 - Calculate a performance score for each regulation resource for each regulating hour
 - Eligibility for regulation credit will be based on meeting a minimum performance factor of 25% for the market hour
 - Disqualification from regulation market will be based on 100 hour rolling average of performance factors below 40% threshold
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- See [Appendix A](#) for more detail of Phase 1

Modified energy ramp rate for regulating resources to minimize the conflict when a unit is ramping for regulation and energy

- Today's algorithms ramp resources for both energy and regulation which leads to poor regulation response and inaccurate clearing prices.
- Benefits of Change – Improved regulation performance and more accurate clearing prices
 - Resource ramping instructions (energy + regulation) will align with resource capabilities which will allow a decrease in the amount of regulation procured.
 - The regulation clearing engine will see the increased Product Substitution Costs (PSC) for units needing large MW ramps for economics which will better incorporate these costs in the Regulation Market Clearing Price.
 - Increased RMCP and PSC will be offset by lower after-the-fact make-whole payments and a lower regulation requirement.

Calculate a performance score for each regulation resource for each regulating hour

- We clearly have different levels of regulation performance today, but we do not calculate that performance or its impact on system control.
- Benefits of Change
 - Performance scores reflect the benefits each resource provides to system control by focusing on the resource's response to our control signals
 - Phase 1 will provide continuous feedback to the regulation resources of their performance using near real time reporting
 - Data posting for each resource through eMKT (or GPM)
- See [Appendix B](#) for examples of performance score calculations

Eligibility for regulation credit will be based on meeting a minimum performance score of 25% for the market hour

- Since we do not have automated scoring today, verification for settlements requires manual analysis for each regulating unit to determine eligibility for hourly regulation credits
- Benefits of Changes
 - Bright line criteria for eligibility
 - Does not compensate resources that do not provide system benefits
 - Performance Score and credit withdrawal on the settlements report for increased visibility

Disqualification from regulation market will be based on 100 hour rolling average of performance factors below 40%

- Today's tests for resources in the regulation market often have unusable results and require manual calculation for each test. These test do not give continuous feedback to operators on performance over time.
- Benefits of Changes
 - Allows continuous verification to help ensure good performance
 - Increased visibility of how well each resource performs
 - Allows reasonable notification time to regulation resources to allow them to improve performance
 - Resources can re-qualify for the regulation market by following the current testing guidelines in Manual 12 which will reset the rolling average.

Phase 2 – Implementation in late 2012

- All Phase 1 components continue
 - Two part offer and settlement – Capacity and Mileage clearing on an hourly basis for the lowest total expected production cost
 - Incorporating performance scores into clearing process to ensure the most economical resources provide regulation and a transparent market
 - Reduction in total regulation requirement based on increased performance and resources following signals more closely aligned with their capabilities
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- See [Appendix A](#) for more detail of Phase 2

Two part offer and settlement – regulation capability and mileage clearing on an hourly basis for the lowest total expected production cost

- Today's compensation mechanism does not align with value provided to system control
- Benefits of Changes
 - Regulation credits will more accurately represent the regulation capability set-aside to provide regulation AND the movement associated with providing regulation
 - Units with the ability to provide fast regulation will receive about 3-4 times more mileage \$ than traditional resources based on analysis of current control signals
 - Resources with best values to come into the market that are both high quality and high value
- See [Appendix C](#) for formulae and an example of two-part clearing price

Incorporating performance scores into clearing process to ensure the most economical resources provide regulation and a transparent market

- The current regulation commitment stack looks at only bids, and not value to system control, when setting regulation assignments
- Benefits of Changes
 - Payment determined by {Mileage Clearing Price * Normalized Miles of the Regulation Control Signal * Performance Factor * Regulation Capability}
 - The commitment process selects the resources with the best value to system control when the clearing engine considers performance scores
 - Incorporating performance scores in the clearing process, rather than only through after-the-fact adjustments, makes the market more transparent

Reduction in total regulation requirement based on increased performance and resources following signals more closely aligned with their capabilities

- The regulation requirement needs to align with the reliability criteria and the design of the regulation market
- Benefits of Changes
 - Decreasing regulation requirements reduces regulation payments
 - Fewer resources providing regulation means more resources available for the energy market

Questions?

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Appendix A

Two-Phased Approach and Current State Outline

Phase 1

Projected Timeline - complete stakeholder process Q4-2011 and implement in Q1-2012

- 1) Performance factors
 - a. Calculated hourly for each interval a resource regulates
 - b. Feedback to the resource owners via GPM or eMKT
 - c. Alerts to resources below minimum threshold in near real time
- 2) Below minimum threshold
 - a. Resources made ineligible for compensation in a regulating hour when regulation performance score is below 25% for that hour
 - b. Disqualification from the regulation market if a resource's rolling average score of last 100 hours falls below 40%
 - c. When disqualified, a resource must re-test and re-qualify
 - d. Once a unit re-qualifies the rolling 100 hour average resets
- 3) Reduce Energy Ramp Rate used by SPREGO and SCED to minimize the conflict when a resource is ramping for energy or regulation
 - a. While regulating, the segment specific ramp rate should be:

$$\text{Bid-in Energy Ramp Rate} = \frac{\text{Cleared Regulation Capacity}}{5}$$
 - b. Minimum MW/min ramp rate constraint applied
 - c. This change incorporates the Product Substitution Cost in the RMCP
 - d. Increased RMCP and PSC may be offset by lower after-the-fact make-whole payments and a lower regulation requirement.

Phase 2

Projected Timeline - Implement by Q4-2012 pending FERC approval

1. Performance factors
 - a. Adjust the merit order stack for both capacity and mileage
 - b. For initial or increased regulation capability use the performance factor scoring technique of a unit's ability to follow the actual regulation signal using the current three test benchmark
2. Two part payment
 - a. Based on Regulation Capability and Mileage
 - b. Hourly clearing based on lowest total expected production cost
3. Mileage
 - a. Payment determined by:
 (Mileage Clearing Price * Normalized Miles of the Regulation Control Signal * Performance Factor * Regulation Capability)
 - b. Units with the ability to provide fast regulation will receive about 3-4 times more mileage \$ based on current signals
4. Reduction in Regulation Capability Procured
 - a. Improved performance of regulating resources due to performance scoring should reduce procurement
 - b. Track actual changes in regulation capability procured with CPS1 and BAAL needs driven by delta load or other estimation

Current State

Change and Phase indicated by color

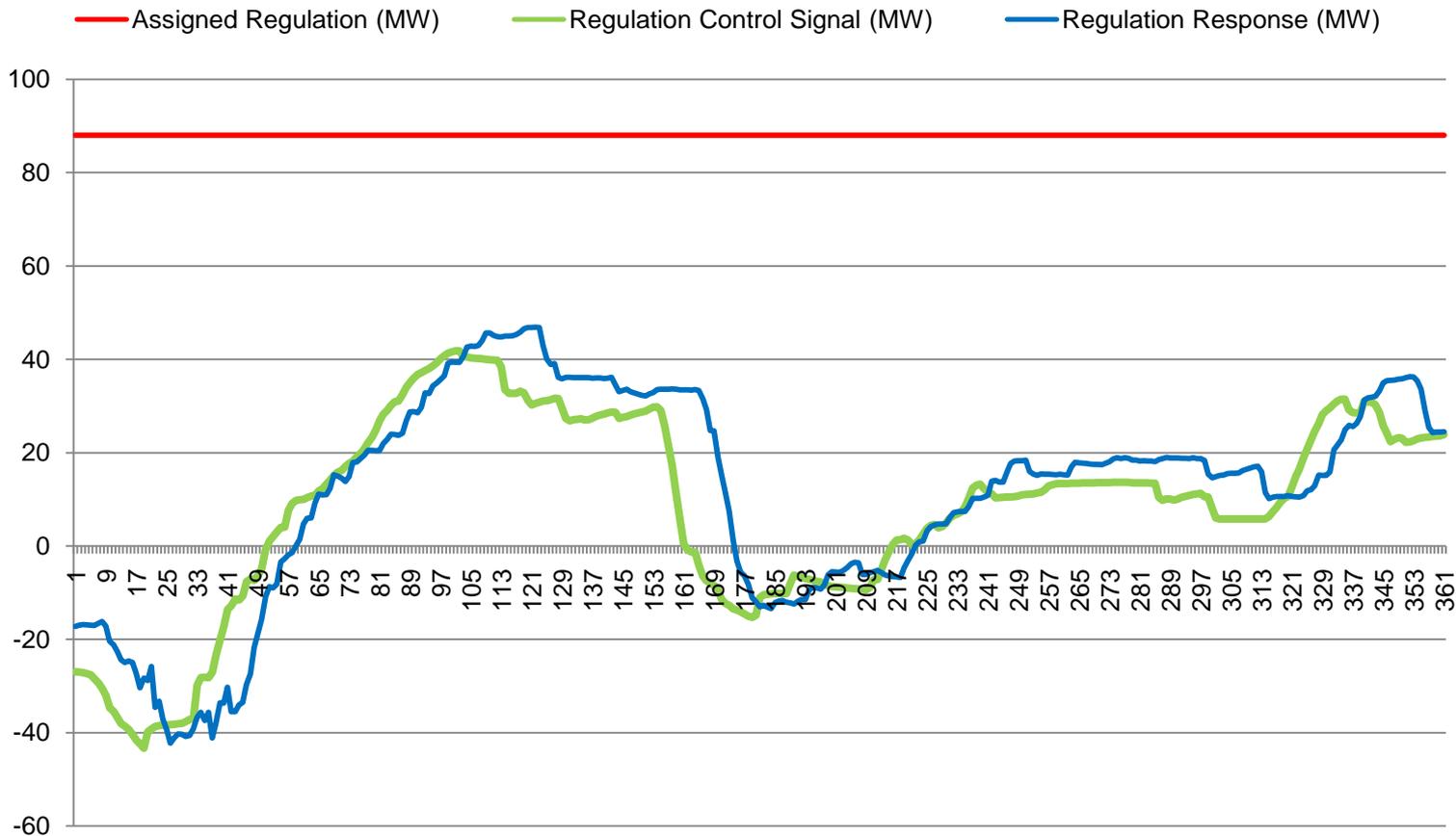
1. Regulation Resource Eligibility Testing
 - a. 0.5 MW minimum of regulation capability for all resource types (in process of changing to 0.1 MW)
 - b. Resources follow square wave control signals for 10 minutes. **Replaced by actual control signals – Phase 2.**
 - c. 75% passing composite score of 3 consecutive tests for initial qualification, then best 3 out of 4, 3 out of 5, 4 out of 6, or 5 out of the last 7 tests for on-going qualification. **Replaced by Performance Factor based qualification and disqualification – Phase 1 & 2.**
2. Data Transfer and Control Signals
 - a. Differentiated by speed
 - i. Slow or traditional signal
 - ii. Fast or dynamic signal
 - b. AREG – unit level hourly assignment, created by SPREGO used by SCED, sent by PJM
 - c. REGA – fleet level regulation signal sent by PJM
 - d. TREG – total fleet capability sent to PJM
 - e. CREG – total fleet response sent to PJM
3. Market Clearing
 - a. Total Regulation Market Size – 1% of forecasted load in on/off peak periods. **Adjusted based on increased performance and alignment with reliability needs – Phase 2.**
 - b. Merit Order Stack – Resource owners submit specific offers to provide Regulation. SPREGO then optimizes the RTO dispatch profile and forecasts LMPs to calculate an hourly Regulation Market Clearing Price (RMCP). **Replaced by two part clearing price – Phase 2.**
4. Verification – After the fact manual process that compares goodness of fit from TReg to resource response. **Replaced with automated Performance Factor based scores and thresholds – Phase 1&2.**
5. Regulation Settlement
 - a. $MW * RCMP + LOC$. **Replaced by two-part clearing – Phase 2.**
 - b. Settlement is a line item
 - c. Regulation Credit Report delivers more detail.
- c. Regulation LOC – takes into account shoulder hour in a make whole payment. **Energy Limited Ramp Rate will alter LOC potentially lowering it – Phase 1&2.**
- d. Regulation TPS – tests for market power of a supplier. When test is failed resource receives regulation cost based offer.

Appendix B

Performance Scoring Summary and Examples

- 1) Accuracy – the correlation or degree of relationship between control signal and regulating unit's response
 - 5 minute rolling correlation with 10 second granularity
 - Re-calculated with a 10 second time shift up to 5 minutes
- 2) Delay – the time delay between control signal and point of highest correlation from Step 1.
 - Up to 5 minutes
- 3) Precision – Difference between the areas under the curve for the control signal and the regulating unit's response.

NOTE: These pieces can be weighted independently.

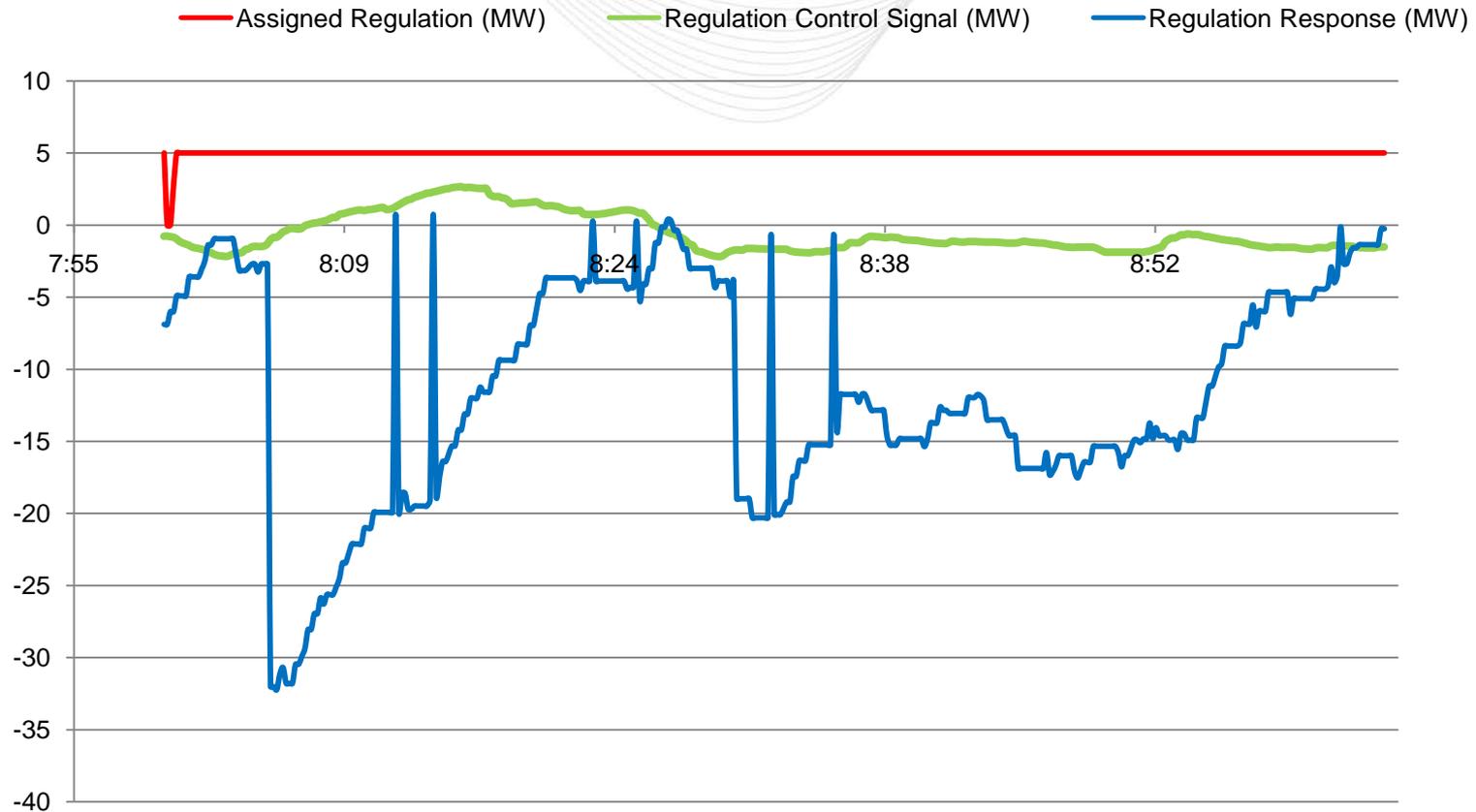


Correlation: 0.95

Delay: 0.66

Precision: 0.74

Total Performance Score: 0.78



Correlation: 0.56

Delay: 0.36

Precision: 0.004

Total Performance Score: 0.31

Appendix C

Two-Part Regulation Market

- Capacity Offers determine the amount of regulation capacity that a resource offers into the regulation market

$$\frac{\text{Capacity Offer}}{\text{MW}} = \text{Lesser of } \left(\frac{\text{Ramp Rate}}{\text{MW/minute}} \right) * (5 \text{ Minutes}) \text{ OR } \frac{\text{Total Regulation Range of Resource}}{2}$$

- The merit order of the regulation offers must be adjusted by the performance of the resources to properly account for the expected benefit to system control.

$$\text{Adjusted Capacity Cost} = \left(\frac{\text{Capacity Offer Price}}{\text{\$/MW}} \right) * \frac{\left(\frac{\text{Capacity Offer}}{\text{MW}} \right)}{\left(\frac{\text{Performance}}{\text{Score}} \right)}$$

- “Mileage” is the total length of the control signal.

$$Mileage_{RegA} = \sum_{i=0}^n RegA_i - RegA_{i-1}$$

- The anticipated mileage costs must be adjusted by the expected movement of the resource during the hour and the expected performance of the resource.
- Expected mileage will be a 30 day average for that type of market hour (on/off peak or high/low delta load)

$$Adjusted\ Mileage\ Cost = \left(\frac{\begin{matrix} \text{Mileage} \\ \text{Offer} \\ \text{Price} \\ \$ \end{matrix}}{\Delta MW} \right) * \left(\frac{\begin{matrix} \text{Expected} \\ \text{Mileage of} \\ \text{Offered Resource} \end{matrix}}{\frac{\Delta MW}{MW}} \right) * \frac{\begin{matrix} \text{Capacity} \\ \text{Offer} \\ MW \end{matrix}}{\begin{matrix} \text{Performance} \\ \text{Score} \end{matrix}} * \begin{matrix} \text{Benefits} \\ \text{Factor} \end{matrix}$$

- Total offer for a resource is the summation of the following components.

$$\text{Adjusted Total Offer} = \left(\begin{array}{c} \text{Adjusted} \\ \text{Capacity} \\ \text{Cost} \\ \$ \end{array} \right) + \left(\begin{array}{c} \text{Lost} \\ \text{Opportunity} \\ \text{Cost} \\ \$ \end{array} \right) + \left(\begin{array}{c} \text{Adjusted} \\ \text{Mileage} \\ \text{Cost} \\ \$ \end{array} \right)$$

- The rank order must be calculated per MW

$$\text{Rank Order} \frac{\$}{\text{MW}} = \frac{\left(\begin{array}{c} \text{Adjusted Total Offer} \\ \$ \end{array} \right)}{\left(\begin{array}{c} \text{Capacity Offer} \\ \text{MW} \end{array} \right)}$$

- The *Rank Order \$/MW* of the last resource assigned will set the *Regulation Market Clearing Price (RMCP)*.
- This single *RMCP* creates the basis for setting the component clearing prices for capacity and mileage.

$$\text{Mileage Clearing Price} = \max_{\text{Assigned Resources}} \left(\begin{array}{c} \text{Mileage} \\ \text{Offer Price} \\ \text{\$/MW} \end{array} \right)$$

$$\text{Capacity Clearing Price} = \left(\begin{array}{c} \text{Regulation Market} \\ \text{Clearing Price} \\ \text{\$/MW} \end{array} \right) - \left(\begin{array}{c} \text{Mileage} \\ \text{Clearing Price} \\ \text{\$/MW} \end{array} \right)$$

- The market will have both a capacity and mileage requirement

$$\text{Capacity Requirement}_{MW} \leq \sum_{i=0}^n \text{Capacity Offer } MW_i$$

$$\text{Mileage Requirement}_{\Delta MW} \leq \sum_{i=0}^n \left[\text{Capacity Offer } MW_i * \left(\begin{array}{c} \text{Expected Mileage} \\ \text{of Offered Resource} \\ \Delta MW / MW \end{array} \right)_i \right]$$

- These requirements will be determined based on historical operations and off-line analysis and set to ensure compliance with NERC and PJM reliability needs.
 - PJM sets limits to ensure compliance with NERC reliability requirements.

RPSTF Two-Part Regulation Market Clearing Price Example

- Assuming Epsilon chosen at marginal based on capacity and mileage requirements being met with that unit.
- Therefore, \$45/MW sets the Regulation Market Clearing Price.

Unit Name	Adjusted Capacity Offer	Adjusted Mileage Offer	LOC	Rank Order \$/MW
Alpha	3	6	0	9
Beta	4	0	6	10
Gamma	0	15	0	15
Delta	10	20	10	40
Epsilon	18	15	12	45
Zeta	7	30	13	50
Eta	11	20	19	50
Theta	1	50	0	51

- We now find the highest Adjusted Mileage Offer, which is \$20/MW.
- This sets the Mileage Clearing Price at \$20/MW.
- The Capacity Clearing Price equals $\$45/\text{MW} - \$20/\text{MW} = \$25/\text{MW}$.
- These component clearing prices will be used in the settlement calculations.

Unit Name	Adjusted Capacity Offer	Adjusted Mileage Offer	LOC	Rank Order \$/MW
Alpha	3	6	0	9
Beta	4	0	6	10
Gamma	0	15	0	15
Delta	10	20	10	40
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Eta	11	20	19	50
Theta	1	50	0	51