Performance-based Regulation Market in PJM

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• October 2011 – FERC Order 755 issued
• March 2012 – PJM Original filing w/ Benefits Factor
• May 2012 – Acceptance Order, subject to additional compliance filing
• October 2012 – PJM “go live” of PBR, but without incentive payment structure
• November 2012 – Acceptance Order, subject to additional compliance filing
• January 2013 – PJM Compliance Filing w/ Mileage Ratio
• July 2013 – Acceptance Order, subject to additional compliance filing
• October 2013 – Final Acceptance Order
5 MAJOR COMPONENTS OF PERFORMANCE-BASED REGULATION
1. TWO REGULATION SIGNALS
Dynamic Signal (RegD):
More ‘zero’ crossings
“Energy neutral” over operating hour
Strong correlation with system frequency

Traditional Signal (RegA):
Greater time constant, more staying power
Slower ramping
Strong correlation with system ACE
Two Signals, Complimentary to System Control: 5 Hour sample of production signal
• What is the relative impact on system control with fast vs. traditional resources?

• What is an optimal mix of fast vs. traditional resources, and how does that impact the Regulation Requirement?
2. CALCULATING MILEAGE
- Mileage is the absolute sum of movement of the regulation signal in a given time period ($\Delta MW/MW$)
- Resources following the dynamic signal will move much more than those on traditional signal
3. CALCULATING PERFORMANCE
**Performance Score – 3 points**

**Accuracy** – the correlation or degree of relationship between control signal and regulating unit’s response

**Delay** – the time delay between control signal and point of highest correlation (from A).

**Precision** – Difference between the areas under the curve for the control signal and the regulating unit’s response.

Composite Performance Score = A [Score\(_C\)] + B [Score\(_D\)] + C [Score\(_P\)]

- A, B, C are scalars from [0..1], total to 1
- Produces a weighted average of component scores
Performance Score – Example, Combine Cycle

Accuracy = 0.95
Delay = 0.66
Precision = 0.74
Total Score = 0.78
4. EFFECTIVE MEGAWATTS (THE BENEFITS FACTOR)
Benefits factor provides a sliding scale that makes dynamic resources more desirable until the optimal resource mix of dynamic and traditional resources is reached.
5. TWO PART OFFER, TWO PART SETTLEMENT - EFFECTED BY 1-4
Regulation Offers – Cost and Price

- **Cost**: Up to limits described in as described in M11, Section 3.2.1 and Manual 15, Section 2.8
  - **Capability ($/MW)**: Reservation Cost for MW which includes the Fuel Cost Increase and $12 Margin Adder
  - **Performance ($/ΔMW)**: Is the incremental cost of MW movement which includes Cost Increase due to Heat Rate Increase during non-steady state operation and Cost Increase in VOM

- **Price**: Up to 100 $/MWH As described in M11, Section 3.2.1
  - **Capability ($/MW)**: the price to reserve MWs for regulation
  - **Performance ($/ΔMW)**: the price to provide regulation movement

- The $/ΔMW will be multiplied by the ratio of ΔMW/MW for the signal that resource follows to convert to ($/MW)
The Capability Offer is adjusted as follows:

Adjusted Regulating Capability Cost ($) = \left( \frac{\text{Capability Offer} \left( \frac{\$}{\text{MW}} \right)}{\text{Benefits Factor of Offered Resource}} \right) \times \frac{\text{Capable of (MW)}}{\text{Historic Performance Score}}

**Resource owner’s Offer for reserving MW’s**

**Qualified Regulation MW’s**

Benefits factor translates a Dynamic resource’s MWs into traditional MWs to estimate Effective MWs. For Traditional resources, this value is “1”.

Average of last 100 hours of performance scores
The Performance Offer is adjusted as follows:

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\text{Adjusted Performance Cost} (\$) = \left( \frac{\text{Performance Offer} (\$/\Delta MW)}{\text{Offered Resource Signal Type (\Delta MW/MW)}} \right) \times \left( \frac{\text{Benefits Factor of Offered Resource}}{\text{Historic Performance Score}} \right) \times \left( \frac{\text{Mileage ratio of Qualified Regulation MW’s}}{\text{Capability (MW)}} \right) \times \left( \text{30 day average of historical mileage} \right)
\]
1 YEAR+ -- RESULTS
Milford Control Center: Solar + Storage
Laurel Mountain, West Virginia (AES Energy Storage)

Largest Li-ion battery in the world
32 MW, 8 MWh
Provides fast-response Frequency Regulation in PJM's Wholesale Markets
Ecoult and Deka Ultrabattery ®

3 MW (<3 MWh)

Regulation Service, from behind the meter
Viridity Energy and Axion PowerCube™

500 kW
Regulation Service, from behind the meter
VCharge, Inc

4-5 kW (aggregated to >100 kW)
Regulation Service, *from behind the meter at multiple locations*
Market Test – Electric Vehicles and Ancillary Services

Credit: Tim Shaffer for The New York Times