

Regulation Mileage Ratio Calculation

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- *Regulation Mileage* is the measurement of the amount of movement requested by the regulation control signal a resource is following.
 - It is calculated for the duration of the operating hour for each regulation control signal: RegA and RegD
 - It is a proxy metric for the amount of work performed while following the regulation signal to correct the RTO Area Control Error

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

$$Mileage_{RegD} = \sum_{i=1}^n |RegD_i - RegD_{i-1}|$$

Regulation Mileage Overview (continues)

- If a signal is “pegged” high or low for an entire operating hour, the corresponding mileage would be zero for that hour
- PJM has seen increased frequency of RegA signal pegging
 - Increased amount of RegD participation
 - RegA supporting conditional neutrality of RegD
- Increased visibility to dispatchers on RegA signal pegging
- No reliability issues as total regulation typically not pegged for long durations

Mileage Ratio Calculation

- Section 3.2.2 (g) of the Operating Agreement and section 3.2.2 (g) of OATT Attachment K - Appendix

The owner of each Regulation resource that actively follows the Office of the Interconnection’s Regulation signals and instructions, will be credited for Regulation performance by multiplying the assigned MW(s) by the Regulation market performance-clearing price, by **the ratio between the requested mileage for the Regulation dispatch signal assigned to the Regulation resource and the Regulation dispatch signal assigned to traditional resources**, and by the Regulation resource’s accuracy score calculated in accordance with subsection (k) of this section.

* traditional resources – RegA resources

$$\text{Mileage Ratio (RegA)} = \frac{\text{RegA Hourly Mileage}}{\text{RegA Hourly Mileage}}$$

$$\text{Mileage Ratio (RegD)} = \frac{\text{RegD Hourly Mileage}}{\text{RegA Hourly Mileage}}$$

- Regulation Market Performance Clearing Price (RMPCP) Credit = 5-min integrated Regulation MW x Five Minute Actual Performance Score x **Mileage Ratio** x Five minute RMPCP /12

- Floor RegA Mileage at 0.1 instead of zero
 - Would allow valid solution for Mileage Ratio while maintaining market design objectives
 - Would have impacted only 0.018% of hours since 2012 (15 hours)
 - No impact to Regulation signal design, Operations or Regulation Market Clearing
 - Consistent with 2018 change flooring Benefits Factor in market clearing to 0.1 instead of 0
- Add one sentence to Section 3.2.2 (g) of the Operating Agreement, section 3.2.2 (g) of OATT Attachment K – Appendix, and sections 4.1 and 4.2 in Manual 28 (Operating Agreement Accounting)
 - In the calculation of Mileage Ratio, the RegA Mileage will be floored at 0.1.

- Section 3.2.2 (g) of the Operating Agreement and section 3.2.2 (g) of OATT Attachment K - Appendix

The owner of each Regulation resource that actively follows the Office of the Interconnection's Regulation signals and instructions, will be credited for Regulation performance by multiplying the assigned MW(s) by the Regulation market performance-clearing price, by the ratio between the requested mileage for the Regulation dispatch signal assigned to the Regulation resource and the Regulation dispatch signal assigned to traditional resources, and by the Regulation resource's accuracy score calculated in accordance with subsection (k) of this section. In determining the ratio between the requested mileage for the Regulation dispatch signal assigned to the Regulation resource and the Regulation dispatch signal assigned to traditional resources, the hourly mileage applicable to traditional resources shall not be less than 0.1.

- Exact proposed language for the Tariff and the Operating Agreement will be included Manual 28, Sections 4.1 and 4.2

Proposed Implementation Schedule

May 2021	June 2021
MIC First Read	MIC Endorsement
MRC First Read	MRC Approval
	MC Approval

Target FERC Filing in June

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Regulation Mileage Ratio Calculation

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Appendix

Undefined Mileage Ratio Calculation - Problem Statement

- Regulation Resource Regulation Market Performance Clearing Price (RMPCP) Credit =
$$\frac{\text{5-min integrated Regulation MW} \times \text{5-min Actual Performance Score} \times \text{Mileage Ratio}}{\text{5-min RMPCP} / 12}$$

$$\text{Mileage Ratio (RegA)} = \frac{\text{RegA Hourly Mileage}}{\text{RegA Hourly Mileage}}$$

$$\text{Mileage Ratio (RegD)} = \frac{\text{RegD Hourly Mileage}}{\text{RegA Hourly Mileage}}$$

- If the RegA signal is flat or “pegged” for an hour (a very rare instance), its mileage will be zero (0)
 - When this occurs, a value of “0” is substituted into the “RegA Hourly Mileage” portion of the above equations, which can produce an imaginary number (i.e. 0/0 = undefined; 1/0 = undefined)
 - This can create a problem on the settlements side, because we don’t really know how to treat an imaginary value for “Mileage Ratio” when it is plugged into the above equation for RMPCP Credit.

Undefined Mileage Ratio Calculation - Issue Charge

Key Work Activities

- Brief education on the Regulation Mileage Ratio calculation and how it is used in the Regulation Market.
- Develop a proposed solution for the undefined Regulation Mileage Ratio calculation error.
- Define an implementation timeline for the proposed solution

Areas To Be Addressed

- The undefined issue with the Regulation Mileage Ratio calculation in Settlement

Areas Not To Be Addressed

- All other aspects of the Regulation Market outside the Regulation Mileage Ratio calculation.

Undefined Mileage Ratio Calculation - Issue Charge (continues)

Expected Deliverables

- A recommendation to the MRC on market rule changes for a proposed solution.
- Updates to the Tariff and/or Manuals as applicable.

Proposed Approach

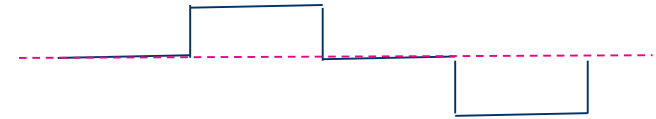
- PJM will seek Tier 1 consensus (unanimity) on a single proposal for this issue.
- PJM will work the issue through the “**Quick Fix**” process at the Markets Implementation Committee (MIC).
- PJM will propose a solution during the first read of the Issue Charge and request a vote at the following meeting.

- *Regulation Mileage* is a measurement of the amount of movement of the regulation signal over a given time period
 - Utilization = Signal / TREG, ranges +1 (full raise) to -1 (full lower)
 - Mileage = Sum(Abs(Utilization[t+1] – Utilization[t]))
 - See Manual 11 Section 3.2.7.3 for more detail
 - *Mileage* is a proxy metric for the amount of work performed while following the regulation signal to correct the RTO ACE
- *Mileage Ratio* is the comparison of Mileage of Signal D to A
 - Since 2012, PJM uses the *Mileage Ratio* to settle the Regulation Performance Credits for Regulation D resources

How is Mileage measured to the Signal?

Example signal sent to a resource:

- T:00 – Resource starts at basepoint
 - T:15 – Resource moves to full raise (+1 mile)
 - T:30 – Resource moves back to basepoint (+1 mile)
 - T:45 – Resource moves to full lower (+1 mile)
 - T:59 – Resource moves back to basepoint (+1 mile)
-
- Unit has moved 4 “miles”, or 4 times its regulation assignment, in the given hour



Regulation Settlement – Use of Mileage Ratio

- Regulation Market Performance Clearing Price (RMPCP) Credit =

$$\frac{\text{5-min integrated Regulation MW} \times \text{Five Minute Actual Performance Score} \times \text{Mileage Ratio} \times \text{Five minute RMPCP}}{12}$$
- Regulation Market Capability Clearing Price (RMCCP) Credit =

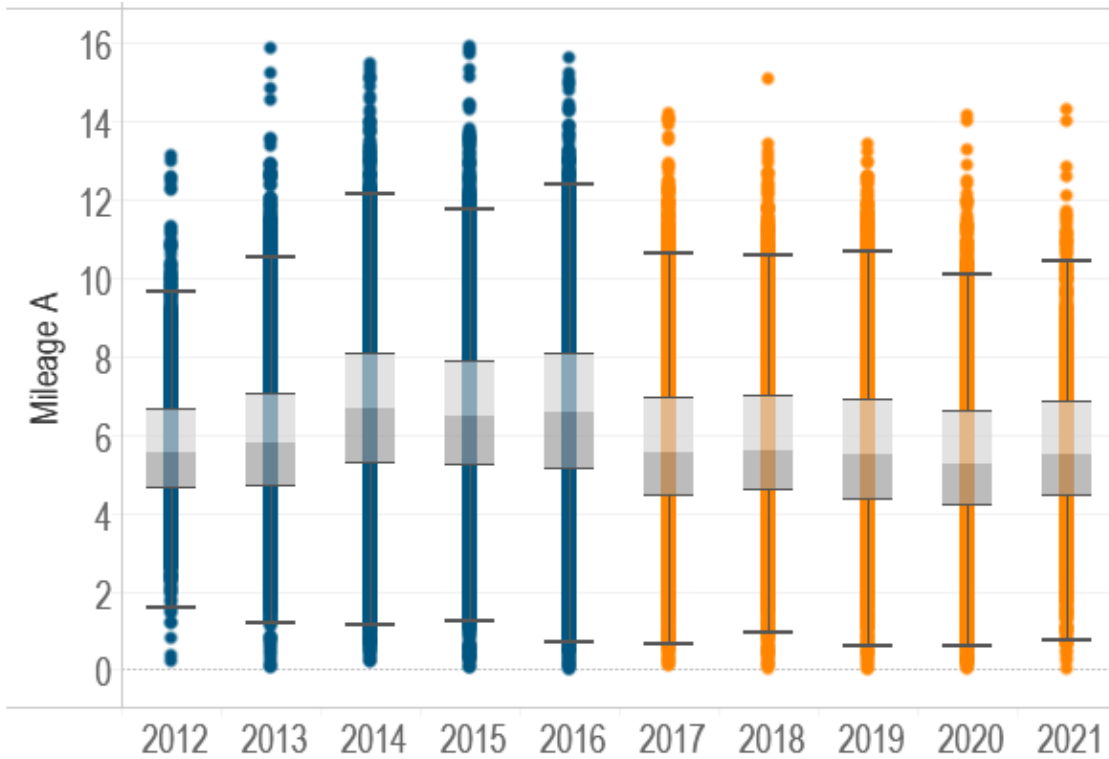
$$\frac{\text{5-min integrated Regulation MW} \times \text{Five minute Actual Performance Score} \times \text{Five minute RMCCP}}{12}$$
- How do we calculate Mileage Ratio when RegA Hourly Mileage is zero?

Example: 0.1 Floor on Hourly Mileage A

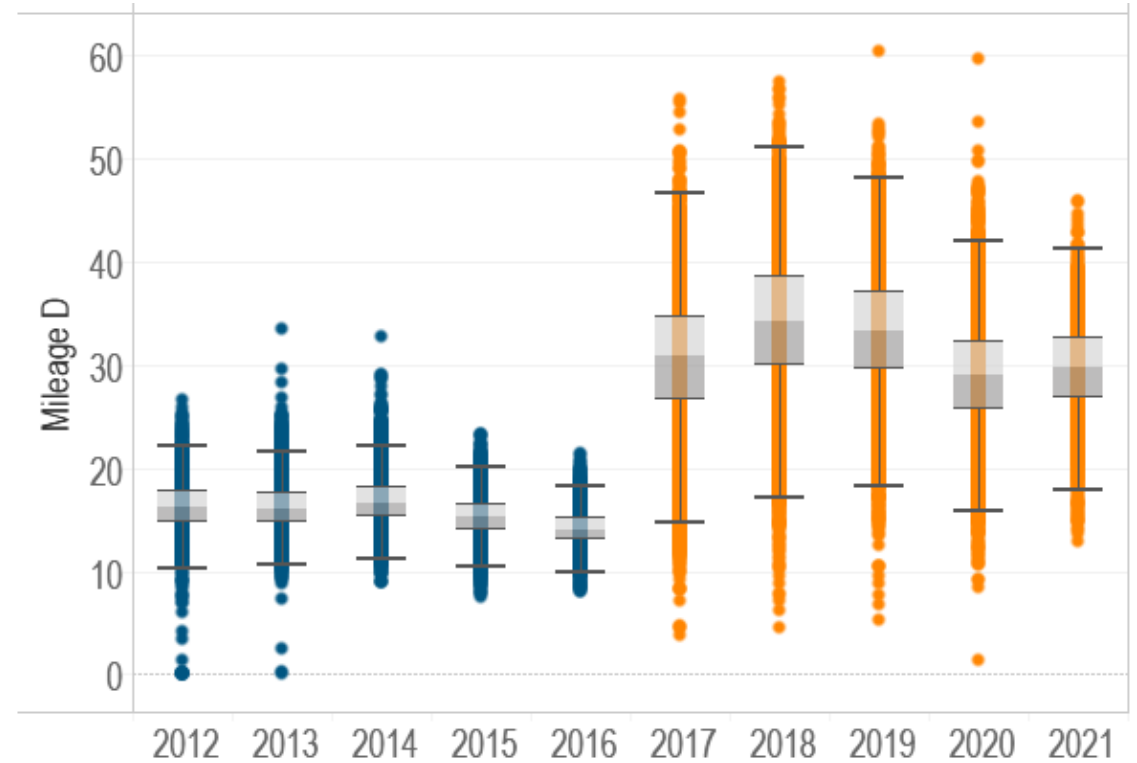
Local Hour	RMCCP	RMPCP	Hourly Mileage A	Hourly Mileage D	Hourly Mileage Ratio (Settled)	Hourly Mileage Ratio (Proposed)	Difference in Mileage Ratio
3/4/2013 18:00	\$37.67	\$0.03	0.074304	0.257536	3.47	2.58	0.89
11/9/2013 18:00	\$12.40	\$0.97	0.072887	15.649591	214.71	156.50	58.21
5/31/2015 15:00	\$187.06	\$0.78	0.070406	14.128501	200.67	141.29	59.39
12/11/2015 16:00	\$12.49	\$0.01	0.078511	13.35094	170.05	133.51	36.54
12/31/2015 18:00	\$0.27	\$0.00	0.056789	12.54787	220.96	125.48	95.48
1/1/2016 2:00	\$8.45	\$0.00	0.013579	10.582214	779.31	105.82	673.49
6/28/2016 16:00	\$3.08	\$0.00	0.018116	11.818568	652.38	118.19	534.20
2/27/2018 9:00	\$0.00	\$0.00	0.040318	20.448624	507.18	204.49	302.70
1/21/2019 11:00	\$313.49	\$0.00	0.006478	27.402607	4230.10	274.03	3956.08
1/30/2019 14:00	\$17.49	\$0.01	0.046133	5.225629	113.27	52.26	61.02
6/22/2020 15:00	\$0.01	\$0.00	0.048004	19.204105	400.05	192.04	208.01
6/26/2020 0:00	\$11.37	\$0.00	0.096609	23.562192	243.89	235.62	8.27
8/12/2020 14:00	\$15.09	\$0.01	0.033320	22.412721	672.65	224.13	448.52
2/17/2021 9:00	\$0.00	\$0.00	0.000000	19.159495	#N/A	191.59	191.59

Historical Hourly Mileage by Signal Type

Mileage of Regulation Signal A

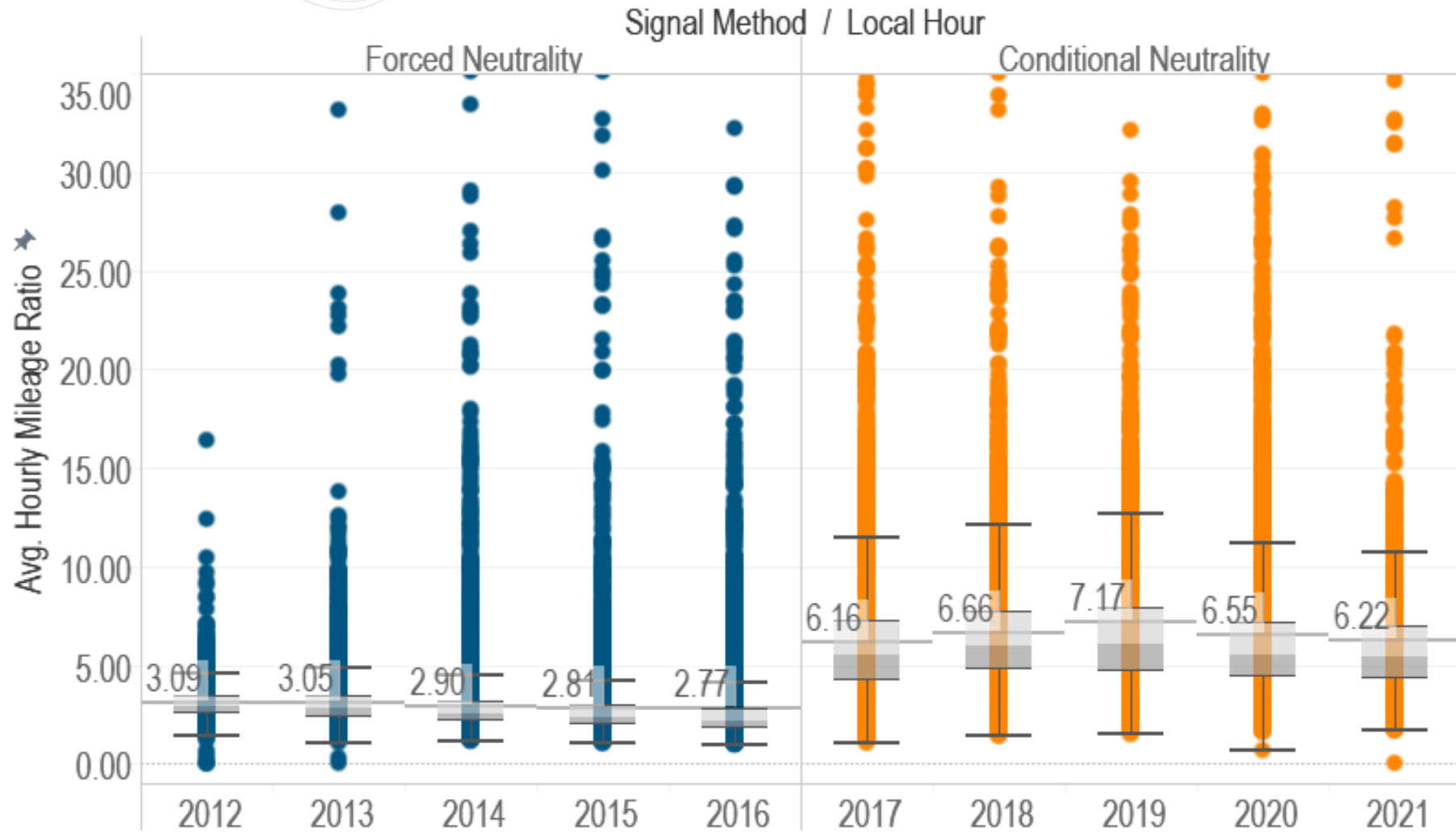


Mileage of Regulation Signal D



Conditional Neutrality logic implemented Jan 2017 resulted in an increase in the movement of the REGD resources

Hourly Mileage Ratio, by Year by Signal Methodology



- The highest adjusted performance cost from the set of cleared resources sets the Regulation Market Performance Clearing Price (RMPCP)
- Why is RMPCP mostly \$0 especially when mileage ratio is high?
 - The Adjusted Performance cost is affected by the real-time mileage of the signal type of the resource

$$\text{Adjusted Performance Cost (\$)} = \frac{\left(\text{Performance Offer (\$/\Delta MW)} \right) * \left(\begin{matrix} \text{Mileage} \\ \text{of} \\ \text{Offered Resource} \\ \text{Signal Type (\Delta MW / MW)} \end{matrix} \right)}{\left(\begin{matrix} \text{Benefits Factor} \\ \text{of} \\ \text{Offered Resource} \end{matrix} \right) * \left(\begin{matrix} \text{Historic} \\ \text{Performance} \\ \text{Score} \end{matrix} \right)} * \left(\begin{matrix} \text{Capability} \\ \text{(MW)} \end{matrix} \right)$$