



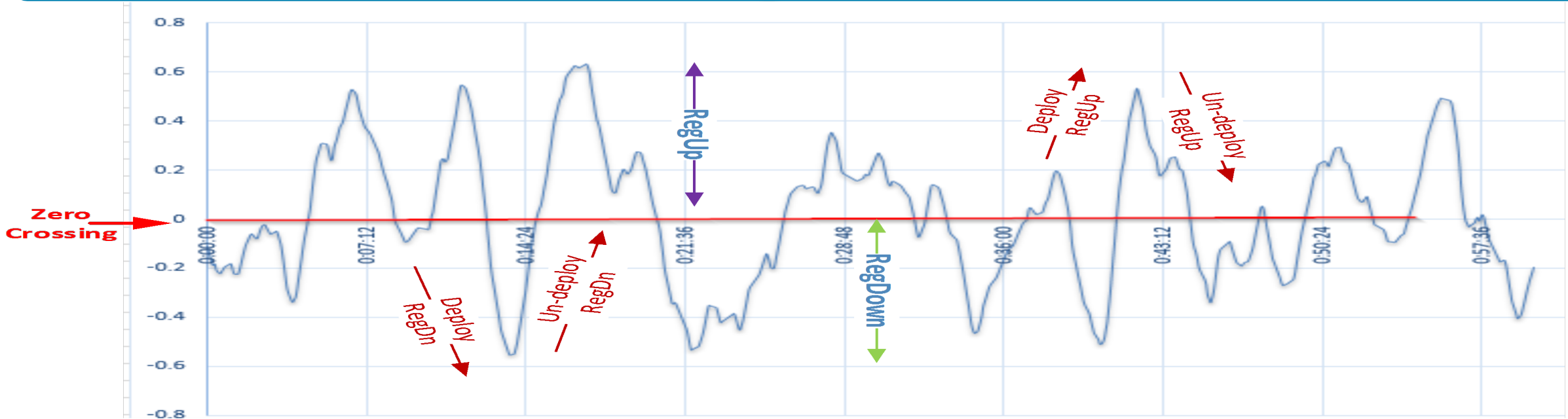
PJM Proposed Package Regulation Re-design

Regulation Market Design Senior Task Force
July 2023

Matrix Item A: Regulation Signal:

1. Signal type and 2. Product type

Moving to a one-signal design and a Regulation Up/Regulation Down Market



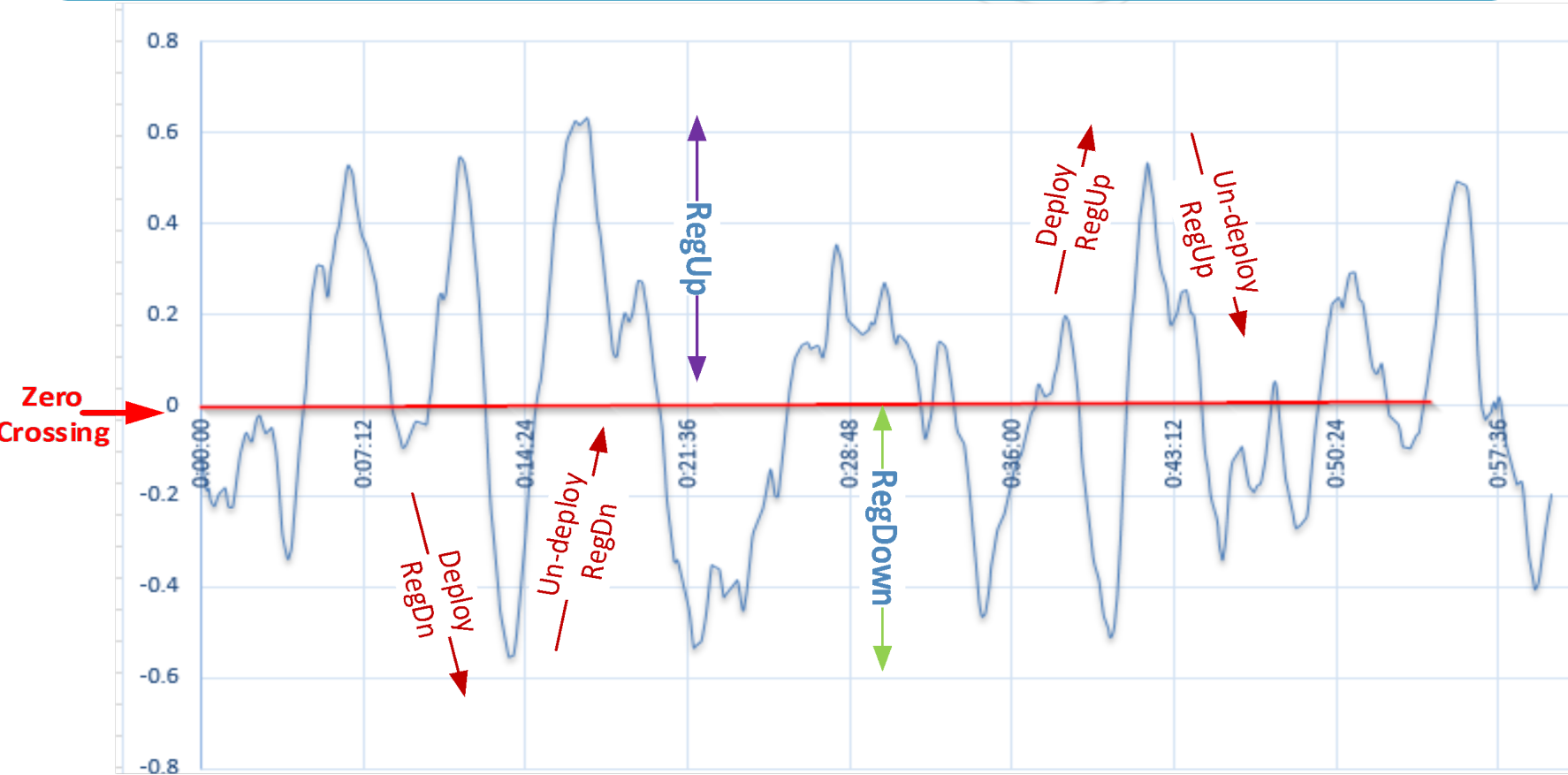
Better aligned with System needs; Provides more flexibility of supply; More market and operational efficiency



Matrix Item A: Regulation Signal:

1. Signal type and 2. Product type

A one-signal design and a Regulation Up/Regulation Down Market in Operations



- RegUp product operates above the zero crossing
- RegDn product operates below the zero crossing
- One product will be fully deployed and un-deployed before the other product is asked to respond to an AGC signal
- Resources will be able to follow the full signal (bidirectional) by being assigned RegUp and RegDn



Matrix Item B: Regulation Requirement

Season	Dates	Hours Ending	Requirement MW
Winter	Nov. 1 – Feb. 28	HE 5 – 10, HE 17 – 24	750
		HE 1, HE 11	650
		HE 2 – 4, HE 12 - 16	550
Spring	March 1 - April 30	HE 19 – 1, HE 6 – 9	750
		HE 2, HE 10	650
		HE 3 – 5, HE 9 – 18	550
Summer	May 1 – Sept. 15	HE 5 – 1	750
		HE 2	650
		HE 3 – 4	550
Fall	Sept. 15 – Oct. 31	HE 6 – 9, HE 18 – 24	750
		HE 1, HE 10	650
		HE 2 – 5, HE 9 - 17	550

Matrix Item B: Regulation Requirement

Put in place an annual review to modify the requirement based on system needs to address the energy transition and integration of renewables

- Maintaining High/Low Regulation Requirement hours

	Δ Requirement			
	-25 MW	No Change	+25 MW	+50 MW
ACE TOB (>2*L ₁₀)	10%	> 10% and < 50%	50%	60%
BAAL	NA	< 50 Mins	50 Mins	75 Mins
RU	20%	> 20% and < 80%	80%	90%
Min/Max Deploy.	NA	< 7.5%	7.5%	10%

Step-Down Constraint: Result cannot be < the prior hour by 150 MW or more

**** Adjustment levels -25/+25/+50 are based on 10%/20% of NERC L₁₀ value (CPS2).**

Matrix Item E: Performance Scoring:

14. Qualification testing and 15. Type specific testing

Disqualified Resources

Change in Capability
(MW)

Change in
Communication Path or
EMS – Existing or New
Owner/MOC

New Resources

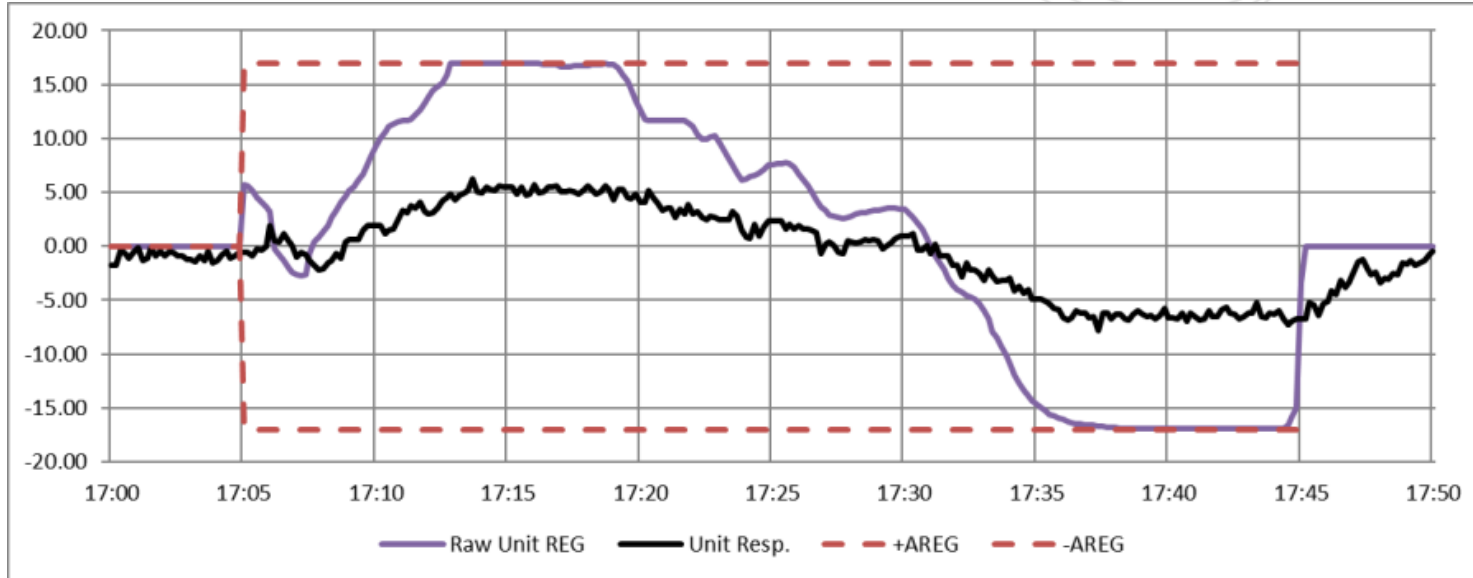
1 PJM-administered test

2 tests = 1 self-
scheduled test + 1 PJM-
administered test or 2
PJM-administered tests

**New Performance Score of (an average of) PJM-
administered test(s)**

16. Components of performance scoring and weight

Moving Performance Scoring to a Precision Only Calculation



	Score
Status Quo Performance Score	0.753
Accuracy	0.908
Delay	0.990
Precision	0.362
Precision Score	0.362

Precision will be calculated as: The lowest of the absolute error between the signal at t0 and the response at t0 and t10. The denominator in the precision calculation will be an average of the regulation award and the absolute average hourly signal.

Matrix Item E: Performance Scoring:

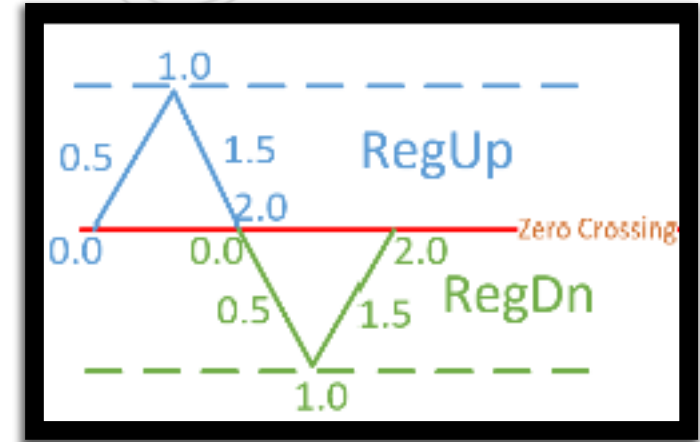
17. Minimum allowable participation threshold

18. Minimum allowable compensation threshold

- Minimum allowable participation threshold - **status quo**
 - 40% historic performance score (average across last 100 operating hour)

- Minimum allowable compensation threshold – **status quo**
 - 25% performance (precision) score for the interval

- Implement mileage consistently in clearing, pricing and settlements
- Calculate RegUp mileage and RegDn mileage Separately



$$Mileage_{RegUp} =$$

$$\sum_{i=1}^n |RegUp_i - RegUp_{i-1}|$$

$$Mileage_{RegDn} =$$

$$\sum_{i=1}^n |RegDn_i - RegDn_{i-1}|$$

OFFER:
\$/Mile

CLEARING AND PRICING:
\$/Mile * Historic Mileage

Mileage Clearing Price
(MCP) = (\$/Mile * **Historic Mileage**) / PerfScore

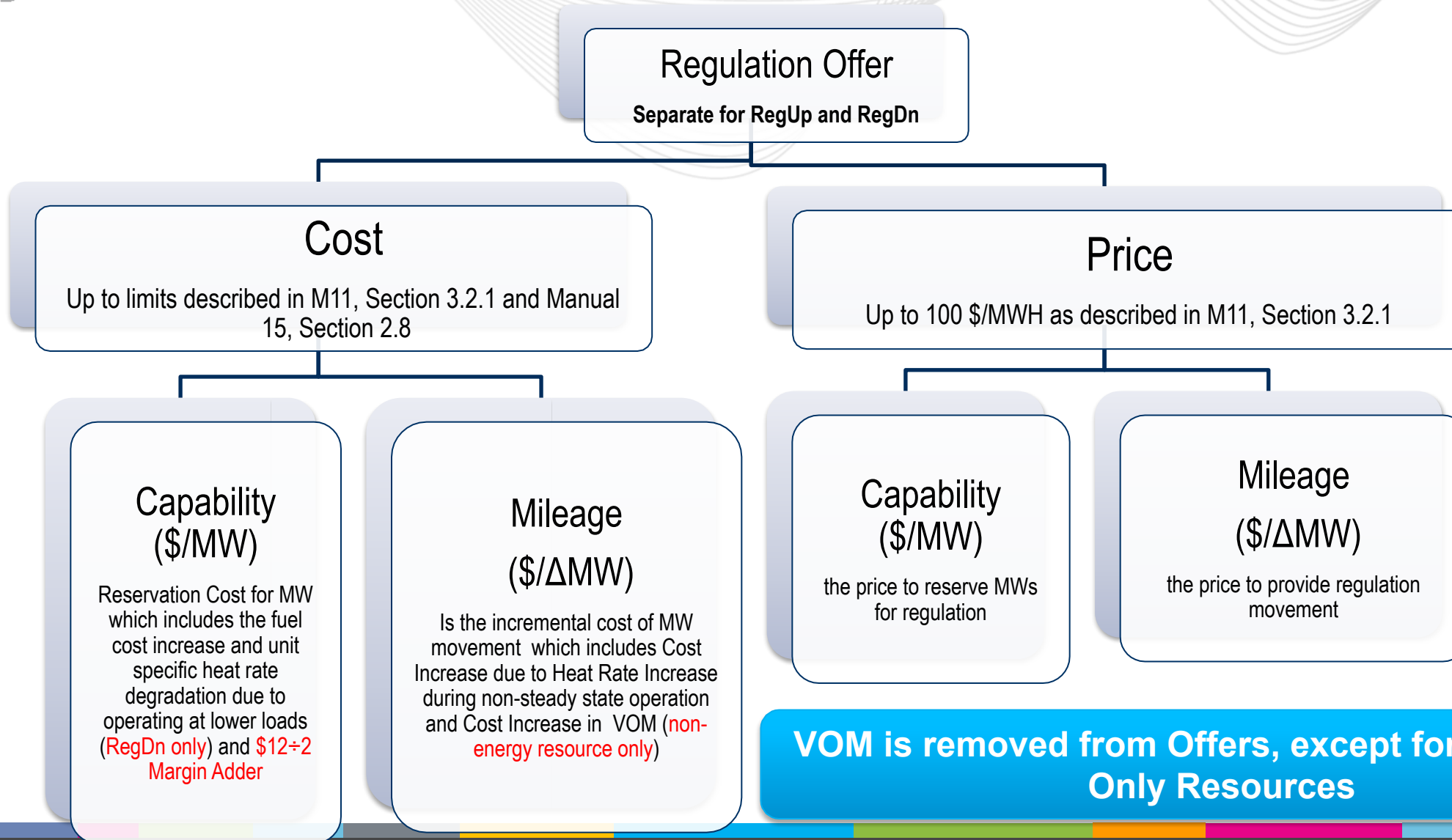
SETTLEMENTS:
Actual Mileage / Historic Mileage

Mileage Credit = MW* MCP*
PerfScore* **Actual Mileage/Historic Mileage**

- Regulation clearing and regulation pricing will use the daily (historical) product signal mileage for the mileage offer price adjustment
 - Historical mileage is a rolling 30-day average by the product signal type

- Settlement will use the ratio of the 5-minute product signal actual mileage to the product historic mileage for the Regulation Mileage (Performance) credit
 - For RegUp:
$$\frac{\text{RegUp signal actual 5-minute mileage}}{\text{RegUp historic mileage for the operating day}}$$
 - For RegDn:
$$\frac{\text{RegDn signal actual 5-minute mileage}}{\text{RegDn historic mileage for the operating day}}$$

22. Components of Offer and 22a. Inclusion of VOM in Regulation Offer



VOM is removed from Offers, except for Regulation Only Resources



Matrix Item H: Offer Structure: 22b & c. Adjusted Offers

Adjusted Regulation Capability Cost (\$/MW)

$$\frac{\text{Capability Offer} \times \frac{\$}{\text{MW}}}{\text{Resource Historic Performance Score}}$$

Adjusted Lost Opportunity Cost (\$/MW)

$$\frac{\text{Lost Opportunity Cost} \times \frac{\$}{\text{MW}}}{\text{Resource Historic Performance Score}}$$

Adjusted Total Cost (\$/MW)

$$\left(\begin{array}{c} \text{Adjusted} \\ \text{Regulation} \\ \text{Capability} \\ \text{Cost} \\ \frac{\$}{\text{MW}} \end{array} \right) + \left(\begin{array}{c} \text{Adjusted} \\ \text{Lost} \\ \text{Opportunity} \\ \text{Cost} \\ \frac{\$}{\text{MW}} \end{array} \right) + \left(\begin{array}{c} \text{Adjusted} \\ \text{Mileage} \\ \text{Cost} \\ \frac{\$}{\text{MW}} \end{array} \right)$$

Capability Component

Mileage Component

Adjusted Regulation Mileage Cost (\$/MW)

$$\frac{\text{Mileage Offer} \times \frac{\$}{\Delta \text{MW}} * \text{Historic Mileage of Offered Resource Product Type} \times \frac{\Delta \text{MW}}{\text{MW}}}{\text{Resource Historic Performance Score}}$$

Regulation Effective MW

$$\text{Regulation MW} * \text{Historic Performance Score}$$

- **Historical Performance Score** – average of last 100 hours of resource's performance scores
- **Historical Mileage** – 30 days average of PJM regulation control signal-type mileage

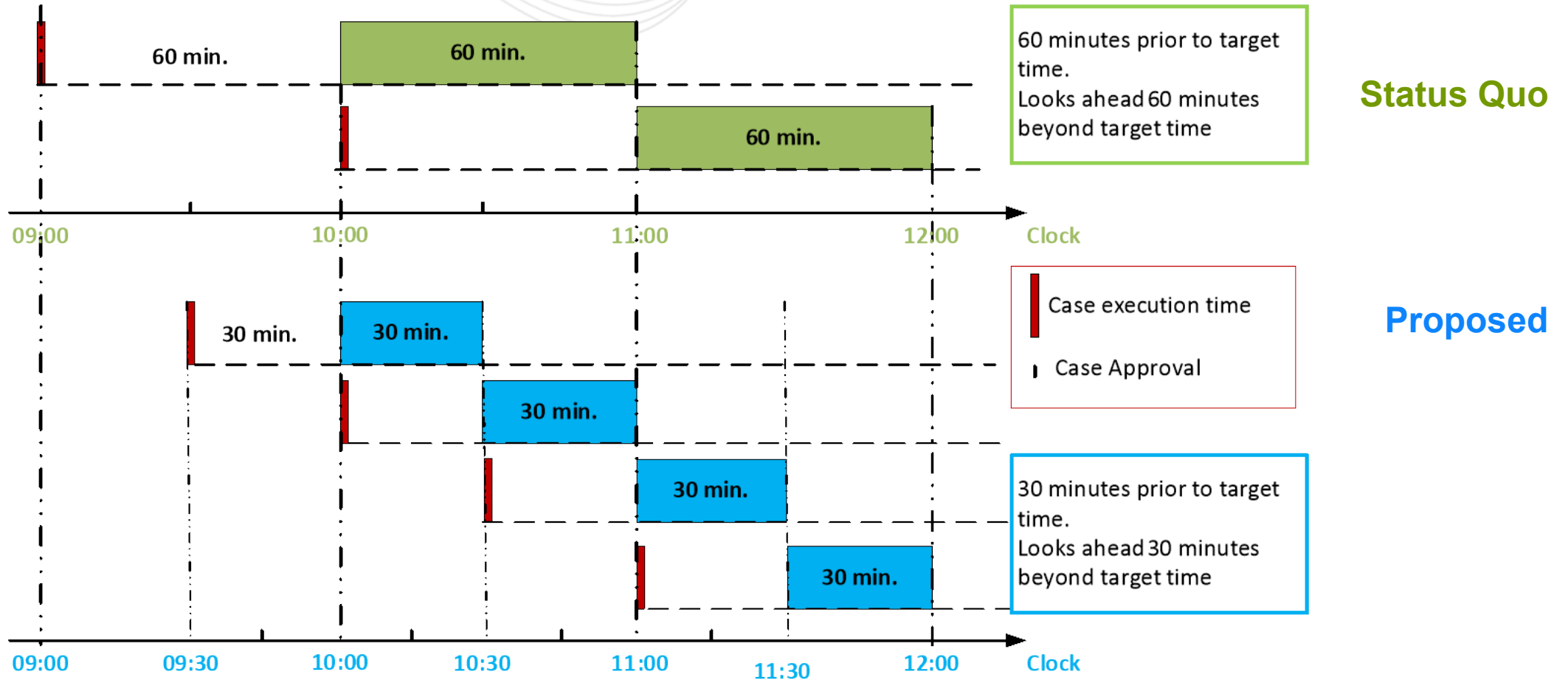
❖ Same adjusted offers and parameters will be used in pricing

Matrix Item H: Offer Structure:

23. Dual Offer and Capability Process

- RegUp only resource will follow regulation signal above the zero crossing only
- RegDn only resource will follow regulation signal below the zero crossing only
- RegUp/RegDn resource may submit offers into (and clear in) both RegUp and RegDn markets for the same interval
 - Option available in Markets Gateway for Market Participants around the clearing constraint (must clear RegUp and RegDn)
- Self de-assign will result in zero performance score in the regulation market interval
- PJM dispatch de-assign does not impact performance score in the regulation market interval

Move to a 30 minute clearing time and commitment duration



12. Schedule used for LOC and

13. Desired MW @ LMP vs Desired MW @ LMP Ramp Limited

- Energy schedule used for LOC
 - For online resources, the schedule on which the resource is committed and running for energy
 - For offline resources, the cheapest of the price-based or cost-based available energy schedules
- Total LOC Calculation- tracking desired MW @ LMP Ramp Limited

Area bounded by LMP, tracking desired MW @ LMP ramp limited, marginal cost @ Reg set point and MW @ Reg set point minus area bounded by energy schedule curve, tracking desired MW @ LMP ramp limited, marginal cost @ Reg set point and MW @ Reg set point.

- Regulation Settlements will be for both the RegUp Settlement and RegDn Settlement
 - RegUp Settlement
 - RegUp capability credit
 - RegUp mileage credit (performance credit)
 - RegDn Settlement
 - RegDn capability credit
 - RegDn mileage credit (performance credit)
- Make whole for Regulation Settlements will be done on a resource basis (RegUp Settlement + RegDn Settlement)
- Settlements will be on a 5-minutes basis (status quo)

- Simple Settlement Example

<u>Clearing -LPC</u>							
	Historic Performance	Assignment	CCP	Historic Mileage	PCP		
RegUp	0.9		5 \$ 1.00	5 \$	0.50		
RegDown	0.8		10 \$ 1.00	5 \$	0.50		

<u>Operational -PSCE</u>							
	RT Mileage	RT Performance	*note we did not ask for regup for this interval so, no mileage and perf=historic				
RegUp	0	0.9					
RegDown	10	0.7					

<u>Settlement</u>							
	MW*PerfScore*CCP + MW*PerfScore*(RT Mileage/Historic Mileage)*PCP						
	CCP	Assignment	Perf Score	Historic Mileage	RT Mileage	PCP	
RegUp	\$ 1.00	5	0.9	5	0	\$ 0.50	
RegDown	\$ 1.00	10	0.7	5	10	\$ 0.50	
CCP RegUp	\$ 4.50	PCP RegUp	\$ -				
CCP RegDown	\$ 7.00	PCP RegDown	\$ 7.00				

- Implement a number of changes that have a shorter development lead time first
 - This will also help orient the fleet with the new signal and performance requirements before splitting the market clearing and operational signals
 - Resources will not need to requalify for the phase 1 implementation of the new signal development
- Design Components include:
 - Moving to 1 signal design
 - Requirement Updates
 - Performance score and testing requirements
 - Mileage Changes
 - Clearing Timing

- The remaining design changes, and the comprehensive reform to RegUp and RegDn will follow. This is ~ 2 year development effort for PJM and Market Participants
 - PJM will have large changes to the clearing engine, AGC, telemetry and settlements
 - Market Participants will have large changes in telemetry and expected other modifications
 - Re-qualification efforts will be required for the RegUp/RegDn market and a testing window will be developed no less than 3 months before go-live. An abbreviated testing option will be available for existing regulation resources (ex. 1 test vs. 2)

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