PJM Proposed Package for Regulation Redesign (RMDSTF)

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December 20, 2023

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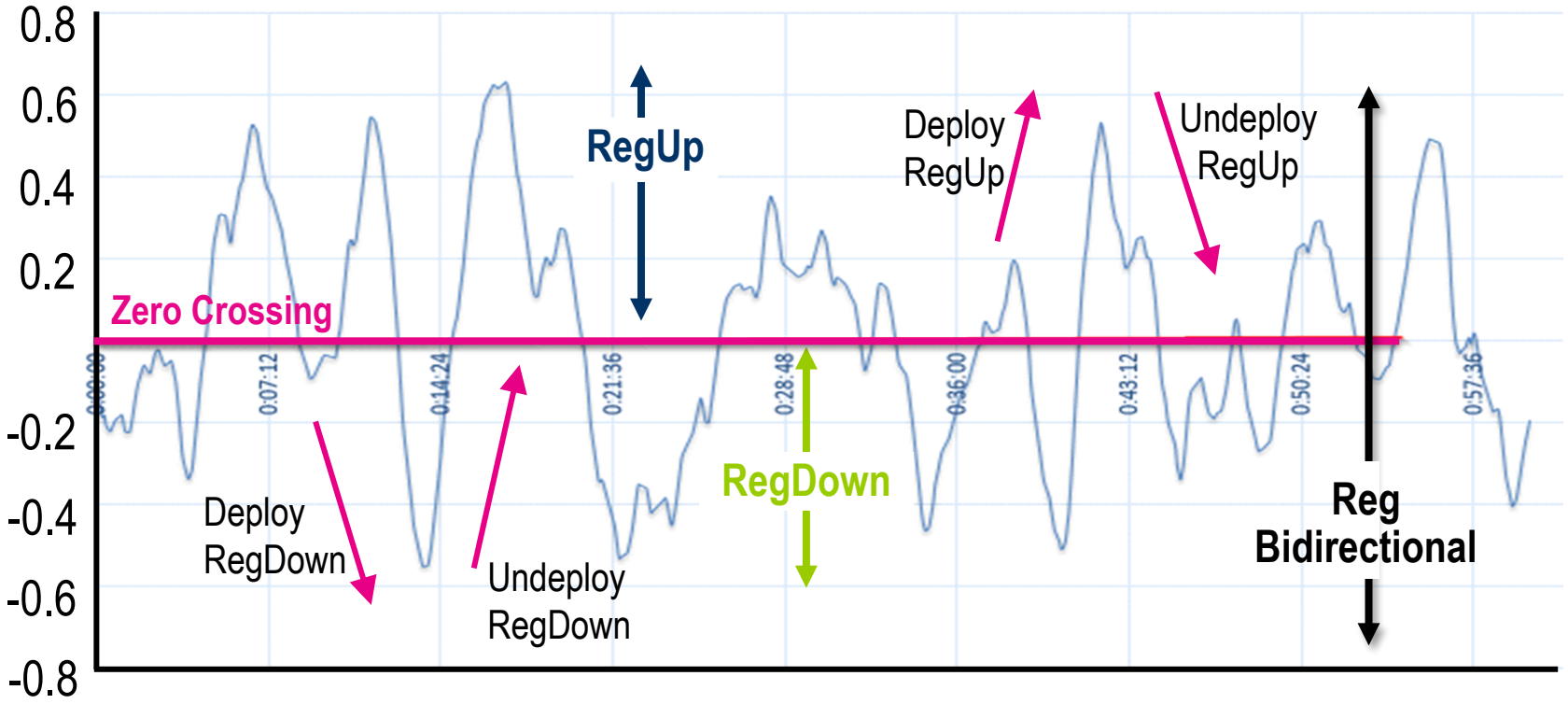
Regulation Signal and Market Products

Moving from the current RegA and RegD signals and a bi-directional product to A one-signal design and a Regulation Up and Regulation Down Products



- Reg-Up product operates above the zero crossing
- Reg-Down product operates below the zero crossing
- Resources will be able to follow the full signal (bidirectional) by being assign Reg-Up and Reg-Down
  - Only one product will be deployed at a time

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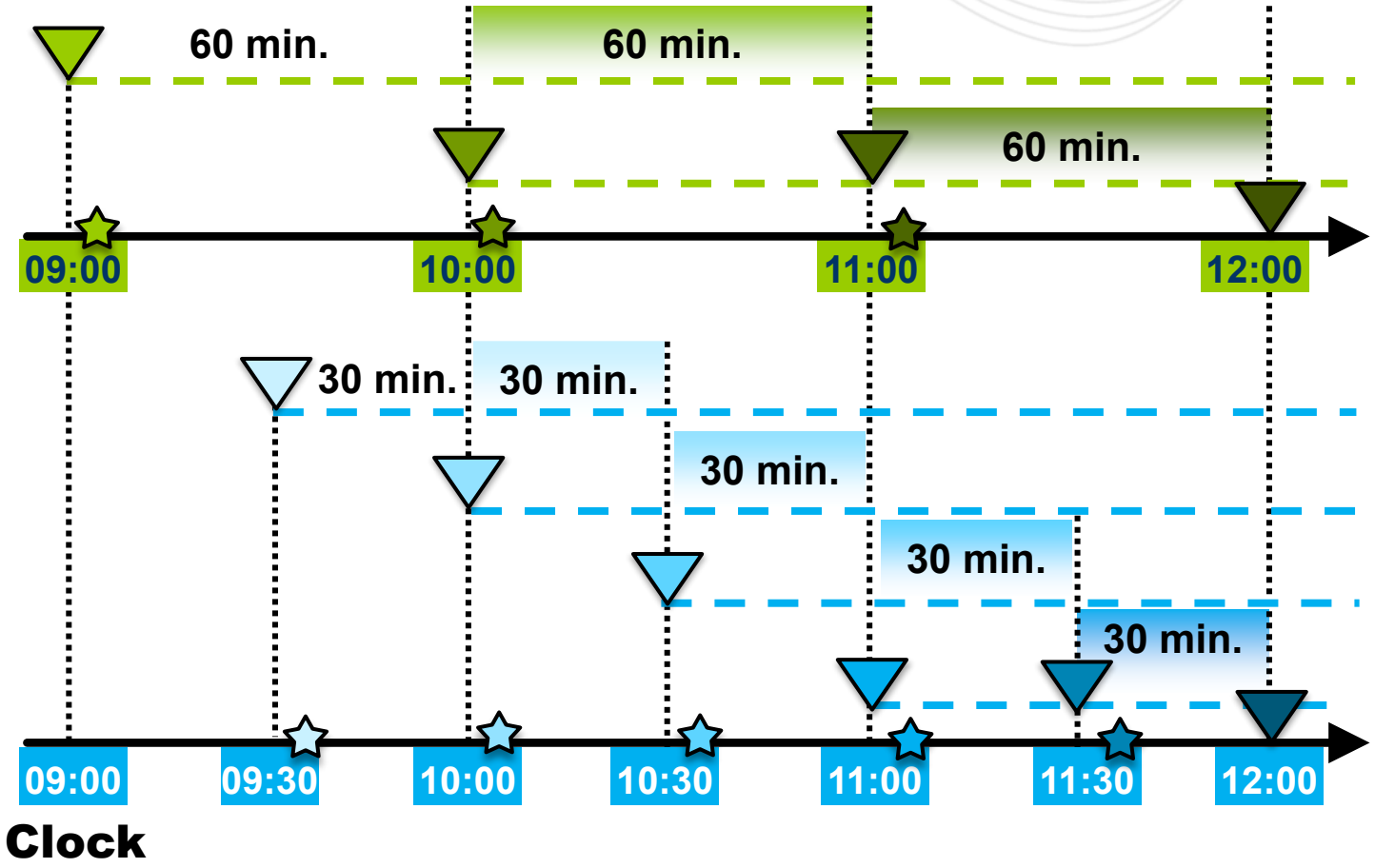
Regulation Clearing and Commitment

Move to a 30 minute clearing time and commitment duration



STATUS QUO

- **60 minutes** prior to target time
- Looks ahead 60 minutes beyond target time

PROPOSED

- **30 minutes** prior to target time
- Looks ahead 30 minutes beyond target time

Legend

- Case execution time
- Case approval
- Service provided

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Regulation Requirement Updates

- Maintaining a similar structure as status-quo
  - Keeping seasonal definitions and high/low hours of regulation
  - Adding a transition hour to allow less operational disruption

- Adding an annual review to modify the requirement based on system needs to address any operational changes amongst the energy transition

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Regulation Requirement Updates

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 11 – 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 11 – 17	550

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Regulation Requirement Updates

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 L_{10} value (CPS2).

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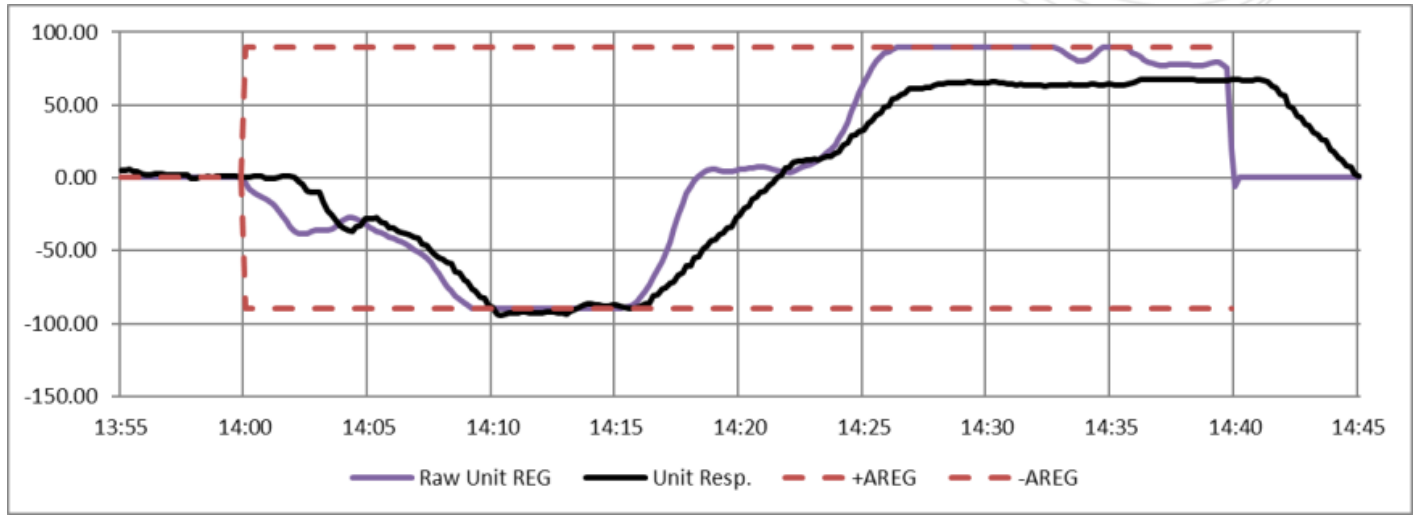
Move to a Precision Only Calculation for Performance Scoring



	Score
Status Quo Performance Score	0.820
Accuracy **Delay** **Precision**	0.834 0.899 0.729
Precision Score	**0.781**

$$Performance\ Score = 1 - \frac{1}{n}\sum Abs(Error)$$

$$Error = Avg\ of \left| \frac{Response - Regulation\ Signal}{Abs(0.5 * Period\ Avg\ Reg\ Signal) + 0.5 * AREG} \right|$$

n = number of sample in the period;
AREG = assigned regulation megawatt

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.

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Qualification Testing

Reduce testing requirements for qualification

- New resources will test 2 times (status quo: 3)
- Disqualified Resources will test 1 time (status quo:3)

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)

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Regulation Offers

Regulation Offer
Separate for RegUp and RegDn

Cost
Up to limits 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 unit specific heat rate degradation due to operating at lower loads (RegDn only) and $6 Margin Adder

Mileage ($/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 (non-energy resource only)

Price
Up to **50 $/MWH** as described in M11, Section 3.2.1

Capability ($/MW)
the price to reserve MWs for regulation

Mileage ($/ΔMW)
the price to provide regulation movement

- VOM is removed from Offers, except for Regulation Only Resources
- Under Regulation-Up and Regulation-Down products the Offer change by:
  - Price is now $50/MWH per product (currently $100/MWH for bidirectional)
  - Margin Adder is now $6 per product (currently $12 for bidirectional)
  - The cost for operating at lower loads is only realized for Reg-Down

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Lost Opportunity Cost Reforms

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

Calculation of LOC using

Status Quo: The Desired MW at LMP – is not ramp limited, and not based on the initial MW of the unit

- Generally overvalues LOC

Proposal: Tracking Desired MW at LMP ramp limited – will incorporate consecutive market conditions to create the profile that units should have achieved if they had been following each dispatch signal based on their ramp rates.

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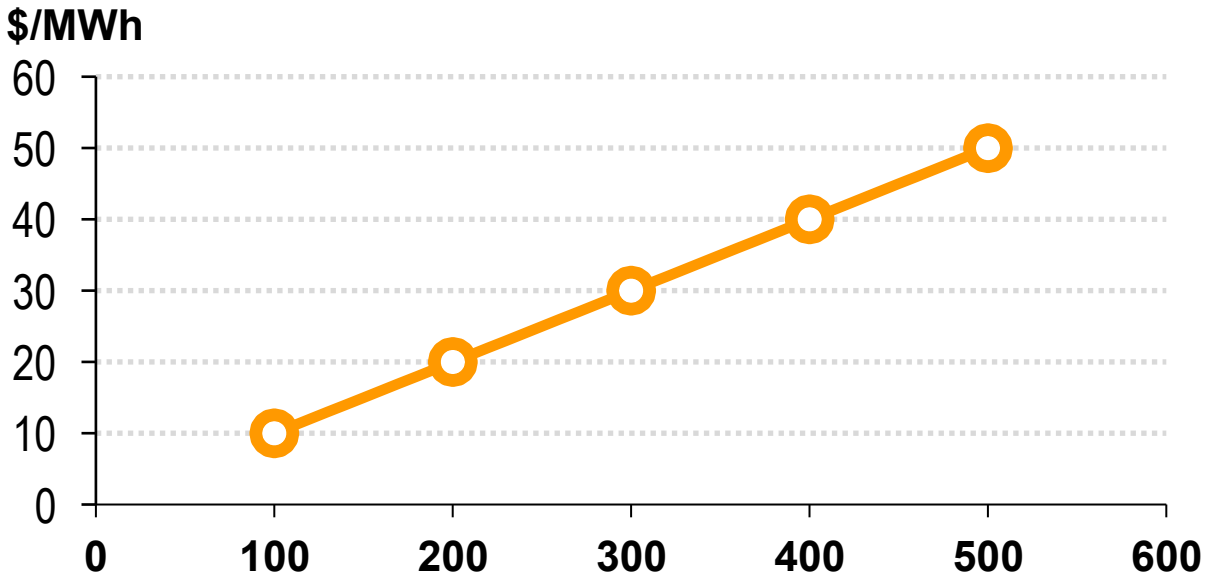
Calculation of LOC moving to a tracking desired MW at LMP Ramp Limited



Reg = 20 MW	**RegLo =** 180, **RegHi =** 220	**Ramp** 10 MW/Min	**Reg set point** 200 MW

Initial MW (MW)	200	200	200
LMP ($/MWh)	20	40	40
Desired MW at LMP (DML) (MW)	200	400	400
Delta MW LOC for DML (MW)	0	200	200
Tracking Desired MW at LMP RR Limited (TDLRL)(MW)	200	250	300
Delta MW LOC for TDLRL (MW)	0	50	100

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Lost Opportunity Cost Reforms

Total LOC Formulation in Dollar

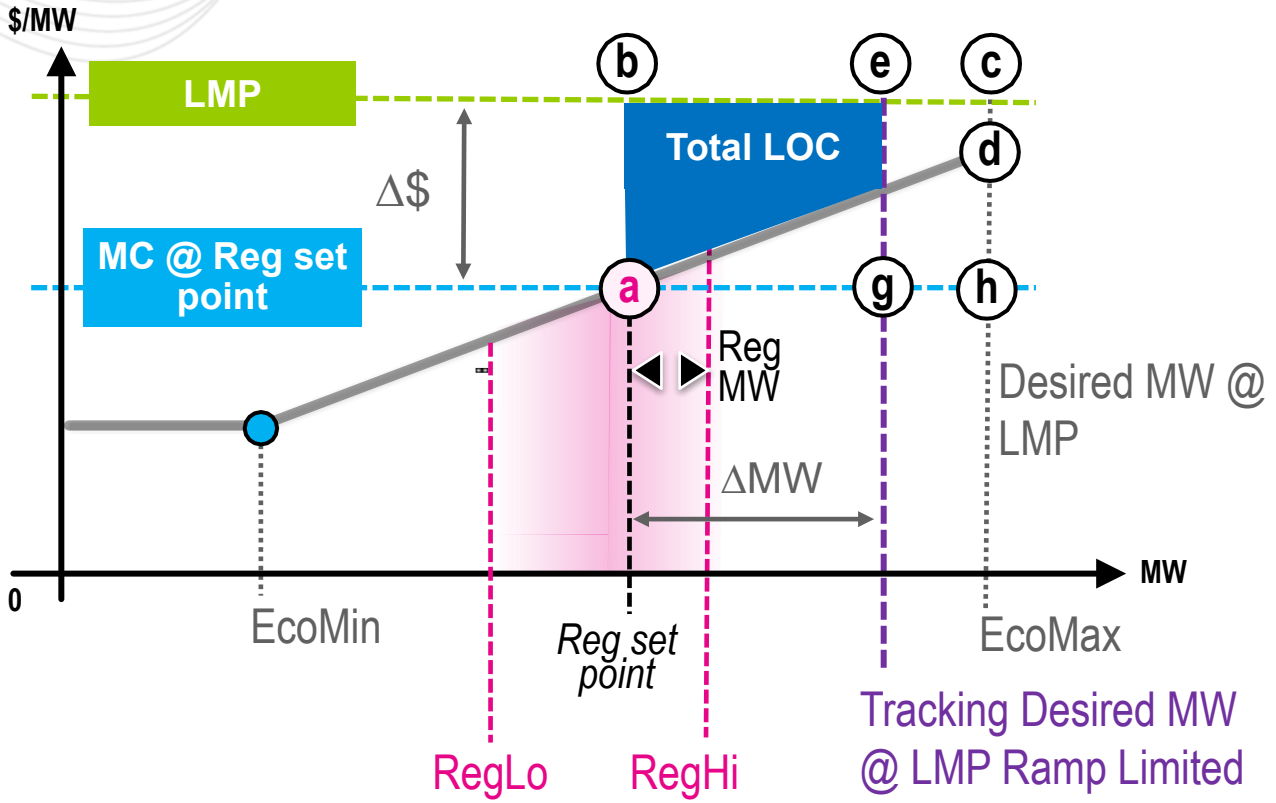
area bounded by

i. the LMP,

ii. the resource's Final Offer

iii. the generation resource's tracking ramp-rate limited expected output level if it had been dispatched in economic merit order, and

iv. the generation resource's regulation set point



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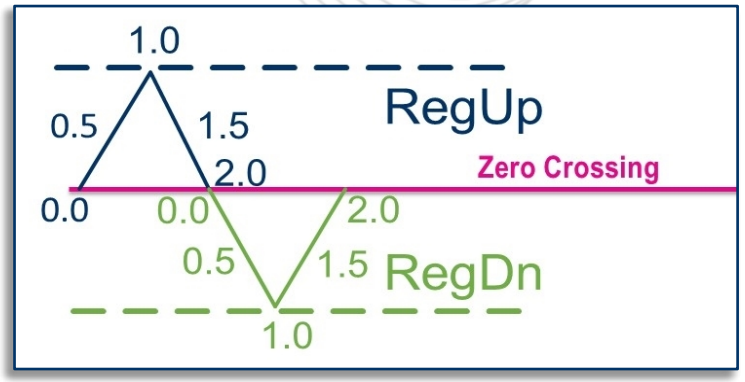
Consistency in the use of Mileage

Mileage will be calculated separately for Regulation-Up and Regulation-Down



OFFER:
$/ΔMW

CLEARING AND PRICING:
Mileage Clearing Price (MCP) = ($/ΔMW* **Historic Mileage** $\frac{\Delta MW}{MW}$) / Performance Score

SETTLEMENTS:
Mileage Credit = MW* MCP* Performance Score*
Actual Mileage/Historic Mileage

Regulation clearing and Regulation pricing will use the daily (historical) product signal mileage for the mileage offer price adjustment

Settlement will use the ratio of the 5-minute product signal actual mileage to the product historic mileage for the Regulation Mileage credit

For RegUp: $\frac{RegUp\ signal\ actual\ 5-minute\ mileage}{RegUp\ historic\ mileage\ for\ the\ operating\ day}$

For RegDn: $\frac{RegDn\ signal\ actual\ 5-minute\ mileage}{RegDn\ historic\ mileage\ for\ the\ operating\ day}$

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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 for Market Participants around the clearing constraint*

- 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

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Settlement components

- Regulation Settlements will be for both the RegUp Settlement and RegDn Settlement
  - RegUp Settlement: RegUp capability credit and RegUp mileage credit
  - RegDn Settlement: RegDn capability credit + RegDn mileage credit

- Make whole for Regulation Settlements will be done on a resource basis (RegUp Settlement + RegDn Settlement)

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Phased Implementation to effectuate the proposal design (without the Up/Down product first and then change to the Up/Down Products.

One year implementation timeline for Phase 1 and one additional year implementation timeline for Phase 2

- This will also help orient the fleet with the new signal and performance requirements before splitting the market clearing and operational signals
- This will accommodate the large development effort for PJM and Members for the Up/Down Products.

This will allow for more development and implementation time for both PJM and Members to move to the Up/Down Products

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