Regulation Redesign
Phase 1 Implementation Update

Damon Fereshetian
Sr. Engineer, Real-Time Market Operations

Markets and Reliability Committee
July 23, 2025

Regulation Redesign – Phase Implementation and Timeline

FERC Approval on June 14, 2024

Clean order accepting our Regulation Market Reform 205 filing

Phase 1 Go-Live

Oct. 1, 2025

Phase 2 Go-Live

Oct. 1, 2026

Phase 1 Summary of Changes

#	Design Components	Summary Description
1	**Signals and Products**	Change from ***two*** signals (RegA and RegD) bidirectional to ***one*** signal bidirectional that all resources that are assigned Regulation in a given market interval will follow.
2	**Requirement MW**	Changes to better reflect operational needs, with consideration both to historic and future system conditions
3	**Performance Scoring**	Change from accuracy, delay and precision to precision only.
4	**Offer and Clearing Timing**	Eliminate “cost increase in VOM” except for Reg-only resources, change from hour clearing and commitment to 30-minute clearing and commitment.
5	**Opportunity Cost Calculation Reform**	1. Use the schedule the resource is running for energy or else the cheaper of available schedule for offline. 2. Use tracking desired MW at LMP ramp rate limited. 3. Use the area between LMP and the energy schedule the resource is running on.
6	**Settlement**	For the eligible resources, Settlement will calculate the shoulder interval opportunity cost for two five-minute ramp-in intervals before the resource Regulation operation and two five-minute ramp-out intervals following the resource Regulation operation (currently, three intervals ramp-in and three intervals ramp-out). Also, Settlement will update the calculation for the Regulation Mileage Credit (currently Performance Credit) such that the mileage ratio is equal to [Real-Time Regulation Mileage/Historic Regulation Mileage]

Posted Documents for Phase 1 Changes

The following documents have been posted on the Ancillary Services page under a new section called **Regulation Redesign**:

PJM.com > Markets & Operations > Ancillary Services >

1. **Regulation Effective MW Requirement Definition (2025-2026) – PDF**
2. **Regulation Cost-Based Offer Validation Phase I – XLS**
3. **Self-Administered Regulation Test – XLS**
4. **40-Minute Performance Score Template – XLSM**
5. **XML Schema – XSD**
6. **PJM External Interface Specification Guide – PDF**
7. **Regulation Redesign Phase 1 FAQ – PDF**
8. **Markets Gateway: Regulation Redesign Phase 1 - Sandbox Virtual Session – PDF**

Email Contacts

No.	Inquiry	Email Contact
1	To request a Regulation test	RegulationTesting@pjm.com
2	Regulation telemetry – signal setup or conversion	PJMTelemetrySupport@pjm.com
3	Regulation Redesign questions	RegulationDesign@pjm.com
4	Communication to PJM Member Relations	custsvc@pjm.com

Manual 11: Energy & Ancillary Services Market Operations

Joseph Tutino
Sr. Engineer, Real-Time Market Ops.

Markets & Reliability Committee
July 23, 2025

M-11 Reg. Redesign Phase 1 Impacts

Action Required	Deadline	Who May Be Affected
Review changes prior to endorsement.	**8/20**	Market Buyers, Market Sellers, CSPs
Communicate to staff about changes to Manual 11 prior to go-live.	**10/1**	Market Buyers, Market Sellers, CSPs

High-Level Review

- Adding Phase 1 Business Rules while preserving still relevant existing language

- New organizational and section structure for Section 3 for better flow, order and joining of topics. *

- Added contextual information to address the most common questions encountered from the existing market and the redesign.

**Note: Similar reorganization effort to M11, Section 4 for Reserve Price Formation project*

Key Highlights

The changes and additions to Manual 11, Section 3 are expansive, moving from 2 to 10 subsections and essentially creating a new section.

Our final product will be a more robust and organized description of the Regulation Market.

There is no traditional redline posted for Section 3 because with all the changes to the text and structure, the document would be unreadable compared to the existing version.

Changes to other sections are marked up compared to the existing version.

Please allow adequate time for review and bring forth any questions/comments as early as possible, preferably before the next stakeholder meeting via email.

Phase 1 of the Regulation Redesign results in major changes to the following areas affecting Manual 11:

ASO Engine Logic / One Signal *Offer, Clearing and Posting Timing*	Regulation Qualification, Disqualification and Requalification
Performance Scoring	Regulation Requirement MW
Regulation Offer Structure	Regulation Lost Opportunity Cost *New Tracking Ramp-Limited Desired Megawatt Concept*

Summary of Updates

		Subsection #
Section 2	New Study Mode depiction graphic	2.5
	Language moving from 60- to 30-minute ASO run times	2.5.1
Section 4	Section reference update	4.4
	Language moving from 60- to 30-minute ASO run times with two cases per hour and with results typically posted 10 minutes prior	4.4.3
	Minor grammatical and clarification additions	4.4.3
Section 9	Non regulation-specific Hydro operation language moved out to new Scheduling section with minor grammatical updates	9.3

Summary of Updates

Section 3	Refreshed	New
3.1 Introduction to Regulation	X	
3.2 PJM Regulation Market Business Rules:	X	
3.2.1 Regulation Market Eligibility	X	
3.2.2 Regulation Qualification, Disqualification and Requalification		X
3.2.2.1 Performance Scoring		X
3.2.3 Regulation Market Data Timeline	X	
3.2.4 Regulation Offer Structure		X
3.2.5 Regulation Market Offer Period Timing	X	
3.2.6 Regulation Range Limits		X
3.2.7 Economic Load Response Participation		X
3.2.8 Ancillary Services Optimizer		X

Summary of Updates

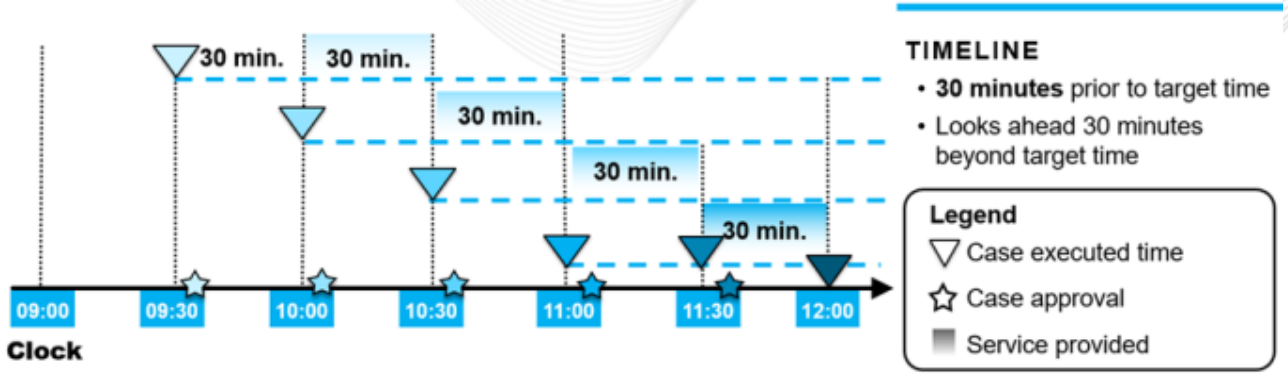
Section 3	Refreshed	New
3.3 Regulation Requirements	X	
3.4 Regulation Market Power Mitigation	X	
3.5 Regulation Mileage		X
3.6 Regulation Lost Opportunity Cost	X	
3.6.1 General LOC Calculation	X	
3.6.2 Tracking Ramp-Limited Desired MW Concept		X
3.6.3 Hydro Opportunity Cost Calculation	X	
3.7 Regulation Market Clearing & Pricing	X	
3.7.1 Regulation Offer Price Conversion and Validation		X
3.7.2 Regulation Offer MW Conversion and Validation		X
3.7.3 Regulation Self-Scheduling		X
3.7.4 Regulation Clearing of Offline Resources		X
3.7.5 Regulation Clearing and Posting Timing	X	
3.7.6 Regulation Pricing		X

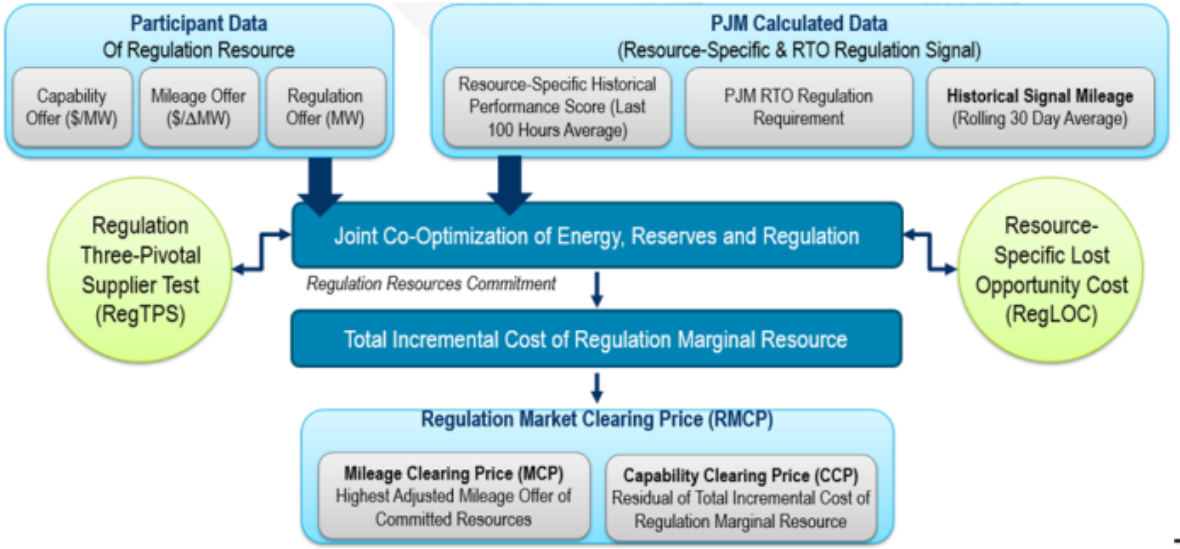
Summary of Updates

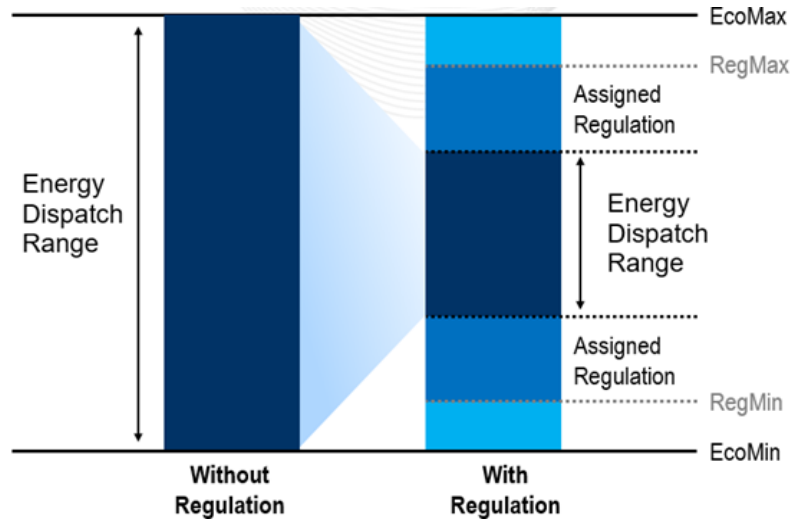
Section 3	Refreshed	New
3.8 Regulation Market Operations	X	
3.8.1 Regulation Dispatch and Reduced Energy Ramp Rate	X	
3.8.2 Self and PJM Deassignments		X
3.8.3 Intra-Interval Manual Assignments	X	
3.8.4 Unapproved or Missing Intervals		X
3.9 Regulation Obligation Fulfillment	X	
3.9.1 Regulation Bilateral Transactions	X	
3.10 Regulation Settlements	X	

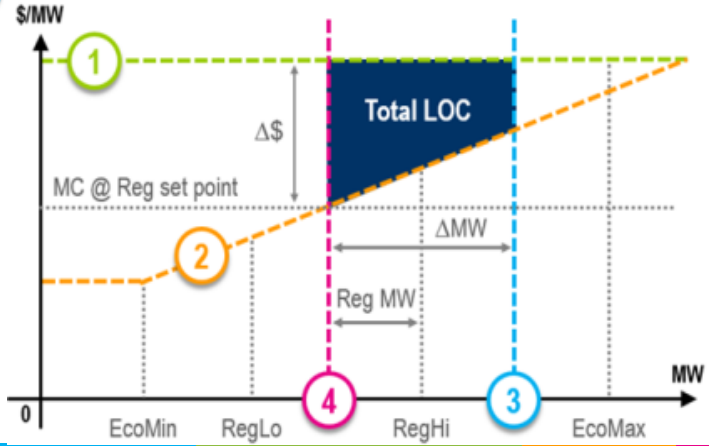
Summary of Updates – New Graphics

- New graphics to depict clearing engine interaction, data timeline/flow, range limits, ASO timing, general/hydro LOC, and adjusted offer formulas.





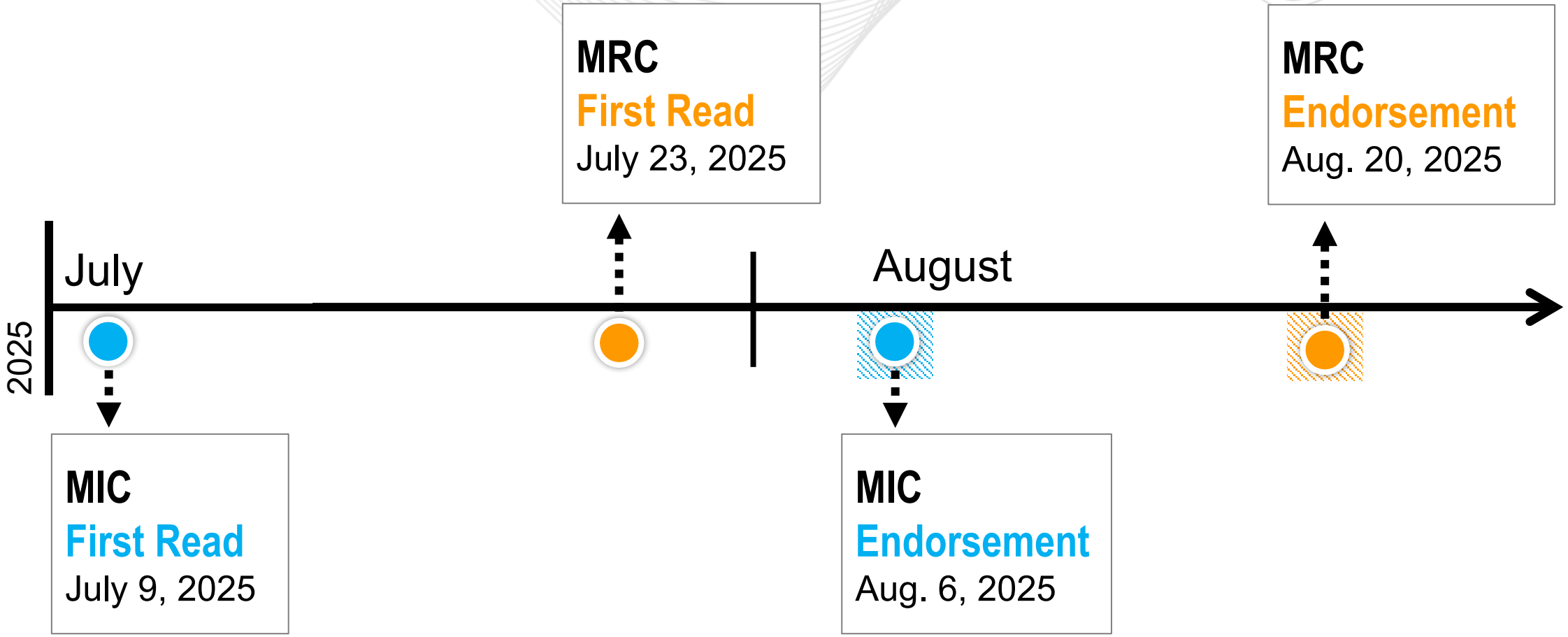




Total LOC Formulation ($) area bounded by:

1. The LMP
2. The resource's energy final offer
3. The generation resource's tracking ramp-rate limited expected output level if it had been dispatched in economic merit order
4. The generation resource's regulation set point

Next Steps



Manual 12, Balancing Operations

Ilyana Dropkin, Sr. Engineer II
Performance Compliance

Markets and Reliability Committee
July 23, 2025

Revision 56 (10/01/2025):

All changes are conforming to Regulation Redesign Phase I

- Subsection 2.1.1 EMS Applications – renamed Area Regulation (AR) to Regulation control
- Subsection 2.1.2 PC Applications – updated definition of Performance Score Calculation Engine (PSCE)
- Subsection 3.1.2 PJM Control Implementation – Removed RegD mentions, Updated Exhibit 5: Real Time Market Application Process Flow and updated definition of Ancillary Service Optimizer (ASO)
- Subsection 3.1.3 PJM Member Control Implementation – Updated Exhibit 6: PJM Member Interface and associated text for Exhibit 6.

Revision 56 (10/01/2025):

All changes are conforming to Regulation Redesign Phase I

- Section 4.3 Regulation and Section 4.4 Qualifying Regulation Resources
  - Updated consistency use of Regulation control signal (RegA)
  - Capitalized Regulation Requirement
  - Updated hour to interval
  - Updated correct numbering of Exhibits
  - Renamed Area Regulation to Regulation; Area Regulation test to Regulation test
  - Removed mentions of RegD

Revision 56 (10/01/2025):

All changes are conforming to Regulation Redesign Phase I

- Subsection 4.3.2 Regulation Signal
  - Renamed section from Regulation Signals to Regulation Signal
  - Renamed: ARegA to Areg, TRegA to Treg, CRegA to Creg; Removed: ARegD, TRegD, CRegD
- Subsection 4.3.3 Determining Regulation Assignment
  - New requirements will be set for Regulation that will be posted on https://www.pjm.com/markets-and-operations/ancillary-services.aspx annually
- Subsection 4.3.4 Dispatching Regulation
  - Removed Regulation Excess

Revision 56 (10/01/2025):

All changes are conforming to Regulation Redesign Phase I

- Section 4.4 Qualifying Regulation Resources
  - Renamed Area Regulation test to Regulation test
  - Removed mentions of RegD tests
  - Updated changes to the signal path re-test – existing resource owner to set the resource performance score to the re-test qualification score for the exception of changes to the signal path are initiated by PJM or impacts all or a large portion of PJM Regulation fleet.
  - Reduce from 3 to 2 consecutive regulation tests for new qualifying resources
  - Deleted subsection 4.4.3 Certifying Multiple Turbines or Hydro Units at a Single Site
  - Re-numbered existing subsections 4.4.3 through 4.4.8

Revision 56 (10/01/2025):

All changes are conforming to Regulation Redesign Phase I

- Subsection 4.4.4 Disqualification and Re-Qualification of a Regulation Resource
  - Reduce from 3 to 1 regulation test for disqualified resources to qualify back into Regulation market
  - Changed from 100 hours to 200 (30 minute) intervals
- Subsection 4.4.5 Performance Score Calculation
  - Removed Accuracy (Correlation), Delay and Precision scores.
  - Updated formulas for Performance scores.
- Subsection 4.4.9 Regulation De-assignment
  - Added a new subsection 4.4.9 to describe a new rule that self-de-assignment will result in zero score for the remainder of the commitment period.

- Subsection 2.1.1 EMS Applications - Renamed Area Regulation (AR) to Regulation control

2.1.1 EMS Applications

- Automatic Generation Control (AGC) — This program runs every two seconds, calculating Area Control Error (ACE), ~~Area~~ Regulation control ~~(AR)~~ and economic dispatch.

- Subsection 2.1.2 PC Applications - Updated definition of Performance Score Calculation Engine (PSCE)

  - Performance Score Calculation Engine (PSCE) – is a ~~.net~~ Java application that calculates the ~~hourly~~ interval and historic performance score of a resource's regulation response compared to the regulation signal sent by PJM. PSCE also calculates the mileage ~~of each regulation signal by hour~~.

- Subsection 3.1.2 PJM Control Implementation - Removed RegD mentions

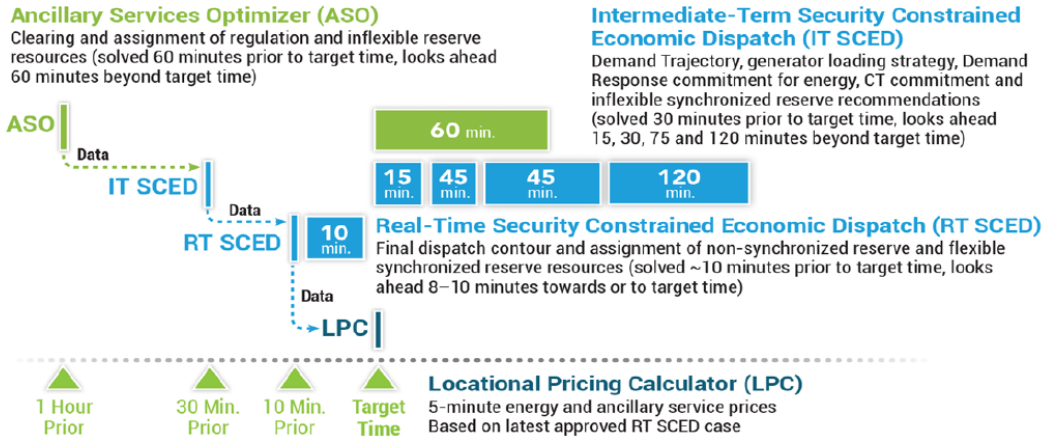
PJM calculates ~~two~~ Regulation signal~~s~~, as shown by Exhibit 3.

- Regulation control signal (RegA) is~~—~~ l~~L~~ow-pass filter of ACE. The Regulation control signal is sent to each resource owner. The resource owners receive the signal and then send the signal to each regulating resource. ~~for traditional regulating resources~~
- ~~RegD – High-pass filter of ACE for dynamic or fast response resources~~

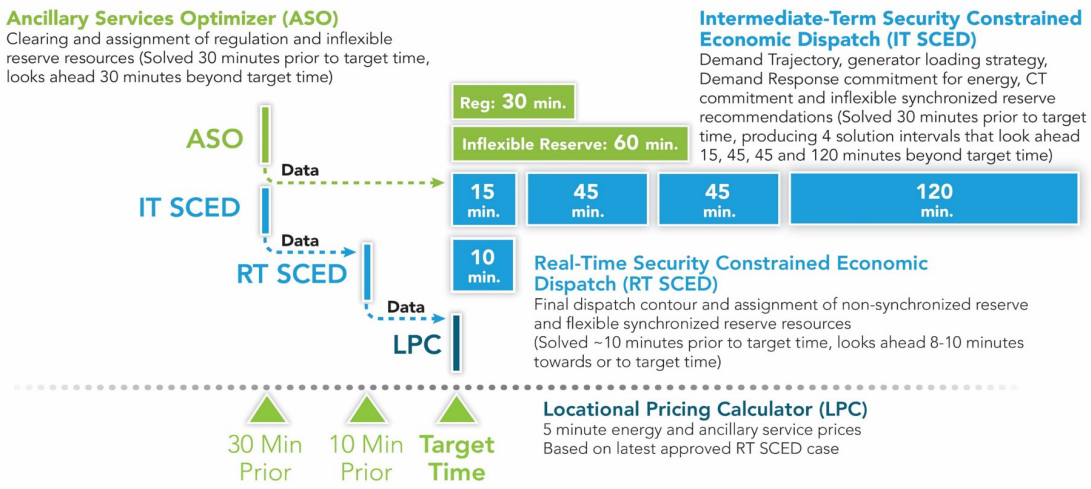
~~At present, PJM sends the Regulation signal in the following form to the participating resource owners:~~

- ~~Digital – The Digital Regulation signal is sent to each resource owner. The Generation Owners receive this signal and then send the appropriate signal to each regulating resource.~~

- Subsection 3.1.2 PJM Control Implementation - Updated Exhibit 5: Real Time Market Application Process Flow



Old Exhibit



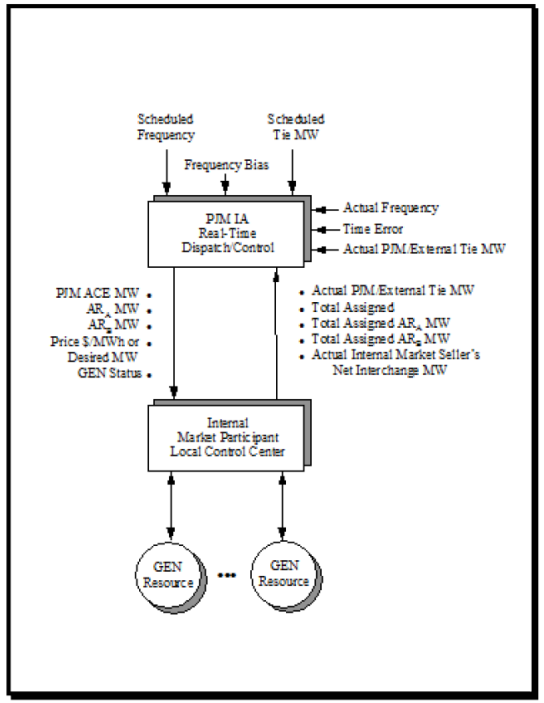
New Exhibit

- Subsection 3.1.2 PJM Control Implementation - Updated definition of Ancillary Service Optimizer (ASO)

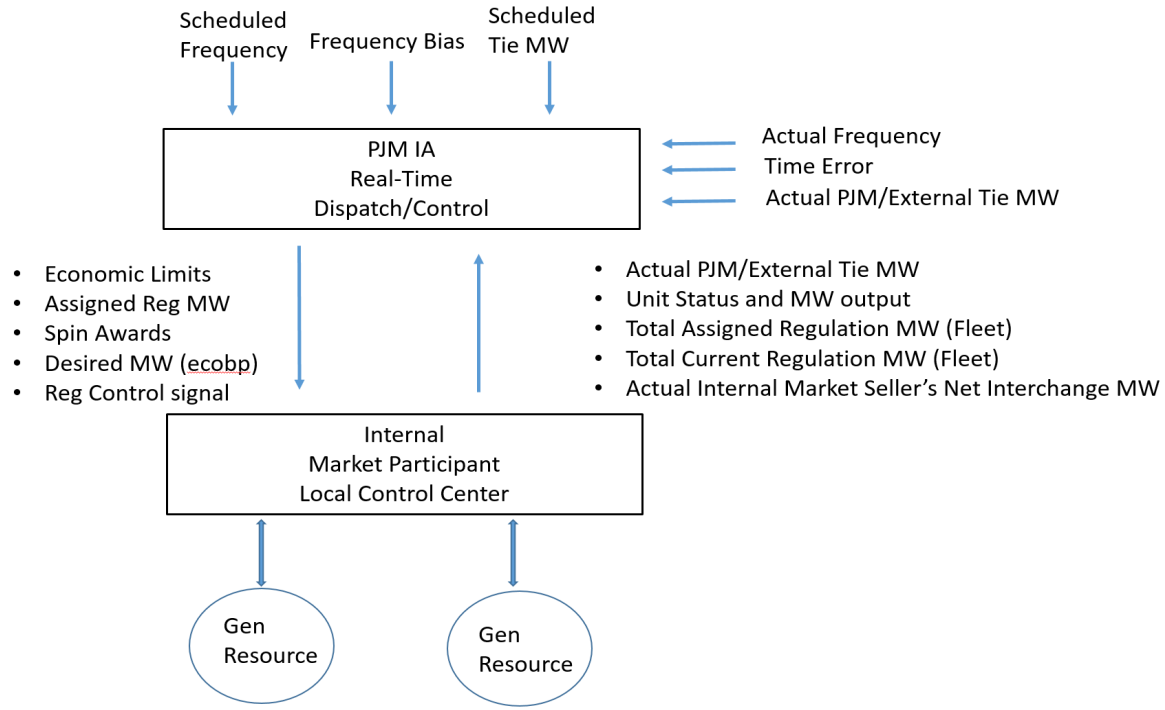
The real-time market applications consist of the following:

- **Ancillary Service Optimizer (ASO):** The Ancillary Services Optimizer (ASO) performs the joint optimization function of energy, reserves and regulation. The ASO creates an interval-based solution over a one half hour look-ahead period, as well as performs the regulation three pivotal supplier test. ASO does not calculate final market clearing prices. The main functions of ASO are the commitment of all regulation resources for the next half hour interval and inflexible reserve resources for the next operating hour. More information about ASO can be found in Manual 11, Section 2.5.1.

- Subsection 3.1.3 PJM Member Control Implementation – Updated Exhibit 6: PJM Member Interface



Old Exhibit



New Exhibit

- Subsection 3.1.3 PJM Member Control Implementation – Updated associated text for Exhibit 6.

The following information is sent by PJM to the Generation Owners:

- Economic Limits~~PJM ACE megawatt~~
- Assigned Regulation megawatt ~~either RegA or RegD~~
- Spin awards
- Desired megawatt (economic basepoint)
- Regulation control signal~~Generator status~~

The following information is sent by the PJM Members to PJM:

- Actual PJM/external tie line megawatt
- Unit status and MW output~~Actual total generation megawatt~~

- Subsection 3.1.3 PJM Member Control Implementation – Updated associated text for Exhibit 6.

  - Total assigned Regulation megawatt (fleet)~~either RegA or RegD~~
  - Total current Regulation megawatt (fleet)
  - Actual net interchange megawatt

  The PJM Member's Generation Owner converts the total dispatch signal ~~(price or megawatt)~~ and the Regulation signal to individual unit control signals. PJM Member resources that are dispatchable by PJM are expected to respond to the dispatch and regulation signals received from PJM. PJM Members are expected to operate their generating resources as close to desired output levels, as practical, consistent with Good Utility Practice.

- Section 4.3 Regulation and Section 4.4 Qualifying Regulation Resources
  - Updated consistency use of Regulation control signal (RegA) rather than Area Regulation; Capitalized Regulation Requirement; Updated correct numbering of Exhibits.

4.3.1 PJM RTO Regulation Market Obligations

The Regulation R~~r~~equirement for the PJM RTO can be found in this manual in Section 4.3.3, Determining Regulation Assignment. The resources assigned to meet this requirement must be capable of responding to the Regulation control~~AR~~ signal immediately, achieve their bid capability within five minutes and must increase or decrease their outputs at the ramping rates that are specified in the data that is submitted to PJM.

The PJM RTO requires that the Regulation range of a resource is at least twice the amount of Regulation assigned, and that the resource can symmetrically provide the total amount of Regulation assigned (a full raise and lower of assigned regulation from set-point) as illustrated in Exhibit 7~~12~~ below.

- Section 4.3 Regulation and Section 4.4 Qualifying Regulation Resources
  - Updated hour to interval
  - Removed mentions of RegD
  - Renamed Area Regulation to Regulation; Area Regulation test to Regulation test

4.4.1 Regulation Qualification Test
~~**Traditional Resource Test**~~

The RegulationAR test is run during a continuous 40-minute period when, in the judgment of the PJM test administrator, economic or other conditions do not otherwise change the base loading of the resources that are being tested. All resources performing a Regulation test must set and hold for the test duration the MW-value base point that the resource is regulating around. Changes in base loading for a resource during the test period invalidate the test for that resource. ~~A separate set of tests are required for qualification for the traditional signal (RegA) and the dynamic signal (RegD).~~ The RegulationAR test follows a simulated Regulation signal and will last for 40 minutes.

- Subsection 4.3.2 Regulation Signal
  - Renamed section from Regulation Signals to Regulation Signal
  - Renamed: ARegA to Areg, TRegA to Treg, CRegA to Creg; Removed: ARegD, TRegD, CRegD

4.3.2 Regulation Signal~~s~~

Resource owners will receive from PJM:

- Assigned Regulation (AReg~~A or ARegD~~) – This is the assigned ~~hourly~~interval Regulation quantity (MW) that is cleared from the Regulation market system. It is assigned for each individual resource that is qualified to regulate in the PJM market. This value, although typically static for the interval~~hour~~, will be sent on a 10-second scan rate. ~~Resources will receive a separate assignment for RegA and RegD if the regulating resource is dual qualified, but the regulating resource will be assigned to follow only one signal for the hour.~~
- Regulation Control Signal~~s~~ (RegA~~, RegD~~) – Real-time instantaneous resource owner fleet Regulation signal (+/- MW). This signal is used to move regulating resources in the owner's

- Subsection 4.3.2 Regulation Signal - Continue
  - Renamed section from Regulation Signals to Regulation Signal
  - Renamed: ARegA to Areg, TRegA to Treg, CRegA to Creg; Removed: ARegD, TRegD, CRegD

Resource owners will send to PJM:

- Total Regulation (TReg~~A or TRegD~~) – This is the real-time fleet regulation capability (MW) that represents the active resource owner's ability to regulate. Ideally the value of this quantity should be the sum of the resource owner's non-zero a~~A~~ssigned Regulation quantities for the majority of the interval~~hour~~, but must reflect any reductions in regulating capability as they occur (resource's AGC limit restrictions, resource "off control" conditions, etc.). This value shall be calculated every two seconds and sent on a two-second scan rate. ~~A fleet owner must separate the fleet so resources following RegA report TRegA and resources following RegD report TRegD.~~
- Current Regulation (CReg~~A or CregD~~) – This is the real-time fleet regulation feedback (+/- MW) that represents the active position of the fleet with respect to the +/- TReg capability.

- Subsection 4.3.3 Determining Regulation Assignment
  - New requirements will be set for Regulation that will be posted on https://www.pjm.com/markets-and-operations/ancillary-services.aspx annually

4.3.3 Determining Regulation Assignment

~~The PJM RTO's Regulation requirement is 525 effective MW during non-ramp hours and 800 effective MW during ramp hours. The ramp and non-ramp period will be determined seasonally, based on system conditions, and~~

The Regulation Requirement megawatt table and methodology is posted on pjm.com at:

http://www.pjm.com/markets-and-operations/ancillary-services.aspx

PJM dispatch may increase or decrease the Rregulation Rrequirements as needed to accommodate system conditions. Each Load Serving Entity (LSE) is required to provide a share of the PJM Regulation Rrequirement. A~~n~~ LSE's actual hourly Regulation obligation is determined for the hour, after-the-fact, based on the LSE's total load in the PJM RTO, as follows:

LSEs Regulation Obligation = (*LSEs Load Allocation* % * *PJM Assigned Regulation*)

PJM Members Actions

- Each LSE determines its estimated Regulation obligation for the operating day based on its own forecast load and the information received via the PJM ALL-CALL.
- Resource owners view the half hour~~ly~~ Regulation market results via Markets Gateway (available at least ten (10) minutes~~half an hour~~ before the operating interval~~hour~~) as to those resources to which Regulation has been assigned. Resource owners that have self-scheduled Regulation on any of their resources inform the PJM dispatcher when those resources are online and able to provide the self-scheduled Regulation.

- Subsection 4.3.4 Dispatching Regulation
  - Removed Regulation Excess

~~**Regulation Excess**~~

~~If, during the period, an excess in assigned Regulation occurs and the total PJM RTO Regulation value exceeds the objectives by 15 MW or more, the PJM dispatcher de-assigns Regulation economically based on each resource's total cost to provide Regulation, including real time opportunity cost and the resource's Regulation offer price.~~

- Section 4.4 Qualifying Regulation Resources
  - Removed mentions of RegD tests

~~**Dynamic Resources**~~

~~The qualification test procedures described above for resources that will follow the dynamic Regulation signal (RegD) are the same as the qualification test for RegA. For each test, resources will follow a signal for 40 minutes and be scored using the performance score calculation. Resources must complete a separate set of tests to qualify for the traditional signal (RegA) or the dynamic signal (RegD).~~

- Section 4.4 Qualifying Regulation Resources
  - Updated changes to the signal path re-test – existing resource owner to set the resource performance score to the re-test qualification score for the exception of changes to the signal path are initiated by PJM or impacts all or a large portion of PJM Regulation fleet.

Changes to the Signal Path Re-Test – Existing Resource Owner

For previously qualified resources where an existing resource owner makes changes to the Energy Management System (EMS) or Generation Management System (GMS), or other changes which would constitute a change in the Regulation signal path, resource owners must conduct testing based on mutual agreement with PJM. This includes, but is not limited to, the EMS/GMS database, Inter-Control Center Communication Protocol (ICCP) servers and Communication Front End (CFE) replacements and/or upgrades. After system verification, the resource~~s' historic~~ performance score will be set to the re-test qualification score~~maintained~~. This test must be administered by PJM. If the changes to the signal path are initiated by PJM or impacts all or a large portion of the PJM Regulation fleet, then keeping historic performance scores will be implemented following test to prove signal path verification.

- Section 4.4 Qualifying Regulation Resources
  - Reduce from 3 to 2 consecutive regulation tests for new qualifying resources

4.4.2 Certifying Regulating Resource

A resource may be certified only after it achieves two~~three~~ consecutive scores of 75 percent or above. Resources providing dispatchable energy and Regulation service needs to provide testing at the low economic and high economic Regulation limits.

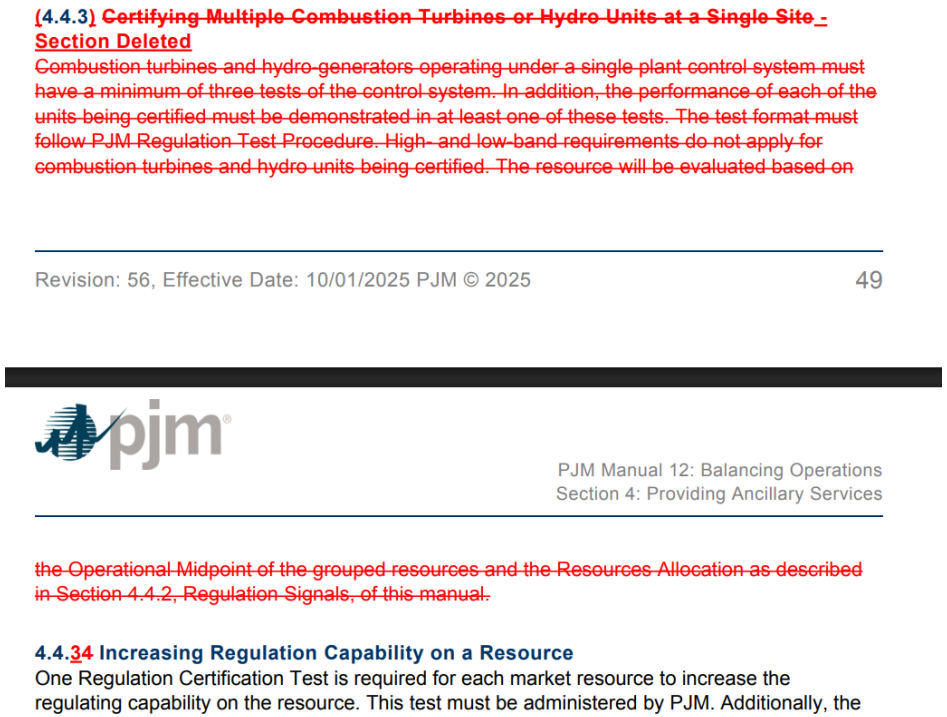
A resource may choose one option that is more preferable for the resource:

1st Option: 1 self-administered test and 1 PJM-administered test

2nd option: 2 PJM-administered tests

If a resource picks the first option, then a self-administered test has to be performed prior to PJM-administered test.

- Section 4.4 Qualifying Regulation Resources
  - Deleted subsection 4.4.3 Certifying Multiple Turbines or Hydro Units at a Single Site
  - Re-numbered existing subsections 4.4.3 through 4.4.8



(4.4.3) ~~Certifying Multiple Combustion Turbines or Hydro Units at a Single Site~~ - Section Deleted

~~Combustion turbines and hydro-generators operating under a single plant control system must have a minimum of three tests of the control system. In addition, the performance of each of the units being certified must be demonstrated in at least one of these tests. The test format must follow PJM Regulation Test Procedure. High- and low-band requirements do not apply for combustion turbines and hydro units being certified. The resource will be evaluated based on~~

Revision: 56, Effective Date: 10/01/2025 PJM © 2025 49

PJM Manual 12: Balancing Operations
Section 4: Providing Ancillary Services

~~the Operational Midpoint of the grouped resources and the Resources Allocation as described in Section 4.4.2, Regulation Signals, of this manual.~~

4.4.34 Increasing Regulation Capability on a Resource

One Regulation Certification Test is required for each market resource to increase the regulating capability on the resource. This test must be administered by PJM. Additionally, the

- Subsection 4.4.4 Disqualification and Re-Qualification of a Regulation Resource
  - Reduce from 3 to 1 regulation test for disqualified resources to qualify back into Regulation market
  - Changed from 100 hours to 200 (30 minute) intervals

4.4.45 Disqualification and Re-Qualification of a Regulation Resource

Regulating resources that have not met performance thresholds over a specified time period will be disqualified and must re-qualify to offer into the Regulationregulating market for applicable signal type (RegA or RegD). The disqualification threshold is based on the historic performance score. The historic performance score is a rolling average actual intervalhourly performance score for the last 200 intervals100 hours a resource has operated or a weighted average of the average of the twothree initial or requalification scores that are then averaged with available actual intervalhourly performance scores. The intervalhourly performance score calculation is described in Section 4.4.56, Performance Score Calculation, of this manual.

When the historical performance score falls below 40 percent by signal type, PJM will notify the resource owner and the resource will no longer be eligible to offer into the Rregulation market for the applicable signal type.

The resource owner may schedule a re-test as soon as practicable. One Regulation Certification Test is required for each resource to re-qualify for Regulation market. When a regulating resource re-tests, it will follow the testing procedure described in Sections 4.4.1–4.4.3

$$Interval = \frac{X^{*}Qualification\ Performance\ Score + Y^{*}Actual\ Performance\ Score}{200}$$

Where 2100 – X = Y and Y is the number of intervalshours after qualification. After 2100 30 minute intervalshours of actual performance scores X → 0.

- Subsection 4.4.5 Performance Score Calculation
  - Removed Accuracy (Correlation), Delay and Precision scores.

Delay and Correlation Score

For each 10-second interval starting from Time 0 +10, PJM will calculate a Delay Score to quantify the delay in response between the regulation signal (RegA) and the resource change in output. To calculate the match, use the statistical correlation function (r), which measures the degree of relationship between the two signals. By shifting the time periods to compare the signals, delay (δ) is defined at the point in time of the maximum correlation between the two signals. This generates both a Correlation and Delay Score as:

Where the Delay Score allows a 10-second latency for signal propagation delay for regulating resources.

Correlation and Delay are determined together by finding the 10-second interval with the highest coincident Correlation and Delay score. The 10 second interval that will determine Correlation and Delay for each scoring period is:

$$\max_{A=0 \text{ to } 5 \text{ Min}} (Delay\ Score + Correlation\ Score)$$

Correlation During Periods of Zero Slope

If the standard deviation of the regulation signal is less than a threshold value, then the Correlation shall be calculated as the 1 – absolute difference between the slope of the regulation signal and the slope of the response. The performance score for Correlation and Delay will be calculated by using linear regression to find the slopes of the regulation signal and the resource response.

Performance Score Calculation

For each 10 second set of calculations the performance score will be averaged over a five minute period for PJM will determine a composite Performance Score per resource as a unit-less scalar ranging from 0 to 1. The Performance Score will be a weighted average of the performance score components, as:

$$Performance\ Score(t) = \max_{t=0 \text{ to } 5 \text{ min}} \left[A * Delay\ Score(t+i) + B * Correlation\ Score(t+i)\right] + C * Precision\ Score(t)$$

- Subsection 4.4.5 Performance Score Calculation
  - Updated formulas for Performance scores.

$$Error = Avg\ of\ Abs\left|\frac{Abs\left(Response_{10sec} - Signal_{10sec}\right)}{0.5 * IntervalSignal_{AvgAbs} + 0.5 * AReg}\right|$$

$$IntervalSignal_{AvgAbs} = \frac{1}{n}\sum Abs\left(Signal\right)$$

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

Where n is the number of samples in the interval and AReg is the assigned Regulation megawatt. The performance score~~hour and the precision~~ allows a 10 second latency for signal propagation delay for regulating resources.

- Subsection 4.4.9 Regulation De-assignment
  - Added a new subsection 4.4.9 to describe a new rule that self-de-assignment will result in zero score for the remainder of the commitment period.

4.4.9 Regulation De-assignment

Self-de-assignment results in zero score for the remainder of the commitment period. PJM Dispatcher de-assignment does not impact performance score.

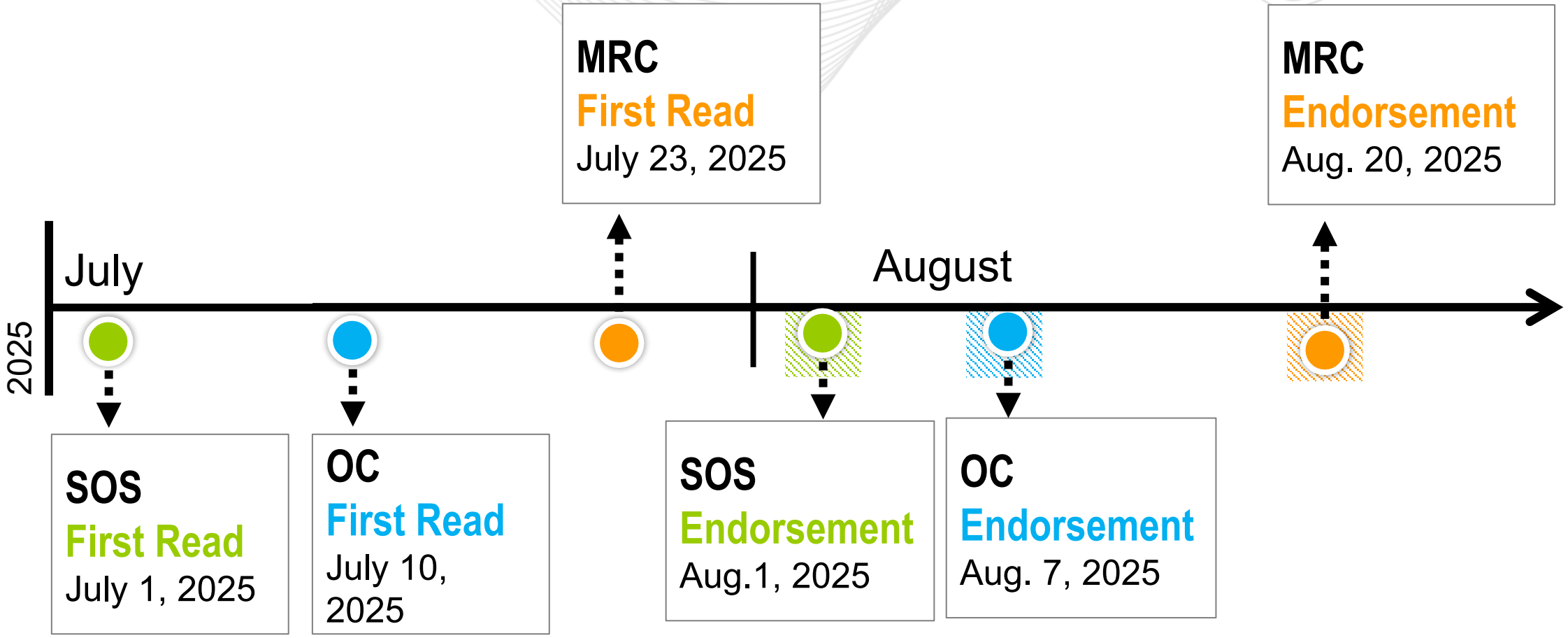
PJM Actions

- PJM will assign zero in performance score for self-de-assignment for the remainder assigned interval.

PJM Member Actions

- None

Next Steps



Manual 15: Cost Development Guidelines

Ilyana Dropkin, Sr. Engineer II
Performance Compliance

Markets and Reliability Committee
July 23, 2025

Revision 47 (10/01/2025):

All changes are conforming to Regulation Redesign Phase I

- Section 2.8:
  - Rename Regulation Performance to Regulation Mileage
  - Cost increase in VOM is for Regulation Only Resources
  - Corrected units from MMBtu/kWh to Btu/kWh, from 12, 5000 to 12, 500 for Heat Rate @ RegMin and update VOM from $3.50 to $0 in an example for a sub-critical coal-fired steam unit providing Regulation Service for the last seven years.
  - Rename Historic Mileage from Reg. Historic Mileage (RegA) to Reg.Mileage
  - Update Regulation VOM Adder from $3.50 to $0
  - Updated calculated value for Exhibit 3: Regulation Maximum Allowable Cost Adder Example

- Section 2.8:
  - Rename Regulation Performance to Regulation Mileage
  - Cost increase in VOM is for Regulation Only Resources

The cost-based regulation offer is split into two portions:

- The Regulation Capability portion consists of the fuel cost increase and unit specific heat rate degradation due to operating at lower loads and the margin risk adder;
- The Regulation Mileage~~Performance~~ portion consists of the cost increase in VOM for Regulation Only Resources, cost increase due to heat rate increase during non-steady state operation and, where applicable, energy losses for energy storage devices. The $/MW value determined in the mileage~~performance~~ offer will be converted to cost per mileage $/ΔMW by dividing the value by the mileage ΔMW/MW for the applicable signal for that offer as described in Manual 11.
- Regulation Capability costs to provide Regulation Service from a unit shall include the following components up to but not exceeding:

$$RegulationCapabilityCosts(\$ / MWh) \leq$$

$$(Fuel\ Cost\ Increase\ and\ UnitSpecific\ Heat\ Rate\ Degradation\ due\ to\ Operating\ at\ Lower\ Loads) + MarginRisk\ Adder$$

- Regulation Mileage~~Performance~~ costs to provide Regulation Service from a unit shall include the following components up to but not exceeding:

$$Regulation\ Mileage\ Costs\left(\frac{\$}{\Delta MW}\right) \leq$$

$$\{Cost\ Increase\ in\ VOM\ \ For\ \ Regulation\ \ Only\ \ Resources + Cost\ Increase\ due\ to\ Heat\ Rate\ Increase\ during\ nonsteady\ state\ operation\ (above\ heat\ rate\ factor\ not\ to\ exceed\ 0.35\%) + (Energy\ Storage\ Unit\ Losses)\} / \Delta MW / MW$$

- Section 2.8:
  - Cost increase in VOM is for Regulation Only Resources

Cost increase in VOM for Regulation Only Resources

The cost increase (in $/MWh of Regulation) of variable operations and maintenance (VOM) cost resulting from operating the unit at lower MW output incurred from the provision of Regulation. This cost component is zero for units participating in the energy market as these VOM costs are already recoverable in a unit's cost based energy offer. ~~VOM costs shall be calculated by the following methods and shall not exceed those levels below:~~

~~For any unit that does not have a PJM approved Maintenance Adder, the following variable operation and maintenance (VOM) costs can be applied by unit type to the following:~~

~~Unit Type~~	~~VOM~~
~~Super-critical Steam:~~	~~$10.00 per MWh of Regulation~~
~~Sub-critical Steam:~~	~~$3.50 per MWh of Regulation~~
~~Combined Cycle:~~	~~$2.50 per MWh of Regulation~~
~~Combustion Turbine:~~	~~$2.00 per MWh of Regulation~~
~~Hydro:~~	~~$1.00 per MWh of Regulation~~
~~Energy Storage:~~	~~Based on OEM estimates initially and actual as history is available~~

~~*Exhibit 1: VOM for all Hydro Units or Non-Hydro Units providing service for less than 10 years*~~

- Section 2.8:
  - Cost increase in VOM is for Regulation Only Resources

~~Any unit that has a PJM approved Maintenance Adder can use the VOM rates above if the annual VOM dollar amounts resulting from those rates included in Regulation cost based offers, are subtracted from the escalated 10 or 20 year historical total VOM accounts and the Regulation MWh based on the average of the last three years.~~

Energy storage units that participate only in regulation Service may~~shall~~ include all their VOM Cost increase in VOM adder in Regulation cost offers~~.~~ based on actual maintenance cost history. These maintenance costs must be submitted and approved by PJM in the annual VOM review process as outlined in Manual 15 Section 2.6 prior to use in the offer.

~~For example, a 100 MW sub-critical coal fired steam unit that has been providing Regulation Service for 30 years. The unit averaged 5,000 MWh of Regulation Service over the last three years and the escalated 20 year historical total VOM = $10,000,000.~~

~~Annual VOM Costs to Subtract~~
~~= ($3.50 per Regulation MWh * 5,000 MWh) * 20 years~~
~~= $17,500 per year * 20 years~~
~~= $350,000~~
~~20 year balance of historical total VOM accounts~~
~~= $10,000,000 - $350,000~~
~~= $ 9,650,000~~

~~*Exhibit 2: Example of VOM for Non-Hydro Units providing Regulation for more than 10 years*~~

Actual ~~Regulation VOM incremental costs submitted and evaluated pursuant to the Cost Methodology and Approval Process.~~

- Section 2.8:
  - Corrected units from MMBtu/kWh to Btu/kWh, from 12, 5000 to 12, 500 for Heat Rate @ RegMin and updated VOM from $3.50 to $0 in an example for a sub-critical coal-fired steam unit providing Regulation Service for the last seven years.

~~For~~ An ~~E~~example for a Sub-critical Coal-Fired Steam Unit providing Regulation Service for the last seven years:

Data Submitted by Participant	Value	Units
Fuel	$1.50	$/MMBtu
Heat Rate @ EcoMax	9,000.00	~~MM~~Btu/KWh
Heat Rate @ RegMin	12,500~~0~~.00	~~MM~~Btu/KWh
VOM	$0~~3.50~~	$/MW of Regulation

- Section 2.8:
  - Corrected units from MMBtu/kWh to Btu/kWh, from 12, 5000 to 12, 500 for Heat Rate @ RegMin and updated VOM from $3.50 to $0 in an example for a sub-critical coal-fired steam unit providing Regulation Service for the last seven years.

$$UnitBaseLoadHeatRateFuelInput =$$

$$UnitBaseLoadHeatRate * RegMin * 1MMBtu / 1{,}000{,}000Btu * 1{,}000\ kW / MW$$

$$UnitBaseLoadHeatRateFuelInput =$$

$$9{,}000\ Btu / kWh * 40\ MW * 1MMBtu / 1{,}000{,}000Btu * 1{,}000\ kW / MW = 360\ MMBtu / Hr$$

$$UnitReducedLoadHeatRateFuelInput =$$

$$UnitReducedLoadHeatRate * RegMin * 1MMBtu / 1{,}000{,}000Btu * 1{,}000\ kW / MW$$

$$UnitReducedLoadHeatRateFuelInput =$$

$$12{,}500Btu / kWh * 40\ MW * 1MMBtu / 1{,}000{,}000Btu * 1{,}000kW / MW = 500\ MMBtu / Hr$$

$$Difference = UnitBaseLoadHeatInput - UnitReducedLoadHeatInput$$

$$Difference = 500MMBtu / Hr - 360MMBtu / Hr = 140MMBtu / Hr$$

- Section 2.8:
  - Corrected units from MMBtu/kWh to Btu/kWh, from 12, 5000 to 12, 500 for Heat Rate @ RegMin and updated VOM from $3.50 to $0 in an example for a sub-critical coal-fired steam unit providing Regulation Service for the last seven years.

Heat Rate Adjustment (Non-Steady State Operation)	Value	Units
Total Operating Point Heat Rate	9,000.0	~~MM~~Btu/kWh
Heat Rate Loss Factor (Max per M15)	0.35%	
Heat Rate Loss	3.15	MMBtu/Hr

$$HeatRateLoss = (EconomicMaximumHeatRate * 0.35\%) * 1 MMBtu / 1{,}000{,}000 Btu * 1{,}000 kW / MW * EconomicMaximumMW$$

$$Heat\ Rate\ Loss = (9{,}000 Btu / kWh * 0.35\%) * 1 MMBtu / 1{,}000{,}000 Btu * 1{,}000 kW / MW * 100 MW = 3.15\ MMBtu / Hr$$

- Section 2.8:
  - Rename Historic Mileage from Reg. Historic Mileage (RegA) to Reg.Mileage

Historic Mileage	Value
Reg. Mileage~~A~~	5

Maximum Mileage ~~Performance~~ Offer	Value	Units
(c+d)/Reg.~~Historic~~ Mileage	$0.1~~8~~0	$/ΔMW

MaximumPerformanceOffer =

[*FuelCostAdder* (*NonSteadyStateOperation*) + *RegulationVOMAdder for Regulation Only Resources*] / *Reg. Mileage*

- Section 2.8:
  - Update Regulation VOM Adder from $3.50 to $0

(d) VOM Adder	Value	Units
Regulation VOM Adder	$0~~3.50~~	$/Hr/MW of Regulation

- Section 2.8:
  - Updated calculated value for Exhibit 3: Regulation Maximum Allowable Cost Adder Example

MaximumPerformanceOffer =

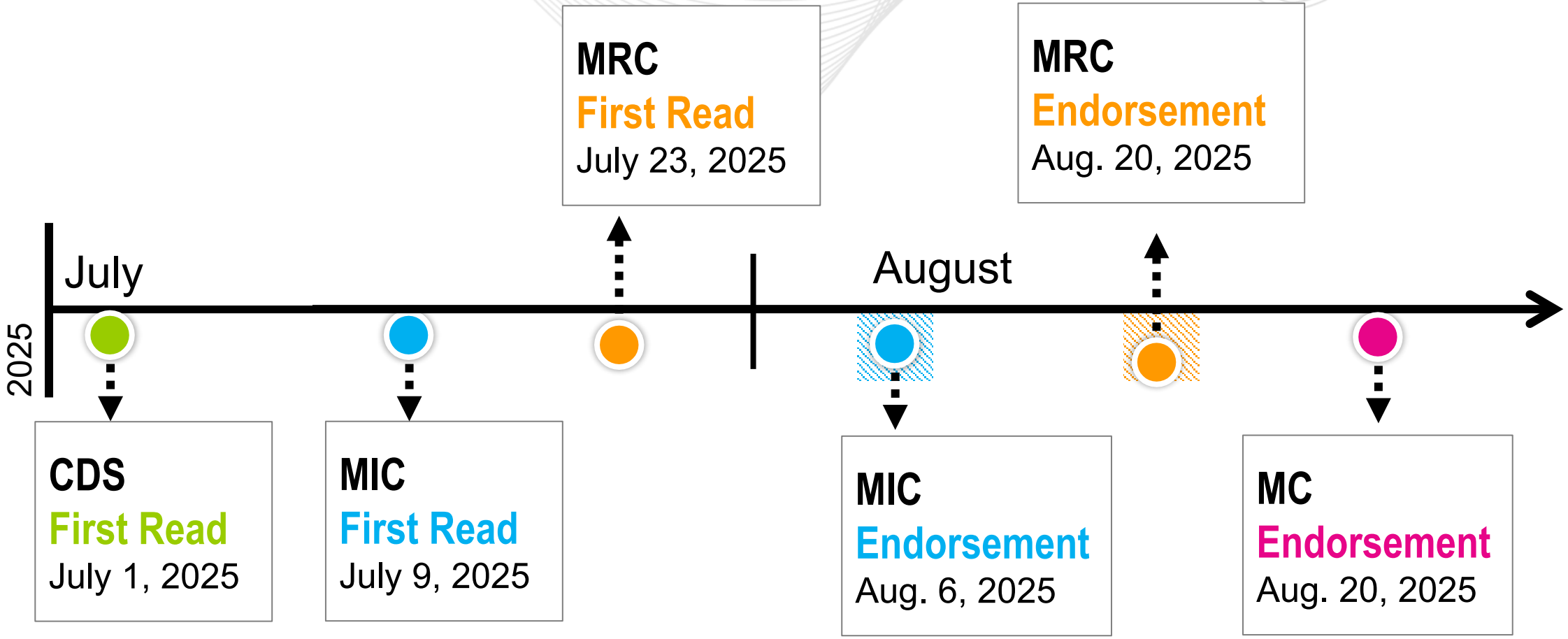
[*FuelCostAdder* (*NonSteadyStateOperation*) + *RegulationVOMAdder for Regulation Only Resources*] / *Reg. Mileage*

Regulation Maximum Allowable Cost Adder Example:

FuelCostAdder =
[$0.50 / *Hr* / *MW* + $0 / *Hr* / *MW*] / 5 Δ *MW* / *MW* = $0.10 / *Hr* / *MWofRegulation*

Exhibit 3: Regulation Maximum Allowable Cost Adder Example

Next Steps



Manual 28: Operating Agreement Accounting

Suzanne Coyne

Principal Consultant, Market Settlements Development

Markets & Reliability Committee

July 23, 2025

Manual 28, Section 4.2.1
Regulation Clearing Price Credit (BLI 2340)

- Regulation Market Capability Clearing Price Credit

If 5-minute performance score < 0.25, credit = $0

$$Regulation\ MW \times Actual\ Performance\ Score \times \frac{RMCCP}{12}$$

- Regulation Market Mileage Clearing Price Credit

$$Regulation\ MW \times Actual\ Performance\ Score \times \frac{Actual\ Mileage}{Daily\ Historic\ Mileage} \times \frac{RMMCP}{12}$$

Changes:

- Single bidirectional mileage ratio using actual and historic mileage replaces Reg A and Reg D signal mileage ratios.
- New Mileage Clearing Price and Credit terminology replaces Performance Clearing Price and Credit.

Manual 28, Section 4.2.2
Regulation Lost Opportunity Cost Credit (BLI 2340)

- If a pool-scheduled resource is not compensated for its offer plus any opportunity costs via the clearing prices, a resource receives a Lost Opportunity Cost Credit.

If 5-minute performance score < 0.25, credit = $0

$$Lost\ Opportunity\ Cost\ Credit = \frac{Regulation\ Offer + Intra\ Commitment\ Opportunity\ Cost + Shoulder\ Opportunity\ Cost}{12} - Regulation\ Clearing\ Price\ Credits$$

Changes:

- Benefits factor is no longer used to adjust the opportunity cost
- Intra-commitment interval terminology replaces intra-hour to align with change to a 30 minute commitment interval

Manual 28, Section 4.2.2.2
Shoulder Interval Opportunity Cost

- Shoulder interval opportunity costs determined for the eligible two 5-minute intervals preceding or following a regulation 30-minute commitment period (previously three 5-minute intervals and hourly commitment periods).
- Updated calculations to use final offer and new Tracking Ramp-Limited Desired
- Updated eligibility requirements to align with change to a 30 minute commitment interval and use of Tracking Ramp-Limited Desired
- Updated calculation descriptions and added illustrative examples

Manual 28, Section 4.3
Regulation Charge (BLI 1340)

- RMCCP Charge and RMMCP Charge
  - LSEs, or other Regulation buyers, are charged hourly obligation ratio share of total hourly RMCCP credits and RMMCP credits .
  - Hourly Regulation obligations equal the real-time load ratio share of the total hourly amount of Regulation supplied, excluding mileage ratio component, further adjusted for any bilateral Regulation transactions
- Lost Opportunity Cost Charge
  - Net Regulation Purchasers are charged hourly purchase ratio share of total hourly Lost Opportunity Cost Credits.
  - Hourly Regulation Purchase is the Hourly Regulation obligation less any self-scheduled Regulation MW

Phase 1 change

- Only change is terminology: New Mileage Clearing Price and Charge terminology replaces Performance Clearing Price and Charge.

Manual 28, Section 4
Other Changes

- Updated terminology for consistency with other PJM Manuals
- Updated capitalization
- Clarified opportunity costs for Economic Load Response resources, Regulation only resources, and self-scheduled resources are zero.
- Clarified list of unit types that are not eligible for shoulder opportunity costs.
- Added additional inputs and calculations to the Regulation Charge section for completeness.

Next Steps

	MIC	MRC
First Read	7.9.2025	7.23.2025
Endorsement	8.6.2025	8.20.2025

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Regulation Redesign Phase 1 Implementation Update

Member Hotline

(610) 666-8980

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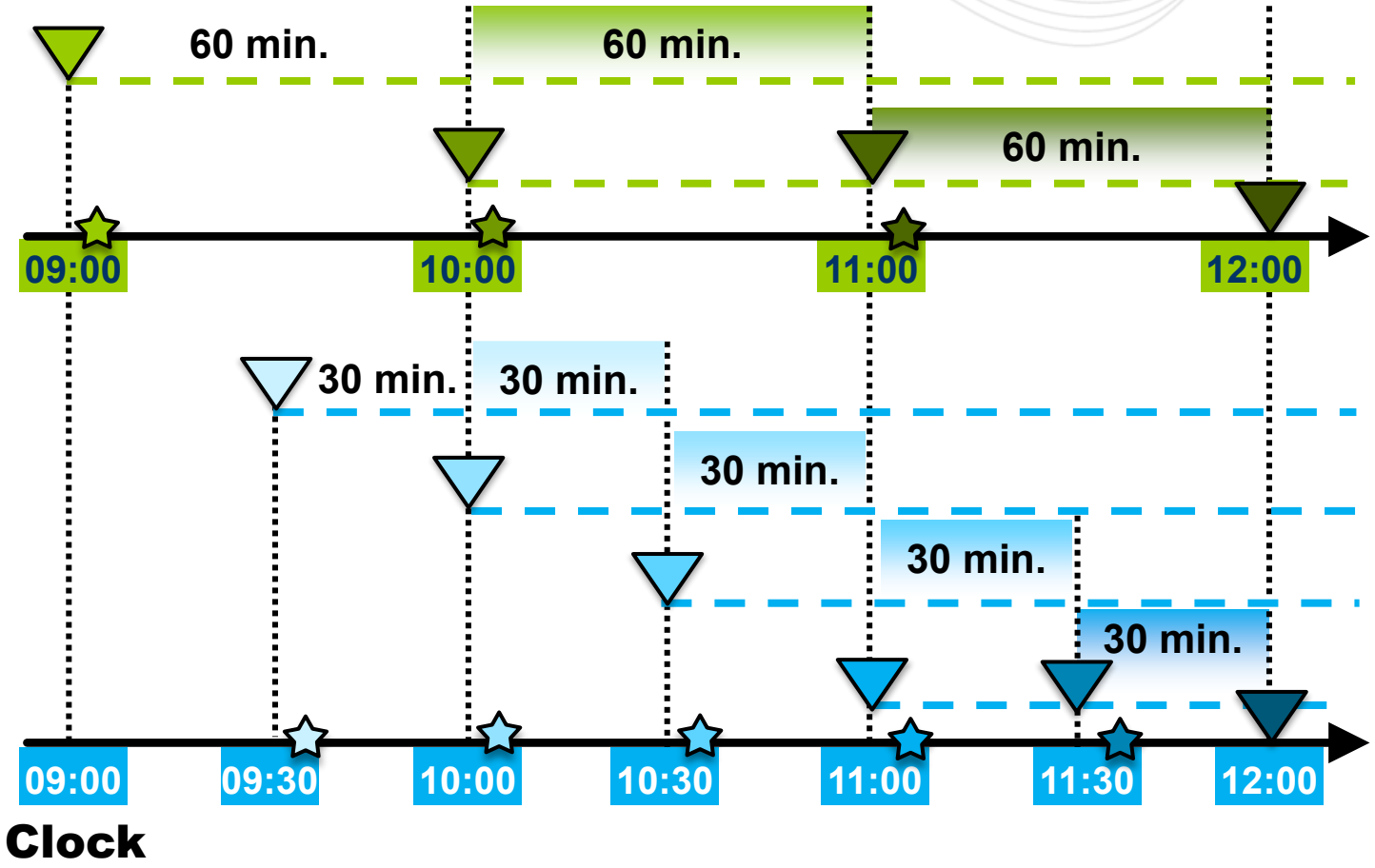
Appendix

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

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

PHASE 1 & 2

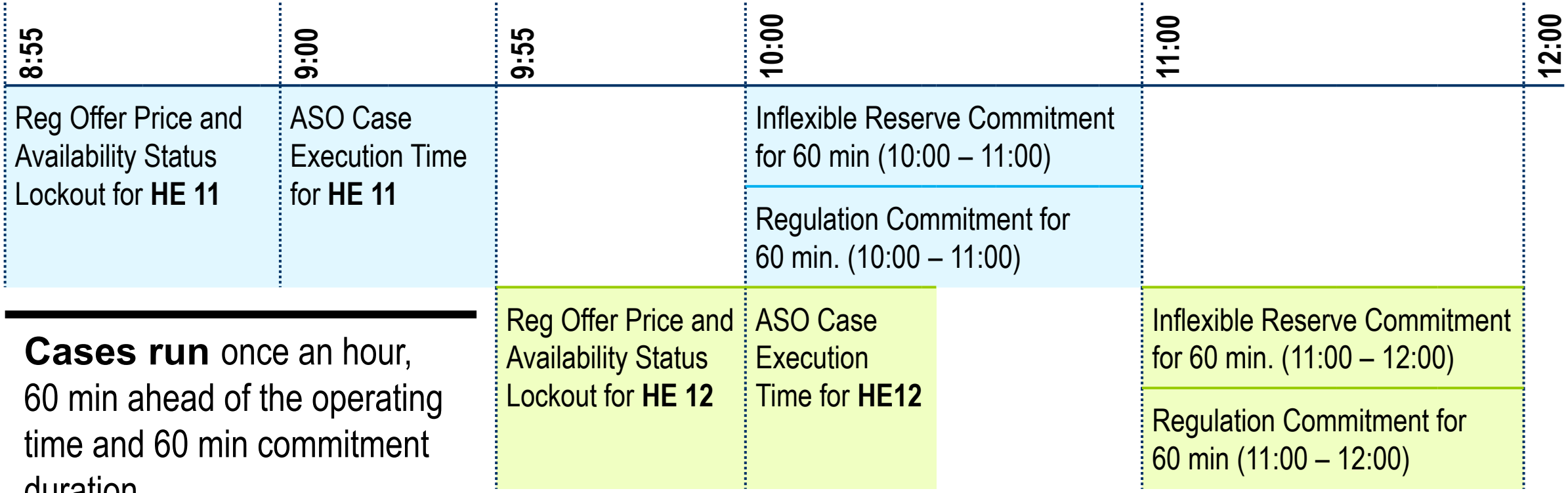
- **30 minutes** prior to target time
- Looks ahead 30 minutes beyond target time

Legend

- Case execution time
- Case approval
- Service provided

Current ASO Cases

Current ASO

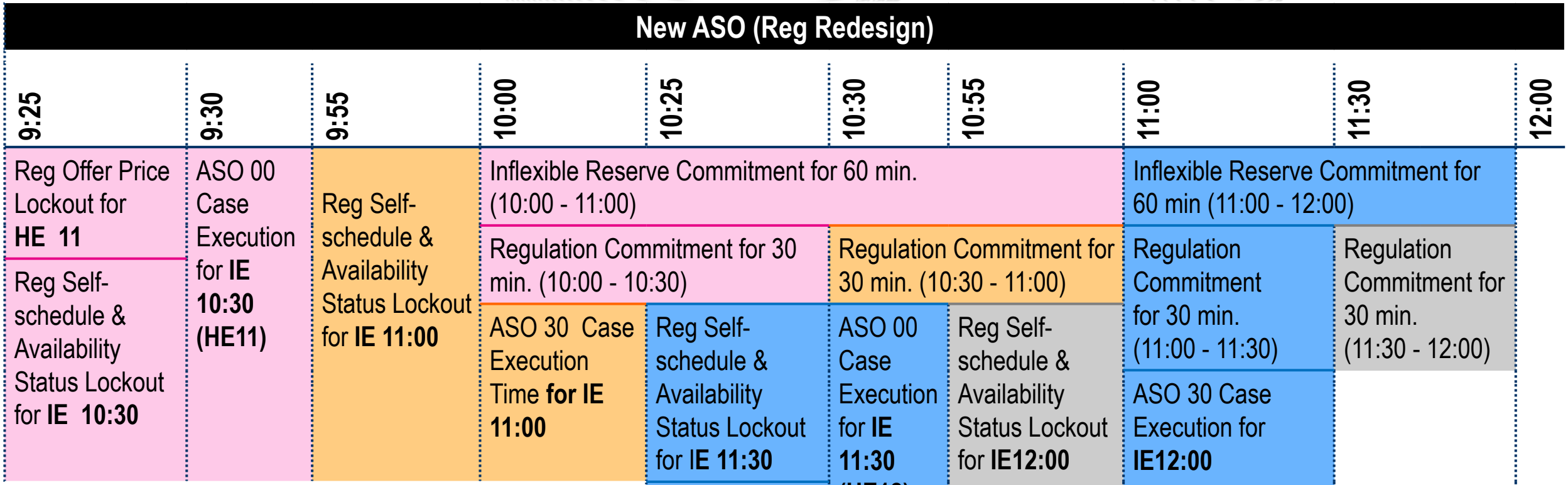


Cases run once an hour, 60 min ahead of the operating time and 60 min commitment duration

Offers lockout 65 min before the operating hour

HE = *Hour ending*

New ASO Input Lockout and Solution Target Times



Cases run twice an hour – hh:00 and hh:30, 30 min ahead of the operating time, 30 min commitment duration for Regulation, and 60 min commitment duration for inflexible Reserves

***HE** = Hour ending | **IE** = Interval ending*

Offer Price and MW lockout 35 min before the ***operating hour***, self-schedule and availability status lockout 35 min before the ***operating interval***;

Sample ASO Case Execution, Posting and Target Intervals

Cases	Execution Time	Products Types	Markets Gateway Posting Deadline	Target Time (Begin)
ASO 00	9:30	Regulation & Reserves	9:50	10:00
ASO 30	10:00	Regulation Only	10:20	10:30
ASO 00	10:30	Regulation & Reserves	10:50	11:00
ASO 30	11:00	Regulation Only	11:20	11:30

- Regulation and Reserves results notification of at least 10 minutes before the operating time
- If ASO 30 is missed, All-Call must go out by **hh:20** to extend the last **Regulation assignment**;
- If **ASO 00** is missed, All-Call must go out by **hh:50** to extend the last **Regulation and Inflexible Reserve assignment**

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)

Phase 1 Milestones and Tentative Timeline

No.	Milestone	Timeline
1	**Regulation Redesign project – information update at the TCF**	May 5, 2025
2	**Regulation Redesign project – information update at the MIC/OC**	May 7- 8, 2025
3	**Markets Gateway Train (Sandbox) Opens for Testing**	May 15 - 30, June 18 and later, 2025
4	**RegD resources conversion testing begins**	June 2025
5	**All related manuals first read (Phase 1): M11, M12, M15, M28**	July 2025
6	**All related manuals endorsed (Phase 1): M11, M12, M15, M28**	August 2025 (September if needed)
7	**Special education session**	August 12 / September 5, 2025
8	**Regulation Redesign Phase 1 market opens**	Sept. 25, 2025
9	**Regulation Redesign Phase 1 go-live (cutover)**	Oct. 1, 2025, at 00:00

PROTECT THE POWER GRID

THINK BEFORE YOU CLICK!

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