4.4.3 Determining Regulation Assignment

The PJM RTO’s Regulating Requirement is 525 effective MW during off-peak hours (0000 to 0459) and 700 effective MW during on-peak hours (0500 – 2359). PJM dispatch may increase or decrease the regulation requirements as needed to accommodate system conditions, a function of the day’s load forecast, as determined by the PJM dispatcher.

- The PJM on-peak Regulation Requirement is based on the PJM Balancing Area’s peak load forecast, as determined prior to the operating day.
- The PJM off-peak Regulation Requirement is based on the PJM Balancing Area’s valley load forecast, as determined prior to the operating day.

The regulation requirement will be adjusted in stages to convert to effective MWs as part of the Performance Based Regulation changes. This approach will utilize the RTO-wide average performance scores leading up to the transition to set the staged requirements. The regulation requirement at the time of implementation will be 0.78% of the applicable load forecast. As system conditions allow, PJM will make a monthly assessment to lower the regulation requirement to a minimum of 0.70% of the applicable load forecast as part of this transition.

Each LSE is required to provide a share of the PJM Regulating Requirement. An 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:

\[
\text{LSEs Regulation Obligation} = \left( \frac{\text{LSEs Load Allocation}}{\text{PJM Assigned Regulation}} \right) \times \text{Regulation Assigned PJM}
\]

An LSE may satisfy its Regulation obligation by any of the following methods:

- Self-Scheduled Resources — An LSE can satisfy its Regulation obligation by self-scheduling Regulation.
- Bilateral Transaction — An LSE can make contractual arrangements with other PJM Members that are able to provide Regulation service.
- PJM Regulation Market Purchases — An LSE can purchase its Regulation obligation from the PJM Regulation Market, i.e., from the excess Regulation capability provided to PJM by Resource owners.

All Regulation offers reported to PJM must provide Regulation that has a quality standard of 75% or greater, as established by verification testing.

**PJM Actions:**

- PJM will notify the Transmission Owners and Generation Owners via the PJM ALL-CALL of changes to the regulation requirement and the expected duration of such change. Prior to the beginning of each day, PJM dispatcher determines the PJM RTO Regulating Requirement as described above.
- At 2230, PJM provides the following information to the Transmission Owners/Generation Owners for the LSE’s, via the PJM ALL-CALL: PJM RTO Regulation Requirement for the following day.
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 hourly regulation market results via eMKT (available at least a half an hour before the operating 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 on line and able to provide the self-scheduled Regulation.

- Once regulation on a resource is self-scheduled by a resource owner, it is no longer eligible to participate as a pool assigned regulating resource for the current operating day.

- If purchasing Regulation from another entity, the buyer and seller negotiate the transaction and the buyer submits the transaction through the Regulation Bilateral page of eMKT. The seller must then confirm the transaction via eMKT by 4:00pm the day after the operating day. The rules for these transactions are described in more detail later in this section of the manual.

4.5 Qualifying Regulating Resources

In order to ensure the quality of Regulation supplied to control the PJM RTO, a quality standard is developed. A resource must meet the quality standard to be permitted to regulate.

In general, there are two phases to qualifying a regulating resource:

- Certifying the resource
- Verifying regulating capability

An Area Regulation (AR) test is used for both certifying and verifying regulating capability for a resource.

Note: It must be emphasized that the Regulation test is not intended to test a resource’s governor response to power system frequency changes.

4.5.1 Regulation Qualification Test

Traditional Resource Test

The AR test is run during a continuous 40-minute period when, in the judgment of PJM test administrator, economic or other conditions do not otherwise change the base loading of the resources that are being tested. 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 test follow a simulated RegA signal. The test will last for 40 minutes.

Once an AR test is announced, a Resource Owner is not permitted to change any resource’s Regulation assignment.

Scoring the AR test is based on compliance to the Performance Score Calculation as described in Section 4.5.6 - Performance Score Calculation of this manual. The score is evaluated on the entire 40 minute test period.

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).

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

For previously qualified resources that are either purchased by a new resource owner, which would constitute a change in the regulation signal path, resource owners must conduct a single, successful re-test to verify that each unit is able to respond to the regulation signal under the new resource owner. This test will be PJM administered and must meet threshold for certification as described in Sections 4.5.2-4.5.3. During the transition resources will not be qualified to offer regulation. After the retest, the resource performance score will be set to the re-test qualification score.

Changes to the Signal Path Re-Test – Existing Owner

For previously qualified resources where an existing resource owner who 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. After system verification, the resources’ historic performance score will be maintained.

PJM Actions:

- PJM Performance Compliance will score the test using the performance score calculation as described in Section - 4.5.6 Performance Score Calculation of this manual within three business days of the test.

- PJM Performance Compliance will send results of test to the generation owner within three business days.

PJM Member Actions:
May contact PJM Performance Compliance at least a day prior to testing stating a regulation test will occur and include the following information: the resource name and identification number, the time of the test, the amount of MWs being tested and what signal the resource will test on.

Contacts the PJM Dispatch at least 60 minutes in advance of a PJM administered test for test scheduling and approval. Contacts PJM Performance Compliance at least 60 minutes before the start of the test to ensure that test can be scored by the Performance Score Calculation Engine (PSCE).

For a new resource owner, schedules a re-test by contacting RegulationTesting@pjm.com for each unit in a manner similar to the guidelines above when a new owner takes control of an already qualified regulation.

For an existing resource owner, schedules system verification by contacting RegulationTesting@pjm.com based on mutual agreement with PJM Staff when an existing resource owner changes the control signal path (e.g. EMS or GMS is changed or upgraded).

### 4.5.2 Certifying Regulating Resource

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

The first of these tests may be performed internally by the member following the PJM Regulation test procedure. To perform a self test the member must use the PJM test shape posted on the Markets and Operations> Ancillary Services>Market Based Regulation page fed into the resource owner’s EMS. Additionally, the member must notify the PJM Performance Compliance at least 60 minutes before the test. The Resource owner should also notify PJM Dispatch who will make a determination whether the test can be run. The resource should be set to unavailable during the test, though the other units may continue to regulate. Up to three self administered tests may be performed on a resource each day.

The remaining tests should be administered by PJM Dispatch. The resource owner should contact PJM Dispatch and PJM Performance Compliance at least 60 minutes before the test though 24 hour notice is preferred. For a PJM administered test, all resource(s) will be taken out of the regulation market for the specific signal. PJM Dispatcher makes the final determination about whether a PJM administered test can be performed. Only one PJM administered test may be performed on a resource each day.

**PJM Actions:**

- PJM Performance Compliance will certify a resource after three consecutive successful tests of 75% or better and make change to enable regulation offers to reflect the new certification within 1 business day.
- PJM Dispatcher determines if a self scheduled test or PJM administered test can be performed based on system conditions.
- PJM maintains a historical database of individual resource Regulation test results and calculates all appropriate compliance information. Individual test results are
provided via email to each participating LSE within three business days to facilitate a review and validation of results at the participant level.

**PJM Member Actions:**

- Before a self–administered test, resource owner notifies PJM Performance Compliance and PJM Dispatch. Before a PJM administered test, the resource owner notifies PJM Performance Compliance and PJM Dispatch.

- For any tests performed by the members for the purpose of certification, the member will supply the resource, the time of the test amount of MW being tested and the signal the resource is following to RegulationTesting@pjm.com.


- Resource owner will set the resources specific operation setpoints for each resource to test around.

### 4.5.3 Certifying Multiple Combustion Turbines or Hydro Units at a Single Site

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 the 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 CTs and Hydro units being certified. The resource will be evaluated based on the Operational Midpoint of the grouped resources and the Resources Allocation as described in Section 4.4.2-Regulation Signals of this manual.

### 4.5.4 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 may be administered by PJM or may be a self test administered by resource owner using the PJM test shape posted on the Markets and Operations page fed into the resource owner’s EMS. Additionally, the member must notify the PJM Performance Compliance and PJM Dispatch at least 60 minutes before the test. The resource should be set to unavailable during the test, though the other units may continue to regulate.

**PJM Actions:**

- PJM maintains a historical database of individual resource Regulation test results and calculates all appropriate compliance information. Individual test results are provided via email to each participating LSE within three business days to facilitate a review and validation of results at the participant level.

- PJM will update the regulation bidding availability to reflect the new certification within 1 business day after a successful test.

**PJM Member Actions:**
• Resource owner notifies PJM Performance Compliance before a self–administered test. The resource owner notifies PJM Performance Compliance and PJM Dispatch before a PJM administered test.

• For any tests performed by the members for the purpose of increasing certification, the member will supply the resource, the time of the test, amount of MW being tested and the signal the resource is following to RegulationTesting@pjm.com.


  Resource owner will set the resources specific operation setpoints for each resource to test around.

4.5.5 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 regulating 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 hourly performance score for the last 100 hours a resource has operated or a weighted average of the average of the three initial or requalification scores that are then averaged with available actual hourly performance scores. The hourly performance score calculation is described in section 4.5.6 Performance Score Calculation of this manual.

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

The resource owner may schedule a re-test as soon as practicable. When a regulating resource re-tests it will follow the testing procedure described in Sections 4.5.1-4.5.3 of this manual. Upon successful completion of requalification, the regulating resource performance score starts a new rolling average without any hours from the previous period counting towards the current period’s rolling average.

When a regulating resource has no historic performance available, either because it is a new resource or a resource that has re-qualified, the average of the qualification test scores will be used as proxy for the historic performance rolling average as follows:

\[ Hour = \frac{X \times \text{Qualification Performance Score} + Y \times \text{Actual Performance Score}}{100} \]

Where 100 – X = Y and Y is the number of hours after qualification. After 100 hours of actual performance scores X → 0.

**PJM Actions:**

• Tracks rolling average of a regulating resource’s performance score by signal type.
• Alerts the regulating resource’s owner when performance by signal type falls below threshold of 40%.
• Blocks the disqualified resource from offering into the market.
• Monitors re-testing of the regulating resource.
• Re-qualifies regulating resource,
• Notifies LSEs of a resource’s certification for Regulation within three business days.

**Member Actions:**
• Schedules re-test to re-qualify as regulating resource status, if desired, while adhering to regulation testing guidelines.

### 4.5.6 Performance Score Calculation

PJM will calculate an hourly performance score which reflects a regulation resource’s accuracy in increasing or decreasing its output to provide frequency regulation service in response to PJM’s dispatch signal. With the Performance Score Calculation Engine (PSCE), PJM will collect regulation signal data every 10 seconds and resource operating parameters that will be inputs into the performance score. The performance score calculation (PSC) evaluates each resource’s accuracy in following the AGC signal.

**PSCE Assumptions**

Unless a resource owner elects to send additional data to detail operational decisions, it is assumed that resources are allocating the regulation control signal(s) proportionally and operating around the PJM Individual Generator Dispatch (IGD) setpoint. If a resource elects to use other than proportional dispatch the resource must send Operation Midpoint and Resource allocation described in Section 4.4.2 Regulation Signals of this manual. In the event that a non-proportional allocation results in a resource receiving a signal with an average absolute value less than one percent of its hourly regulation assignment, PJM will apply that resource’s historical average performance score as the hourly performance score.

**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:

\[
\text{Correlation Score } = \left| r_{\text{Signal,Response}}(\delta, \delta + 5\text{Min}) \right|
\]

\[
\text{Delay Score } = \left| \frac{\delta - 5\text{Minutes}}{5\text{Minutes}} \right|
\]
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:

\[
\text{max}_{\delta = 0 \text{ to } 5 \text{ Min}} (\text{Delay Score} + \text{Correlation Score})
\]

**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.

**Precision Score**

For each 10 second interval starting from Time 0 +10, PJM will calculate a Precision Score as a function of the difference in the energy provided versus the energy requested by the regulation signal while scaling for the number of samples. For each 10 second sample averaged over an hourly basis, PJM calculates the Precision Score as the absolute error (\(\varepsilon\)) as a function of the resource’s regulation capacity, as:

\[
\text{Error} = \text{Avg of } \text{Abs} \left( \frac{\text{Response} - \text{Regulation Signal}}{\text{Hourly Average Regulation Signal}} \right)
\]

\[
\text{Precision Score} = 1 - \frac{1}{n} \sum \text{Abs}(\text{Error})
\]

Where \(n\) is the number of samples in the hour and the precision allows a 10 second latency for signal propagation delay for regulating resources.

**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:

\[
\text{Performance Score} = \max \left[ A \ast \left( \text{Delay Score} \right) + B \ast \left( \text{Correlation Score} \right) \right] \ast \left( A \ast + B \ast \right) + C \ast \left( \text{Precision Score} \right)
\]

The component scalars will be weighted equally with each at one-third (1/3). For periods when assigned regulation is 0, no score will be calculated. Correlation, Delay and Precision
will be calculated with all applicable samples. Null scores will not be included in the hourly average performance score.

PJM Actions:
- PJM will calculate the Performance Score for each regulating resource after the operational hour and report the score to resource owners.

**Member Actions:**
- None

### 4.5.7 Use of Performance Groups in the Performance Score

Resources may elect to use a performance group for performance score evaluation. Performance groups can only be created for resources that satisfy one of the following criteria:

- Resources not eligible for LOC and total to less than or equal to 10 MWs across Transmission Owner boundaries.
- A performance group can be any number of resources not eligible for LOC inside a transmission owner’s boundary.
- Resources within a fleet with equivalent applicable offers and point of interconnection.

Resources that are part of a performance group will send the Operational Midpoints and Resource Allocation of the group TReg for the grouped resources by signal type as described in Section 4.4.2 - Regulation Signals. Each resource will be metered independently.

**PJM Actions:**
- PJM will receive additional control data to be used in the Performance Score Calculation to be reflected resource owner’s dispatch.

**Member Actions:**
- Resource owners will notify PJM via RegulationTesting@pjm.com that they satisfy one of the Performance Group criteria.
- Resource owners will add required information to their data transfer link to PJM.

### 4.5.8 Performance Scores for Regulation Resources during a Synchronized Reserve Event

Regulation Resources choosing to respond to a Synchronized Reserve event will receive synchronized reserve compensation based on Manual 11, Section 4.2.11.

Resources that choose to respond to a reserve event for their reserve zone in an hour when they are cleared or assigned regulation are expected to return to their regulating band within 10 minutes of the end of the Synchronized Reserve event. From the start of the event,
through the event, and for the 10 minutes after the end of the event, the performance scores for all regulating resources in the reserve zone where the Synchronized Reserve Event takes place will be null.

**PJM Actions:**

- PJM logs the time of the start and end of a Synchronized Reserve event.
- PJM will score performance for all regulating resources as null for the period during the Synchronized Reserve event and 10 minutes after the end of the event for those resources in that reserve zone.

**PJM Member Actions:**

- If the resource owner chooses to respond to an event the resource will return to the regulating band as soon as possible after the end of the reserve event.

### 4.5.9 Performance Scores during Periods with Insufficient Data

In rare cases of data disruption, circumstances may arise when PJM does not have sufficient data to calculate performance scores. During these disruptions, PJM will calculate performance scores for all intervals with at least fifteen contiguous minutes of sufficient data. All intervals with performance scores, and only those intervals, will contribute equally to the hourly performance score. In the event that an operating hour does not contain fifteen contiguous minutes of sufficient data, the historical score will be used as the hourly performance score for that operating hour.

PJM will also use the historical score as the hourly performance score for an operating hour when a partial-hour regulation assignment does not result in fifteen contiguous minutes of sufficient data.

### 4.5.10 Performance Scores for Regulation Assignments with Limited Notification

Performance Scoring will begin ten minutes after PJM Dispatch logs a resource to provide regulation service. This will not impact the length of time a resource is considered to be providing regulation service for settlement calculations. For purposes of scoring under section 4.5.9, the fifteen contiguous minutes condition will begin ten minutes after PJM Dispatch logs a resource to provide regulation service.