Regulation Market

Web-based Training

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OPERATIONAL PERFORMANCE, TRAINING AND INTEGRATION
Disclaimer for Customer Training

ISO New England (ISO) provides training to enhance participant and stakeholder understanding.

Because not all issues and requirements are addressed by the training, participants and other stakeholders should not rely solely on this training for information but should consult the effective *Transmission, Markets and Services Tariff* (“Tariff”) and the relevant *Market Manuals, Operating Procedures* and *Planning Procedures* (“Procedures”).

In case of a discrepancy between training provided by ISO and the Tariff or Procedures, the meaning of the Tariff and Procedures shall govern.
Course Objectives

• Provide an overview of the key concepts and the basic features of the Regulation Market
• Explain the basics of Regulation
• Explain recent changes to the Regulation Market with specific emphasis on:
  – The new Energy Neutral Regulation Signal
  – The selection process of Regulating Resources
  – Monitoring of the performance of Regulating Resources

Intended audience: Regulation Market participants and those considering participation in the Regulation Market
Acronyms

ACE - Area Control Error (units in: MW)
AGC - Automatic Generation Control
ARR - Automatic Response Rate (units in: MW/minute)
ATRM - Alternative Technology & Regulation Market
ATRR - Alternative Technology Regulating Resources
CON – Conventional (AGC setpoint)
CPS - Control Performance Standard
ENC – Energy Neutral Continuous (AGC setpoint)
ENT – Energy Neutral Trinary (AGC setpoint)
FERC - Federal Energy Regulatory Commission
IPO - Instantaneous Perfect Output (units in: MW)
NERC - North American Electric Reliability Corporation
NFE - Narrow Failure Envelope
Acronyms

NSE - Narrow Scoring Envelope
ONFGP – Outside Narrow Failure Grace Period
OWFGI– Outside Wide Failure Grace Intervals
RHL - Regulation High Limit (units in: MW)
RIPS - Regulation Interval Performance Score
RLL - Regulation Low Limit (units in: MW)
RSI - Regulation Settlement Interval (one hour)
WBS - Wide Band Score
WFE - Wide Failure Envelope
WSE - Wide Scoring Envelope
Changes to ISO-NE Documents

• Market Rule 1
  – Section I.2.2 Definitions
  – Section III.14 Regulation Market

• Manuals
  – Manual 11, Sections 1.2, 2.5, 5.1, 5.2 have general info
  – M-REG
What is Regulation?

Resources under automatic control

Receive signals approximately every 4 seconds

Independent of economic cost signal

Provide fine tuning that is necessary for
• system-frequency control
• maintenance of scheduled interchange.
What is Regulation?

- Resources under Regulation Control respond to minute-to-minute changes in load.

- ISO’s Success determined by compliance with NERC Control Performance Standards
  - CPS1, CPS2 Criteria
The Energy Balance

Frequency Bias
Obligation

Load

Losses
Exports

Area Control Error
MW

Imports
Power Generated

DEMAND
SUPPLY
The Energy Balance

Frequency Bias
Obligation
Load
Losses
Exports
 Imports
Power Generated

Area Control Error
MW

DEMAND

SUPPLY
The Energy Balance

- Frequency Bias
- Obligation
- Load
- Losses
- Exports
- Imports
- Power Generated
- Area Control Error
- MW

Demand

Supply
Basic Features

ISO Regulation requirements defined (month, day type, hour)

- Capacity
- Service

Posted to ISO website
(http://www.iso-ne.com/isoexpress/web/reports/operations/-/tree/daily-regulation-requirement)

During abnormal conditions, the ISO may deviate from these requirements for reliability
Regulation Market Resource Selection

Resources are selected based on a least-cost algorithm based on:

- **Regulation Offer**
  - Regulation Capacity Offer
  - Regulation Service Offer

- **Estimated Energy Opportunity Cost**

- **Opportunity Cost Sensitivities due to the shape of the Resource’s Supply Offer price curve**

- **Operational requirements related to reliability**
Input: Regulation Offer

- Entered into eMarket
- Daily offers provide default values that carry over
- Hourly offers supplant the daily offer, but do not carry over
- Unit regulating status
  - Available
  - Unavailable
- Physical offer data
  - Automatic Response Rate (ARR) in MW/minute to nearest tenth (e.g., 3.9 MW/minute)
  - Regulation High Limit (MW)
  - Regulation Low Limit (MW)
- Economic offer data
  - Regulation Capacity offer price
    - Floor at $0/MW and Cap at $100/MW
  - Regulation Service offer Price
    - Floor at $0/MW-mile and Cap at $10/MW-mile
- Dispatch Methodology (ATRRs only – must choose 1 of 3 possibilities)
  - CON
    - Conventional AGC Setpoint – default
  - Energy Neutral
    - Energy Neutral Continuous AGC Setpoint
    - Energy Neutral Trinary AGC Setpoint
Two Regulation Signals

• Two Regulation dispatch signals are available for ATRRs
  – Conventional signal as has previously existed
  – New statistically Energy Neutral signal created by high-pass filtering

• The sum of the AGC setpoints of the Energy Neutral regulation resources modifies the AGC setpoints for conventionally dispatched resources.

• Two sub-groups within the Energy Neutral Dispatch category
  – Energy Neutral Trinary
    • Trinary means that the dispatch and expected response is either full power charge, full power discharge, or midpoint.
    • All ENT dispatched resources will simultaneously be sent to their Regulation High Limits, Regulation Low Limits, or Regulation midpoints
  – Energy Neutral Continuous
    • The Energy Neutral fleet AGC target is distributed by participation factors (which includes offered Automatic Ramp Rate (ARR) in MW/minute).
    • Dispatch is then apportioned across ENC dispatched resources.
Summary of eMkt Submission Windows
taking effect 3/31/2015
(from the perspective of a single operating day)

Energy Market Offer Windows

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/1/2015 - 4/8/2015</td>
<td>Operating Day (D-9) Through</td>
</tr>
<tr>
<td></td>
<td>Operating Day (D-2)</td>
</tr>
<tr>
<td>4/8/2015</td>
<td>DA Bid Window 00:00 - 10:00</td>
</tr>
<tr>
<td>4/8/2015</td>
<td>DA Bid Window 18:30 - 23:59</td>
</tr>
<tr>
<td>4/9/2015 - 4/9/2015</td>
<td>NLT 13:30 - 14:00 Reoffer for D</td>
</tr>
<tr>
<td></td>
<td>Operating Day (D-1)</td>
</tr>
<tr>
<td>4/10/2015</td>
<td>RT Intra Day Re-offer window for D-1</td>
</tr>
<tr>
<td></td>
<td>18:30 - 22:30</td>
</tr>
<tr>
<td>4/11/2015</td>
<td>Operating Day (D)</td>
</tr>
<tr>
<td>4/12/2015</td>
<td>Operating Day (D+1)</td>
</tr>
</tbody>
</table>

Regulation Market Offer Windows

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/8/2015 - 4/9/2015</td>
<td>Reg Bid Window (Daily &amp; hourly)</td>
</tr>
<tr>
<td></td>
<td>Ten Days Prior until 14:00 D-1</td>
</tr>
<tr>
<td></td>
<td>** Intra-day updates (hourly values only):**</td>
</tr>
<tr>
<td></td>
<td>Day D-1:</td>
</tr>
<tr>
<td></td>
<td>* up to 23:55 for HE01</td>
</tr>
<tr>
<td></td>
<td>Rest of Operating Day:</td>
</tr>
<tr>
<td></td>
<td>* up to 5 min prior to hour, ends 22:55</td>
</tr>
<tr>
<td>4/1/2015 - 4/8/2015</td>
<td>Cannot change daily values during OP Day</td>
</tr>
<tr>
<td>4/11/2015</td>
<td>No eMkt modifications to data after OP Day has ended</td>
</tr>
</tbody>
</table>

** Intra-Day Updates (hourly values only):**

- Gen: financial parameters only
- ATRRR (non-gen): financial and physical parameters

http://www.iso-ne.com/support/user_guides/index.html

December 15, 2014
eMarket Data Exchange Specification Ver 10 dt Dec, 2014
Ramp Constrained

Regulation Capacity

Lesser of

- $5 \times ARR$
- $\frac{(Reg\ High - Reg\ Low)}{2}$

Generator “A”

$$ARR = 5 \frac{MW}{minute}$$

$$5 \times ARR = 5 \times 5 = \pm 25\ MW$$

$$\frac{(Reg\ High - Reg\ Low)}{2} = \frac{(375 - 225)}{2} = \pm 75\ MW$$
Range Constrained

Regulation Capacity

Lesser of

- $5 \times \text{ARR}$
- $\frac{(\text{Reg High} - \text{Reg Low})}{2}$

Generator “B”

$$\text{ARR} = 20 \frac{\text{MW}}{\text{minute}}$$

$$5 \times \text{ARR} = 5 \times 20 = \pm 100 \text{ MW}$$

$$\frac{(\text{Reg High} - \text{Reg Low})}{2} = \frac{(375 - 225)}{2} = \pm 75 \text{ MW}$$
Range Constrained - ATRR

Regulation Capacity

Lesser of

- \( 5 \times ARR \)
- \( \frac{(Reg\ High - Reg\ Low)}{2} \)

ATRR “A”

\[
ARR = 10 \ \text{MW/minute}
\]

\[
5 \times ARR = 5 \times 10 = \pm 50 \text{ MW}
\]

\[
\frac{(Reg\ High - Reg\ Low)}{2} = \frac{[2 - (-1)]}{2} = \pm 1.5 \text{ MW}
\]
Basic Features

• All resources must offer economically
  – i.e. self-scheduling for regulation is no longer allowed*
  – * except for the new Regulation test environment where resources will always be selected (if Participant declares available)
  – Resources in the regulation test environment must still submit availability information via eMarket

• Regulation test environment is
  – Short-term (i.e. weeks)
  – Until sufficient operational information has been collected to
    • Verify reasonable operating parameters
    • Or determine that resource does not meet eligibility for Regulation Market
Estimated Regulation Opportunity Cost Calculation

- Economic Level represents where a resource would have been generating if not providing Regulation Service
  - based on energy offer curve & forecast LMP; between EcoMin & EcoMax

- Estimated Actual Generation is an estimation of the actual generation while successfully providing Regulation Service.
  - based on energy offer curve & forecast LMP; between (RHL-Reg Cap), (RLL + Reg Cap)

- Estimated Opportunity Cost is the MW weighted average offer (minus forecasted LMP) associated with the MW between the economic level and Estimated Actual Generation.

Regulation Market Resource Selection

For the purposes of least-cost Resource selection, the following penalty factors are used for any violation of the Regulation requirements constraint:

• $100/MW plus the Energy Component of the Real-Time Locational Marginal Price at the reference point for each megawatt of Regulation Capacity shortfall

• $10/MW for each megawatt of Regulation Service shortfall

These penalty factors are used to allow the selection process to undershoot the requirements by a small amount, if meeting the requirements would be excessively costly.
Regulation Market Eligibility

Each Resource must...

• be completely electrically located within ISO-NE Control Area
• have a Control System capable of Regulation
• be able to receive AGC set point
• demonstrate minimum performance standards & exhibit satisfactory performance on dynamic evaluations
• adequately telemeter MW output to ISO-NE Control Center
• have a minimum ARR of 1MW/minute
• meet ISO-NE OP-14 and OP-18 standards
Regulation Market Eligibility (cont.)

Generating Resource must...

- Have a 10 MW minimum regulation capacity
- Utilize Unit-specific minimum range sized to assure feasible Regulation range

ATRR must...

- Have a 1MW minimum regulation capacity*
  *Aggregation of sub-resources is allowed
  - Select a dispatch methodology (CON, ENC, or ENT)
Regulation Market Resource Selection

A Resource may be omitted from providing Regulation due to operational restrictions, including, but not limited to:

• Binding transmission constraints
• Planned shutdown prior to the end of the settlement interval
• Known or anticipated system operating conditions
• Not dispatchable
Basic Features

• Regulation Clearing Price for Capacity (RCPc) is Real-Time, hourly values are computed from the average 5 minute samples

• Regulation Clearing Price for Service (RCPs) is Real-Time, hourly values are computed from the average of 5 minute samples

• No self-scheduled regulation
Basic Features

• Three Payments
  – Regulation Capacity Payment
  – Regulation Service Payment
  – Regulation Make Whole Payment

• Alternative Technology Regulation Pilot Program (a.k.a. the Pilot Program) is retired

[Link to the document]
Regulation Monitoring - Goals

Goals of the Regulation Performance Monitoring System (RegMon):

• Encourage offers with performance parameters that (over time) match observed performance characteristics

• Encourage offers with performance parameters that provide sufficient sustainability to achieve consistently high performance scores

• Avoid penalizing apparent performance deviations that result from normal resource characteristics that are understood, but not modeled in the Regulation (AGC) dispatch, such as:
  – Response delay time
  – Ramp rates that vary over the resource’s regulating range.
Regulation Monitoring - Goals

If observed performance closely matches AGC Setpoints (which are derived from offer parameters), Regulation Interval Performance Score will be 100%
Regulation Monitoring – Market Rule Guidance

• “The performance of a Resource providing Regulation will be monitored in Real-Time.” (Section III.14.7)
• Achieved by comparing actual Regulation MW to the AGC signal in a systematic manner
• If a resource movement is inconsistent with the AGC Setpoint, it will not get credit for the rest of the hour (Section III.14.7)
• Specific guidance on measurement process includes:
  – Tolerance band(s) based on offered Automatic Response Rate and Regulation Capacity
  – Grace periods to allow reasonable time lags
  – ARR: allow uncertainty up to +/- 20% of offered ARR
  – Regulation Capacity: allow uncertainty up to +/- 15% of the calculated Regulation Capacity.
• Two different Parameter sets are used in order to more accurately track the performance of resources following the two types of dispatch methodologies
  • One for Conventionally dispatched resources
  • One for Energy Neutral Dispatched resources
• Two parameter sets are required due to fundamental differences in the nature of the Conventional and Energy Neutral AGC setpoints
• Otherwise the performance monitoring of the resources following these two different dispatch methodologies is exactly the same.
Regulation Monitoring – Implementation

• RegMon conducts on-line performance monitoring of regulating resources
  – It runs continuously and calculates scores every hour using that hour’s measurements plus a few minutes of measurements before (for initialization)
  – It scores the performance of each resource’s actual tracking of the AGC setpoint for every instant that the resource was assigned to perform regulation (i.e. Unit Control Mode 6)
  – It scores all resources providing regulation during the hour

• Using a single algorithm/software solution that implements the Market Rule requirements, the ISO can support an accurate, transparent RIPS

• The RIPS adjusts compensation for the regulation settlement period (an hour) in proportion to the score
Four continuously-updated performance envelopes for each regulating resource

• NSE (shown here)
• WSE (shown here)
• NFE
• WFE
Performance Envelopes

Actual output inside the NSE receives an instantaneous score of 100%
Performance Envelopes

Actual output outside the NSE but within the WSE receives a pro-rated score between WBS and 100%
Actual output that touches the edge of the WSE will receive an instantaneous score equal to the WBS.
Performance Envelopes

Actual output outside the WSE will receive an instantaneous score of 0%
Regulation Monitoring – method overview

Sample of AGC Performance Monitoring

For example:

2 minutes
Regulation Monitoring – Two exceptions

• Acceptable Overshoot
  – AGC Setpoint is at or above (less than) the high regulating limit (low regulating limit) and the resource’s output is at or above (less than) high regulating limit (low regulating limit)
  – Acceptable Overshoot gets a 100%
  – Acceptable Overshoot will not override failure

• UCM6 grace period
  – First few minutes a resource is in UCM6 will not count towards failure, provided that it has been OFF UCM6 for extended duration e.g. at least an hour.
Regulation Monitoring – Finalizing Scores

- Except during acceptable overshoot, output outside the wide scoring envelope will get a 0 score for that AGC cycle.
- Regulation Interval Performance Score (RIPS) = arithmetic average of the instantaneous scores of all time intervals on UCM 6 within the regulation settlement interval
- RIPS will linearly scale both:
  - total requested movement (mileage): service payment calculated in Settlements
  - also the integrated regulation capacity: capacity payment calculated in Settlements
Regulation Monitoring – developing parameters

• ISO is finalizing the parameters that control the performance and failure envelopes and times

• Appropriate parameters for the Regulation Performance Monitor will be
  – Developed using historical data
  – Guided by the overarching goal of
    • creating a performance monitoring system that reflects real world resource response
    • while still having the kind of regulation performance that we need for system reliability.

• The parameters will not be resource specific – they will apply to the entire fleet of regulation resources that choose to participate in the regulation market.

• Two different Parameter sets are used in order to more accurately track the performance of resources following the two types of dispatch methodologies
  – One for Conventionally dispatched resources
  – One for Energy Neutral Dispatched resources

• Two parameter sets are required due to fundamental differences in the nature of the Conventional and Energy Neutral AGC setpoints

• Otherwise the performance monitoring of the resources following these two different dispatch methodologies are exactly the same.
Regulation Monitoring – developing parameters

• These parameters may change over time as the needs and characteristics of the system evolve – advance notice will be provided

• The parameters used in the illustrative examples to follow are initial estimates

• The parameters will be announced before the 755 Regulation Market upgrade is implemented.

• Will be posted at:
  http://www.iso-ne.com/isoexpress/web/reports/operations/-/tree/daily-regulation-requirement
Regulation Monitoring – Figure 1

Sample of AGC Performance Monitoring

Score for the interval is: 96.7
Sample of AGC Performance Monitoring

AGC Setpoint
Actual Output
UCM6
Narrow Scoring Envelope
Wide Scoring Envelope
Narrow Failure Envelope
Wide Failure Envelope

Score for the interval is: 96.7

Instantaneous Score
Cumulative Score

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 3

Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Score for the interval is: 98.7

Instantaneous Score
Cumulative Score

Sample Number [900 4-second samples in an hour]
Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Reg High

MW

Score for the interval is: 96.7

Sample Number [900 4-second samples in an hour]
Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Score for the interval is: 96.7

Instantaneous Score vs Cumulative Score

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 6

Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Score for the interval is: 96.7

Sample Number [900 4-second samples in an hour]
Sample of AGC Performance Monitoring

Regulation Monitoring – Figure 7

Score for the interval is: 96.7
Regulation Monitoring – Figure 8

Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Midpoint

Reg Low

Score for the interval is: 0.8
Sample of AGC Performance Monitoring

Midpoint

Reg Low

Score for the interval is: 96.7

Instantaneous Score
Cumulative Score

AGC Setpoint
Actual Output
UCM6
Narrow Scoring Envelope
Wide Scoring Envelope
Narrow Failure Envelope
Wide Failure Envelope

Score

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 10

Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Midpoint

MW

Reg Low

Score

Sample Number [300 4-second samples in an hour]
Regulation Monitoring – Figure 10

Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Score for the interval is: 96.7
Sample of AGC Performance Monitoring

Score for the interval is: 96.6

Score

Sample Number [900 4-second samples in an hour]
Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Score for the interval is: 96.7
Midpoint Sample of AGC Performance Monitoring

Midpoint

Reg Low

Score for the interval is: 0.6

Sample Number [900 4-second samples in an hour]

Score

Instantaneous Score
Cumulative Score
Regulation Monitoring – Figure 14

Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Score for the interval is: 96.6

Score

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 15

Sample of AGC Performance Monitoring

- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Midpoint
Reg Low

Score for the interval is: 96.8

Instantaneous Score
Cumulative Score

Sample Number [900 4-second samples in an hour]
Sample of AGC Performance Monitoring

Score for the interval is: 96.7

Sample Number [900 4-second samples in an hour]

Instantaneous Score
Cumulative Score
Sample of AGC Performance Monitoring

RegLow

Score for the interval is: 96.7

Score

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 18

Sample of AGC Performance Monitoring

Score for the interval is: 96.7

Instantaneous Score
Cumulative Score

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 19 (Envelope Creation)

Sample of AGC Performance Monitoring

Score for the interval is: 96.7

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 20 (Envelope Creation)

Sample of AGC Performance Monitoring

Score for the interval is: 96.7

Instantaneous Score
Cumulative Score

Sample Number [900 4-second samples in an hour]
Regulation Monitoring – Figure 21 (Envelope Creation)
Example for ENT
Example for ENC
Course Objectives

• Provide an overview of the key concepts and the basic features of the Regulation Market

• Explain the basics of Regulation

• Explain recent changes to the Regulation Market with specific emphasis on:
  – The new Energy Neutral Regulation Signal
  – The selection process of Regulating Resources
  – Monitoring of the performance of Regulating Resources

Intended audience: Regulation Market participants and those considering participation in the Regulation Market
Customer Support

• **Ask ISO**
  – Self-service interface for submitting inquiries
  – Accessible through the SMD Applications Homepage
  – Requires a valid digital certificate with the role of Ask ISO/External User
  – Contact your security administrator for assistance

• Phone: (413) 540-4220
  – Monday through Friday, 8:00 A.M. to 5:00 P.M. Eastern Time
  – Recorded/monitored conversations

• Email: custserv@iso-ne.com

• Pager: (877) 226-4814
  • Outside of the regular business hours, Customer support can be reached for emergency inquiries by pager