Regulation Services through Automatic Generation Control

Revised June, 2026

Introduction

The purpose of this Quick Take is to provide Market Participants (MPs) with a clear, accessible explanation of how regulation services function within the IESO-controlled grid and the IESO-administered electricity market. This Quick Take focuses on three foundational questions:

1. **What is Regulation Service?**
This section introduces the concept of regulation service as a real-time operational tool that helps maintain the balance between electricity supply and demand. It explains how regulation differs from other ancillary services and how it supports system frequency and reliability on a second-to-second basis.

2. **Why does the IESO need regulation services?**
This section describes the operational need for regulation within Ontario's power system. It explains why supply and demand must remain in constant balance, how deviations affect system frequency, and why the IESO relies on regulation capable resources to continually correct Area Control Error (ACE) and maintain system reliability.

3. **How do resources provide regulation services?**
This section outlines how individual resources participate in regulation, covering concepts such as real-time energy schedules, regulation basepoints, headroom and foot room requirements, regulation setpoint instructions, and how a resource's physical capabilities determine how it follows Automatic Generation Control (AGC) signals. Examples and figures illustrate how resources move up and down around their basepoint to meet the scheduled regulation range.

The aim of this document is to **educate potential and existing MPs** on how regulation service works in practice, what is expected of a resource providing the service, and how the IESO's tools interact with a facility's operational characteristics. By understanding these principles, MPs will be better equipped to assess their resource's capability to provide regulation, understand IESO requirements, and effectively and confidently provide the service.

What is Regulation Service?

Regulation service is an ancillary service that the IESO currently contracts to help ensure the reliable operation of the power system. Regulation services provide balancing on a granularity as low as every 4-seconds, within a 5-minute dispatch interval, to ensure electricity supply matches demand.

Regulation is currently provided by generation facilities with automatic generation control capability, which permits them to vary their output to deviate either up or down from their economic dispatch instruction within the 5-minute dispatch interval, in response to a separate regulation signal sent through telemetry by the IESO in the form of a regulation setpoint.

Why does the IESO need Regulation Services?

Real-time changes in supply and demand cannot be predicted exactly, which results in system imbalances that occur on a second-by-second basis within 5-minute dispatch intervals.

Supply and demand balance must be maintained within strict tolerances to keep system frequency as close as possible to 60 Hz. If the system deviates from 60 Hz by a large amount or for prolonged periods, it can lead to system instability and potentially local or widespread blackouts. When Ontario's system is not balanced, it affects neighbouring jurisdictions and the Eastern Interconnection as a whole. Over-generation results in more actual energy flowing across interties than scheduled, while under-generation results in less.

As a Balancing Authority, the IESO uses Area Control Error (ACE) as a metric to measure how well the Ontario system is balanced in real-time. ACE indicates whether the right amount of power is being generated to meet Ontario demand while supporting scheduled net-intertie flows and frequency in the Eastern Interconnection. A positive ACE indicates over generation, and a negative ACE indicates under generation. Maintaining ACE within acceptable bounds, and keeping it as close to zero as possible, is essential for reliable operations.

To help maintain this supply-demand balance, the IESO schedules regulation as required by the market rules, and to maintain the IESO's compliance with the North American Electric Reliability Corporation (NERC) standard, BAL-001-2

How do resources provide regulation services?

The IESO uses a built-in function within the IESO's Energy Management System (EMS) system to send Automatic Generation Control (AGC) signals, through telemetry in the form or setpoints, that constantly requests to make small adjustments to how much power resources providing regulation services produce. Think of AGC as the power system's control system requesting resources providing regulation service to increase or decrease power output within the dispatch interval to keep everything balanced.

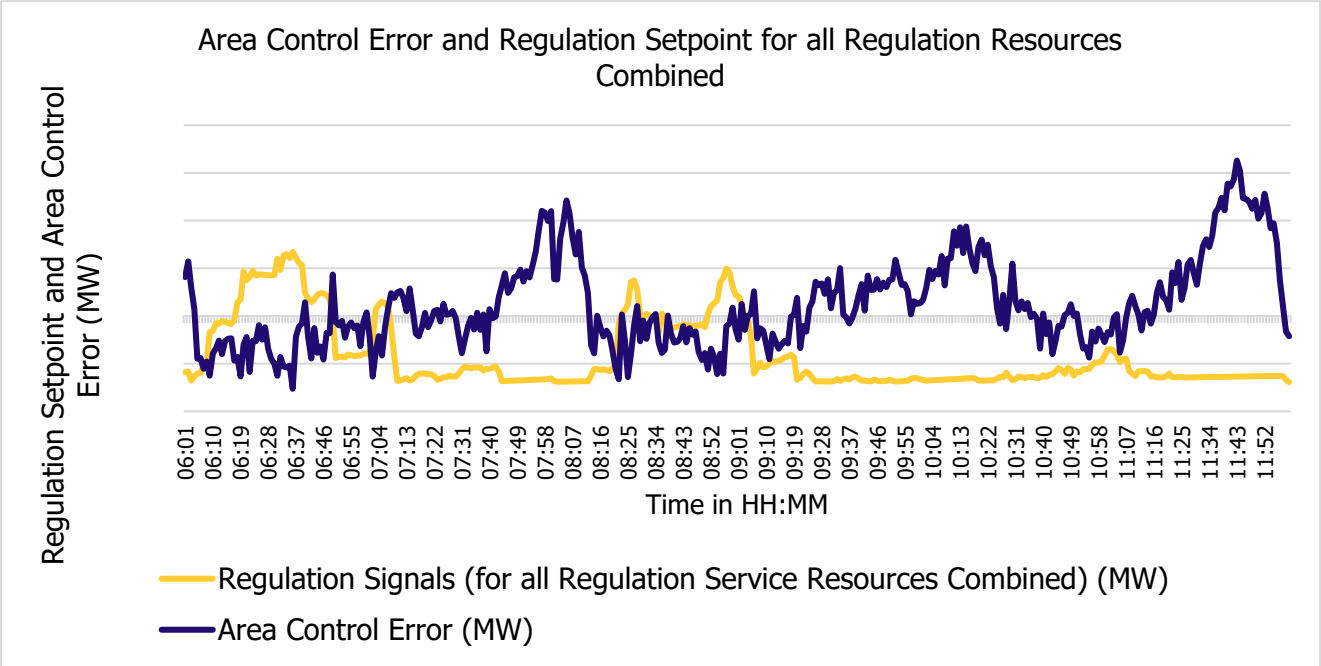
The AGC function checks the system every couple of seconds (AGC gets inputs every two seconds, but only recalculates and sends setpoints every four seconds). It looks at real-time telemetry measuring

system frequency and actual power flows into and out of Ontario, which is then used to update the instructions it sends to resources providing regulation services.

Because the grid naturally has a lot of small, quick fluctuations, the AGC function smooths out signals to mitigate excessive cycling of regulation resources that are driven by small temporary fluctuations in supply and demand.

In **Figure 1** below, ACE as well as the total regulation setpoint signals for resources providing regulation for a 6-hour period are shown. As shown in the figure, when ACE is below 0 MW, resources are requested to generate more than their real-time energy schedules (i.e., regulation setpoints are above the energy schedule), and when ACE is above 0 MW, resources are requested to generate less than their real-time energy schedules (i.e., when regulation setpoints are below the energy schedule).

Figure 1 | Area Control Error and Regulation Setpoint for all Regulation Resources Combined



How does the resource respond to setpoint?

Figure 2 shows how a resource's real-time energy schedule (economic dispatch) and its regulation setpoint interact over time as the IESO's AGC responds to changes in system conditions.

In this example, the resource is providing 20 MW of regulation, up or down from its real-time energy schedule. This means that the regulation setpoints can be 20 MW higher, or 20 MW lower, than the real-time energy schedule (i.e. a 40 MW regulation range). The resource's ramp rate is 40MW/min, and the regulation setpoints as shown in this example do not exceed the resource's ramp rate. The red line line represents the real-time energy schedule (which is called the basepoint) assigned to the resource. This is the level around which the resource must be able to move up or down in order to provide regulation service.

The blue line shows the regulation setpoint, which is the output level AGC is actively requesting from the resource every few seconds. Because AGC responds to ACE, the setpoint moves above or below the real-time energy schedule depending on whether the system needs the resource to produce more or less energy relative to the real-time economic schedule to help balance supply and demand.

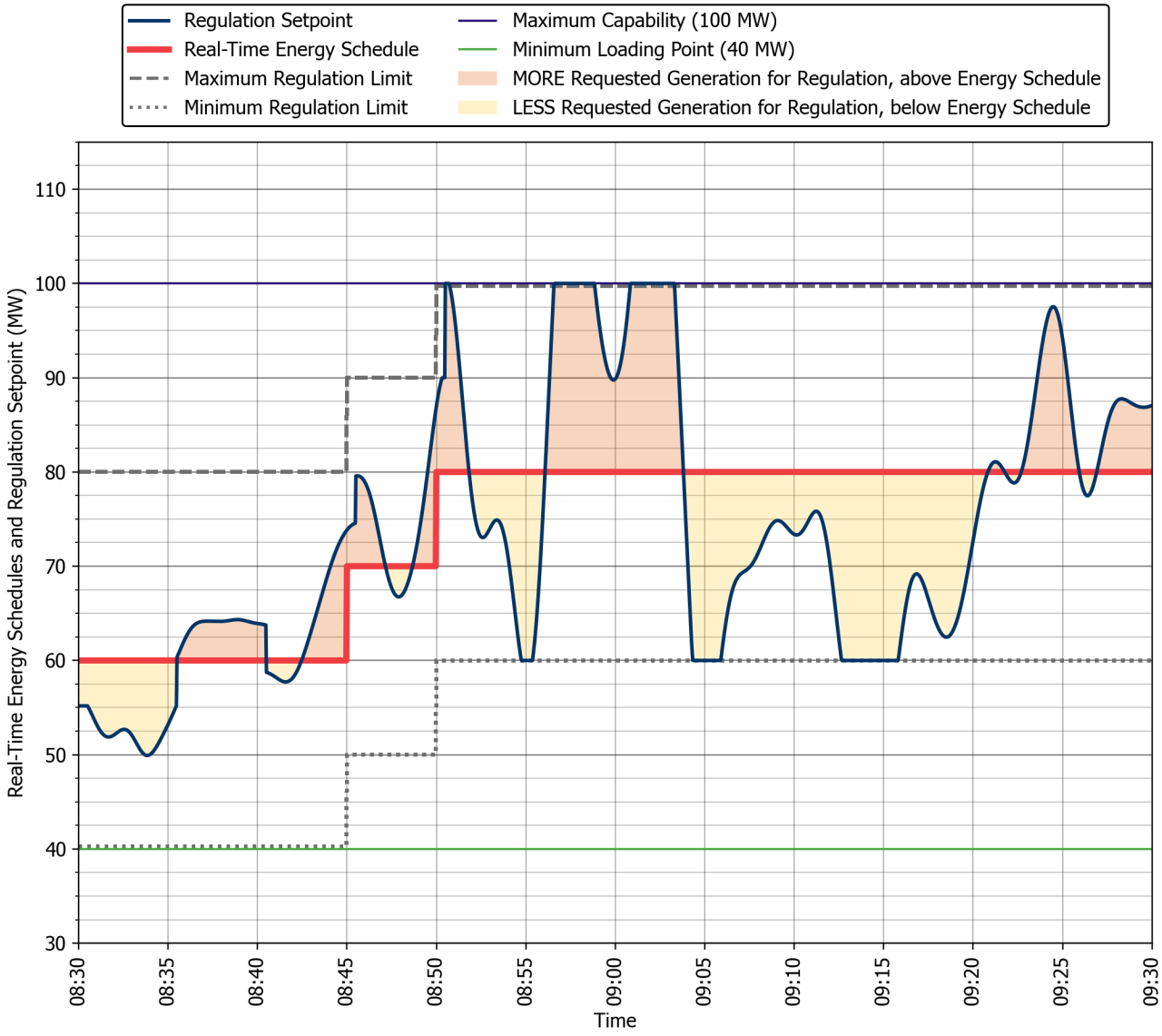
- When ACE is negative (meaning, the system needs more generation), the AGC setpoint rises above the basepoint, signaling the resource to increase its output.
- When ACE is positive (meaning, the system has too much generation), the AGC setpoint moves below the basepoint to reduce output.

The orange and yellow shaded areas in the figure highlight these moments:

- Orange shows times when the resource is asked to generate more than its economic dispatch (up regulation).
- Yellow shows times when it is asked to generate less than its economic dispatch (down regulation).

The regulation setpoint for an individual resource represents that resource's assigned share of the total regulation signal dispatched across all regulation service providers (the yellow line in **Figure 1**).

Figure 2 | Example of how a resource providing regulation services responds to setpoints



In **Figure 2**, there is a period where the real-time energy schedule increases. This illustrates that the IESO may still dispatch the resource up or down in the regular 5-minute dispatch cycle based on changing system conditions. When this happens, the regulation setpoint is automatically adjusted to reflect the required output based on the dispatch and AGC then moves the resource's output up or down around this new basepoint to supply the required amount of regulation service. As the resource follows the regulation setpoint, its actual changes in output help correct the system's ACE. This ongoing feedback pulls ACE toward zero, bringing system frequency and supply/demand balance back into alignment. This is why, in practice, the setpoint constantly moves up and down relative to the real-time energy schedule throughout the figure.

When the regulation service is scheduled on the resource level, the AGC basepoint is equal to that resource's own real-time energy schedule. The basepoint must be positioned so that the resource has enough "headroom" (ability to go up) and "footroom" (ability to go down) to deliver the required regulation range.

For example, if the resource needs to provide ±20 MW of regulation and the minimum loading point (MLP) is 40 MW and the resource is economic for 40 MW, the real-time energy schedule is adjusted so the basepoint will not be lower than 60 MW. This gives AGC 20 MW of room upward (to 80 MW) and 20 MW of room downward (to 40 MW), as the resource can't be operated below 40 MW.

Similarly, when the resource is operating closer to its maximum capability (for example, 100 MW), and the resource is economic for 100 MW, the real-time energy schedule is adjusted downward (to 80 MW). This gives AGC 20 MW of room upward (100 MW) and 20 MW of room downward (to 60 MW), as the resource can't be operated above 100 MW.

In both cases, the basepoint is set in a way that guarantees the resource can deliver the full scheduled regulation range.

A battery storage system can provide regulation services in the same way a generator does, as described in the example above. When a battery is discharging (generating), regulation service is delivered as in the generator example above. When a battery is charging, and AGC requests more generation, it reduces the charging level by the requested amount and when AGC requests less generation, it increases the charging level by the requested amount. Batteries can also provide regulation as only a portion of their total capacity (e.g. 10 MW), which will require only small, controlled adjustments from AGC when the resource is either generating or consuming. These small changes use only a narrow band of state of charge, and because batteries can ramp almost instantaneously and follow setpoints with high precision, they are very effective providers of regulation services.

Additional Resources

Training Materials are available on the IESO Marketplace Training web page:

- Work Book: Introduction to Ontario's Physical Markets
- Guide: Communicating with the IESO: Dispatchable Loads
- Quick Take: Requirements for Facilities to Provide Regulation Service

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