Technical Specification: Automatic Generation Control, SCADA Dispatch Instructions, and Fast Start Facility Operational Behaviour

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Version Release History

Version	Effective Date	Summary of Changes
1.0	September 2018	Initial release, titled: "ABC and AGC Interface Requirements".
2.0	October 2022	Updates to prepare for WEM Reform, including title change to "Technical Specification: Automatic Generation Control, SCADA Dispatch Instructions, and Fast Start Facility Operational Behaviour."
3.0	July 2024	Updates to information on Relevant Setpoints and Indications for AGC Participation, AEMO Linear Ramping: Semi-Scheduled Facility, Desired Ramp Rate setpoints, AGC Control Deadband, Communications Failure, Self-Starting Facilities, Facility Look-Ahead signals, Fast Start Facility signals, Linear ramping and Frequency Response, Testing and Commissioning.

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Contents

Tables

Figures

1. Introduction

1.1. Purpose and scope

1.1.1. The *Electricity Industry Act 2004*, the WEM Regulations, the WEM Rules and the WEM Procedures prevail over this document to the extent of any inconsistency.

1.1.2. The purpose of this document is to outline the technical requirements necessary for a Registered Facility to operate under Automatic Generation Control (AGC).

1.1.3. AGC operation encompasses dispatch of Energy, or Energy and Essential System Services together.

1.1.4. Facilities not operating under AGC may be required to acknowledge any Dispatch Instructions issued by AEMO via alternate mechanisms as set out in the WEM Procedure: Facility Dispatch Process.

1.1.5. Any technical requirements specified in this document are in addition to any other requirements by either AEMO or the respective Network Operator as part of connecting the Facility to the South West Integrated System (SWIS).

1.2. Definitions

1.2.1. Terms defined in the *Electricity Industry Act 2004*, the WEM Regulations and the WEM Rules have the same meanings in this document unless the context requires otherwise.

1.2.2. The following definitions apply in this document unless the context requires otherwise.

Table 1 Definitions

Term	Definition
ACE Assist Region	A range of ACE within which AEMO uses Registered Facilities cleared to provide Regulation and/or Contingency Reserve to correct SWIS Frequency, in addition to any droop response.
ACE Normal Region	A range of ACE within which AEMO only uses Registered Facilities cleared to provide Regulation to correct SWIS Frequency, in addition to any droop response.
AEMO Linear Ramping	The process of AEMO setting progressive setpoints via AGC to achieve a linear ramping profile as described in paragraph 3.1 of this document.
AGC Control Availability Status	A SCADA point from a Registered Facility indicating if it is available for AGC control.
AGC Control Mode	One of the AGC control modes as per Appendix A of this document.
Area Control Error (ACE)	The accumulated control error, in megawatts, for frequency in the AGC system's control model.
Basepoint	The SCADA point that indicates what the Registered Facility's Injection or Withdrawal would be if it was dispatched for energy, without any enablement for Regulation or Contingency Reserve. This setpoint will be ramped through the interval if the Facility is participating in AGC Linear Ramping.
Calculated Linear Ramp Rate - WEMDE	The resulting assumed Linear Ramp Rate for a Registered Facility in a Dispatch Interval, which is calculated as: $\frac{Dispatch\ Target - Initial\ MW}{5}$
Contingency Reserve	The Contingency Reserve Raise and/or Contingency Reserve Lower Essential System Services.

Term	Definition
Desired MW Setpoint	The SCADA point that indicates the real-time target that AEMO is instructing the Registered Facility to move to, subject to any ramp rate restrictions or requirements. This setpoint can be issued at a maximum of every 4 seconds.
Dispatch Cap MW Setpoint	The SCADA point that indicates the Dispatch Target for the current Dispatch Interval to the Semi-Scheduled Facility.
Dispatch Target MW Setpoint	The SCADA point that indicates the Dispatch Target for the current Dispatch Interval to the Registered Facility.
Dispatch Target Ramp Rate Setpoint	The optional SCADA point that indicates the expected linear ramp rate, as calculated by WEMDE, from the Injection or Withdrawal quantity at the start of the Dispatch Interval to the current Dispatch Target.
Distributed Control System (DCS)	The Registered Facility's control system that receives, enacts, and responds to signals sent from AEMO via the Network Operator's SCADA system.
Energy Management System (EMS)	As defined in the WEM Procedure: Communications and Control Systems, which at the time of this document was published read: "A system used to monitor and control elements of the SWIS in real time."
Facility Deadband	The AGC deadband provided by the Registered Facility to AEMO. AEMO will not issue updates to a Registered Facility's Desired MW Setpoint that is within this deadband relative to the last issued value.
Facility Lag	The time in seconds that it takes between a Registered Facility receiving an update to its Desired MW Setpoint and the Registered Facility beginning to respond to this update.
Initial MW	The level of Injection (positive) or Withdrawal (negative) that the Registered Facility begins a given Dispatch Interval at, as estimated by AEMO as a snapshot of the actual Injection or Withdrawal just prior to the commencement of the Dispatch Interval.
Minimum Basepoint Delta	The minimum change in MW required to result in a change to the internal Basepoint value within AEMO's AGC system for the Registered Facility. This is linked to Facility Deadband provided to AEMO by the Facility.
Primary Dispatch Interval	The first Dispatch Interval in a Dispatch Schedule, which is used to determine operative Dispatch Instructions and Market Clearing Prices.
Regulation	The Regulation Raise and/or Regulation Lower Essential System Services.
Supervisory Control and Data Acquisition (SCADA)	As defined in the WEM Procedure: Communications and Control Systems, which at the time this document was published read: "Supervisory Control and Data Acquisition (SCADA) is a system that is used to monitor and control field device(s) at remote locations."

1.3. Interpretation

1.3.1. The following principles of interpretation apply in this document unless the context requires otherwise.

(a) Clauses 1.3 to 1.5 of the WEM Rules apply in this document.

(b) References to time are references to Australian Western Standard Time.

(c) Terms that are capitalised, but not defined in this document, have the meaning given in the WEM Rules.

(d) A reference to the WEM Rules or WEM Procedures includes any associated forms required or contemplated by the WEM Rules or WEM Procedures.

(e) Words expressed in the singular include the plural and vice versa.

(f) A reference to a section refers to a section of this document.

(g) A reference to a clause refers to a clause or section of the WEM Rules.

(h) The body of this document prevails to the extent of any inconsistency with the figures, diagrams, appendices, schedules, annexures or attachments contained within this document.

1.4. Related documents

1.4.1. The documents in Table 2 are associated with this document.

Table 2 Related documents

Reference	Title	Location
Technical Specification	Operational Data Points for Registered Facilities	WEM Website
WEM Procedure	Communications and Control Systems	WEM Website
WEM Procedure	Dispatch Algorithm Formulation	WEM Website
WEM Procedure	Frequency Co-optimised Essential System Services Accreditation	WEM Website
WEM Procedure	Facility Dispatch Process	WEM Website

2. Background

AEMO's SCADA system provides various options for the communication of Dispatch Instructions to Market Participants depending on what services Registered Facilities are providing.

Dispatch Targets or Dispatch Caps can be issued to Market Participants via SCADA setpoints along with other market data to support local alerting or automation. Facilities can also be linearly ramped via AEMO's SCADA system in order to meet linear ramping requirements.

AEMO's AGC system is a module of AEMO's EMS. AGC is defined as the system into which Dispatch Targets or Dispatch Caps are entered and processed by AEMO for Registered Facilities operating on automatic generation control. AGC provides closed-loop control of SWIS Frequency for participating Registered Facilities. AGC is essential for maintaining SWIS Frequency close to the nominal frequency of 50 Hz. It achieves this by:

- issuing commands to Registered Facilities enabled for Regulation Raise and/or Regulation Lower services to vary their Injection or Withdrawal in response to changes in ACE when it is within the ACE Normal Region; and
- additionally issuing commands to Registered Facilities enabled for Contingency Reserve Raise and/or Contingency Reserve Lower to vary their Injection or Withdrawal in response to changes in ACE when it is in the ACE Assist Region or beyond.

Additionally, AGC can be used to implement the commands to linearly ramp a Registered Facility between their Initial MW quantities, and their end of Dispatch Interval Dispatch Targets. This functionality can be combined to work concurrently with Regulation and Contingency Reserve provision to achieve an overall desired MW command signal to the Registered Facility.

The requirements for SCADA and AGC control are listed in the WEM Procedure: Communications and Control Systems In general:

- Registered Facilities wishing to provide Regulation or Contingency Reserve1 must be configured for AGC Control. AEMO will ramp the Registered Facility for energy via its AGC system.
- Registered Facilities not providing Regulation or Contingency Reserve must still be linearly ramped. Market Participants may either choose to have AEMO do this for them via AGC, or may implement their own linear ramping as per the options in section 3.2 of this Technical Specification.

Details of the required SCADA points for Registered Facilities can be found in the Technical Specification: Operational Data Points for Registered Facilities, available on the WEM Website.

[1] Unless exempted by AEMO from participating in AGC while delivering Contingency Reserve as part of their accreditation for the service.

3. AGC Control and Linear Ramping

This section details the various forms of SCADA-telemetered Dispatch Instruction and AGC participation, and the expected response from Registered Facilities.

3.1. Relevant Setpoints and Indications for AGC Participation

Appendix C of AEMO's Technical Specification: Operational Data Points for Registered Facilities documents the list of required SCADA points, and details as to their functionality.

AEMO's AGC system allows for a Facility Deadband to be configured such that a minimum MW change is required before a "Facility Desired MW" setpoint is issued. Additionally, AEMO's AGC system requires parameters to be configured to reflect Facility Lag. AEMO will work with Registered Facilities to calibrate the relevant deadbands and other configurations for linear ramping based on the characteristics of the Facility's response to setpoint changes as part of the SCADA commissioning process.

AEMO also uses SCADA-telemetered limits in its AGC system to prevent sending a "Facility Desired MW" setpoint outside of the real-time capability of a Facility. The following telemetered limits are used in AGC where provided by Market Participants:

- "Facility Max Operating Limit" - represents the maximum sent-out MW capability that the Facility can achieve, and should be dynamic, taking into account factors such as temperature or any local or manual limits in the Facility's control system.
- "Facility Min Operating Limit" - represents the minimum sent-out MW capability that the Facility can be dispatched to via AGC.

These limits must be set such that they do not prevent AGC from ramping the Facility to its Dispatch Target when physically capable of doing so. For example, when a Facility is off-line its instantaneous maximum capability is typically zero, however during Facility start-up if AGC control is enabled and the Facility Max Operating Limit remains at zero, AGC will not be able to control the Facility to its Dispatch Target. When under AGC control it is important that these limits be set based on the physical capability of the Facility in that Dispatch Interval.

- "Facility Max Ramp Rate Up"[2] – in MW/min, used to determine the most that can be dispatched up by the Facility in a Dispatch Interval (taking into account the current output of the Facility and the Facility Max Operating Limit). Note that this is not necessarily the "active" ramp rate that the Facility is using (see below).
- "Facility Max Ramp Rate Down" – in MW/min, used to determine the most that can be dispatched down by the Facility in a Dispatch Interval (taking into account the current output of the Facility and the Facility Min Operating Limit). Note that this is not necessarily the "active" ramp rate that the Facility is using (see below).

[2] Note that a single bi-directional maximum ramp rate may also be provided

AEMO's Dispatch Engine uses these limits to determine how much a Facility can be ramped during a Dispatch Interval. Therefore, even when a Facility is not being actively ramped by AGC, it is important that these limits be set such that they allow the Facility to be dispatched based on its physical capability.

For example, if during a start-up sequence a Facility would ramp at a higher rate than normal to reach its minimum dispatch level – the Facility Max Ramp Rate Up limit must be set to reflect this otherwise the Dispatch Engine may set a Dispatch Target that is below the Facility's minimum dispatch level.

- "Facility Ramp Rate In Use" – in MW/min, represents the "active" ramp rate that is being used by the Facility. It should reflect any manual ramp rate limits that have been applied in the Facility's local control system.

This limit is used by AGC to determine how much it will be able to respond to a frequency event when actively providing an Essential System Service. It is important that this value be set correctly to avoid AGC from over/under controlling other Facilities during a frequency event.3

3.2. Linear Ramping

3.2.1. General

Where Market Participants are providing Frequency Co-optimised Essential System Services (FCESS), AEMO will linearly ramp Registered Facilities via its AGC system (unless otherwise agreed with AEMO for some Contingency Reserve service arrangements). When not providing FCESS, Market Participants may choose for AEMO to linearly ramp Registered Facilities or may linearly ramp the Registered Facilities themselves.

If Market Participants elect for AEMO to linearly ramp their Facilities, the method for linear ramping depends on the type of Facility, as described in section 3.2.2 and section 3.2.3. Market Participants are still required to self-ramp Facilities that are normally linearly ramped by AEMO when the Facility is under local control (e.g. as a result of a SCADA communications failure, during testing or following maintenance activities).

AEMO may also send additional SCADA signals to Market Participants, where requested, to assist them in self-ramping as described in section 3.2.4. These additional signals can also used by Facilities that are participating in AEMO linear ramping to self-ramp in situations when AGC is not available (e.g. communications failure, or during commissioning/testing).

3.2.2. AEMO Linear Ramping: Scheduled Facility with AGC control

Linear ramping involves AEMO sending regular updates to the "Facility Desired MW" setpoint which reflects the expected linear ramping profile of the Facility between its Initial MW[4], and its effective Dispatch Target.

[3] Note that when providing Regulation services Facilities should typically be operating at their maximum ramp rate.

[4] Initial MW is a snapshot taken by AEMO's Dispatch Engine typically several seconds prior to the start of the Dispatch Interval. The exact Initial MW used for any Dispatch Interval can be found int the Solution File data published on AEMO's Market Data website.

It is important to understand that AEMO's AGC system does not use the "Facility Max Ramp Rate Up" and "Facility Max Ramp Rate Down" to limit the "Facility Desired MW" setpoint. These are used to determine the maximum change in a Dispatch Interval that can be achieved, and it is expected that the Facility manages the ramping of its Facility based on its normal active ramp rate ("Facility Ramp Rate In Use"). An example of AEMO Linear Ramping is shown in Appendix C.

In addition, if the "Dispatch Target Ramp Rate" signal is being sent to the Facility to support self-ramping (see section 3.2.4), it is important that this is not used to set the active ramp rate of the Facility when it is actively being linearly ramped by AGC. AEMO will not actively adjust the "Desired Ramp Rate" setpoint when in this mode (if that point is commissioned). Registered Facilities operating under AGC linear ramping should follow their nominated ramp rates, or the "Desired Ramp Rate" setpoint if configured, when following their "Facility Desired MW" setpoint, unless directed otherwise by AEMO (see section 3.4).

A Registered Facility participating in Regulation must participate in AEMO Linear Ramping, as during Regulation provision, any changes in "Facility Desired MW" setpoint combines the effects of any changes to the Dispatch Target with the required Regulation movements based on system frequency changes.

A Registered Facility participating in Contingency Reserve services must participate in AEMO linear ramping except where exempted from AGC participation as part of its accreditation for these services.

3.2.3. AEMO Linear Ramping: Semi-Scheduled Facility

A Semi-Scheduled Facility (SSF) participating in linear ramping will be ramped when it is either curtailed or released as a result of changes to its Dispatch Cap. A SSF which is being curtailed to a lower Injection level will be ramped down to the new Dispatch Cap from its current Injection level. A SSF being released will be ramped to its new Dispatch Cap, noting that this may be a value greater than the Unconstrained Injection Forecast of the SSF, or less than the Unconstrained Withdrawal Forecast, depending on whether the SSF is Injecting or Withdrawing.

SSFs are not typically configured via AEMO's AGC system, and so AEMO implements linear ramping for these Registered Facilities via another module of its SCADA system. This is achieved by sending updates to its "Desired MW" setpoint and "Desired Ramp Rate" setpoint reflecting the Dispatch Cap and Dispatch Target Ramp Rate for the Dispatch Interval.

When ramping from one constrained level to another (i.e. not unconstrained), SSFs must ramp at the rate reflected in the "Desired Ramp Rate" setpoint. Once the SSF has reached the new Dispatch Cap, or the Dispatch Cap is above the available sent-out capacity of the SSF (i.e. can no longer be controlled), the SSF may return to an unconstrained ramp rate – but must still remain operating below the active Dispatch Cap and within relevant dispatch tolerances.

SSFs may calculate their own linear ramp rates to follow when being actively dispatched, however must remain within relevant dispatch tolerances.

Where an SSF does not have a "Desired Ramp Rate" setpoint, AEMO may agree to linearly ramp the Facility via periodic adjustment of the "Desired MW" setpoint, reflecting the expected linear ramping profile of the Facility between its Initial MW and its effective Dispatch Forecast (similar to AGC-based linear ramping).

An SSF can also choose to self-ramp using a "Dispatch Target MW" setpoint and "Dispatch Target Ramp Rate" as per section 3.2.4.

An SSF must participate in linear ramping when providing Regulation (via AEMO's AGC system as per section 3.2.2).

3.2.4. Self-Ramping

Where a Registered Facility is not participating in AEMO linear ramping (including when AGC is not available), it is required to manage its Injection or Withdrawal so as to achieve a linear ramp profile, and to meet their effective Dispatch Target by the end of the current Dispatch Interval.

To support this AEMO can issue two signals to Market Participants:

- "Dispatch Target MW" (or Dispatch Cap MW) – the current required Dispatch Target (or Dispatch Cap); and
- "Dispatch Target Ramp Rate" – the required linear ramp rate, as calculated by AEMO based on the Initial MW of the Facility.

Market Participants may use these signals to either automate linear ramping or to provide the indications to support manual ramping of the Facility.

Market Participants must take note however that during a communications failure event, these signals may also be stale.

3.3. Dispatch Caps

An SSF receives a Dispatch Cap in place of a Dispatch Target (except when participating in FCESS provision). The value of the Dispatch Cap will be set to a suitable value to prevent restriction of Injection or Withdrawal unless required by dispatch outcomes.

- "Facility Dispatch Injection Cap MW" – a non-negative setpoint that indicates a limitation in the quantity of Injection (i.e. inject no more than that quantity).
- "Facility Dispatch Withdrawal Cap MW" – a negative setpoint that indicates a limitation in the quantity of Withdrawal (i.e. withdraw no more than the absolute value of that quantity).

3.4. Desired Ramp Rate setpoints

The Desired Ramp Rate setpoint is used by AEMO to "cap" the ramp rate of a Facility. It is not used as part of the normal AEMO linear dispatch process and would typically only be used under abnormal operating conditions, or to limit extreme ramping of very fast moving Facilities in order to mitigate impacts to power system frequency.

Under normal operating conditions AEMO will set the Desired Ramp Rate setpoint to match the normal operating ramp rate of the Facility. It is expected that this is the normal ramp rate that the Facility would use during linear ramping (and would be reflected in the "Facility Ramp Rate In Use"). It is also expected that Market Participants would prevent this from being set to a value higher than the maximum ramp rate capability for the Facility, and that the Desired Ramp Rate setpoint from AEMO would not impact any droop function (i.e. does not limit droop ramp rate).

Market Participants may still adjust the active ramp rate to a value lower than this if required (e.g. due to a Facility limitation). It is expected that any local limit applied would also be reflected in the "Facility Ramp Rate In Use".

In addition, where Market Participants are either automatically or manually setting the active ramp rate of the Facility based the Dispatch Target Ramp Rate signal when self-ramping (see section 3.2.4), it is important that this is reflected in the "Facility Ramp Rate In Use".

Appendix D has a visual representation of this functionality.

4. Facility Remote Control Equipment Design Requirements and Considerations

4.1. Control selection

In order for a Facility to provide FCESS services via AGC or be linearly ramped by AEMO's SCADA system, the following indication is required:

- "Facility AGC Control Selection"5 – for Facilities being linearly ramped by AEMO
    - The Facility AGC Control Selection is set by the Market Participant, and indicates to AEMO if the Registered Facility is capable of receiving and actioning AGC Desired MW setpoints.
    - A status of "On" indicates that the Registered Facility control system should be capable of receiving a Desired MW setpoint and implementing that instruction (up to every four seconds).
    - A status of "Off" indicates that the Facility will not process a Desired MW setpoint from AEMO's AGC system.

Where AEMO has direct control over a Facility other than for linear ramping, (e.g. to support remote start/stop or as part of a Non-Cooptimised Essential System Service arrangement), this additional signal may be required:

- "Facility Remote Control"
    - The Facility Remote Control status is set by the Market Participant and indicates whether the Facility is in Local or Remote control mode.
    - A status of "Local" indicates that the Facility is not able to be controlled by AEMO. When in this mode Market Participants are responsible for implementing any linear ramping (or other) requirements.
    - A status of "Remote" indicates that the Facility is able to respond to controls from AEMO.
    - If the "Facility Remote Control" is in "Local", Market Participants must also set their "Facility AGC Control Selection" to "off".

Where a Facility is able to be controlled by the Market Participant remotely from another control room (i.e. not on site), AEMO may also require an indication of when the Facility is selected to the remote control "other" location.

Regardless of whether the Facility is being controlled by AEMO or by the Market Participant, the following signals should always show the current active setpoints being utilised by the Facility:

- "Facility Target Net Setpoint" – the active net MW the Facility is seeking to Inject or Withdraw, or in the case of a Semi-Scheduled Facility the active Dispatch Cap.
- "Facility Ramp Rate In Use"6 – the active ramp rate being used by the Facility.

[5] Note that for Semi-Scheduled Facilities, the terminology is Facility AGC Control Selection however the ramping is not done by AGC, as described in section 3.2.3 above

[6] Or Upwards Ramp Rate and Downwards Ramp Rate in use where these are independent.

4.2. Additional AGC Indications and Logic

Facilities that are linear ramped via AEMO's AGC system may require some additional handshaking singals as listed below. Some are mandatory and some are optional, depending on the Facility's implementation. Typically, Semi-Scheduled Facilities that are participating in AEMO linear ramping outside of AGC do not need these signals, however this is also dependent on the specific implementation for the Facility (e.g. whether they will be providing Essential System Services).

Each setpoint is configured to send a new value on-change, i.e. these are typically not re-issued periodically if the value has not changed. A changed value is issued after a configurable time-lag after the start of the Dispatch Interval (typically between 20s and 40s), in order to avoid overloading communication channels. AEMO will consult with Market Participants to set the most appropriate timings for these signals during commissioning.

Unless otherwise agreed by AEMO, all setpoints issued by AEMO must have return back-indications indicating that the value has been received, and these back-indications must be received by AEMO within 10 seconds of the setpoint being issued or as agreed with AEMO.

4.2.1. AGC Control Deadband

Some Facilities have limitations in how small the change in Desired MW can be before the local control system will adjust the output of the Facility. AEMO's AGC system has a configurable parameter that specifies the smallest permissible change in Desired MW, the AGC control deadband. For example if the AGC control deadband is set to 0.1MW it means that AEMO's AGC system will not issue a Desired MW signal as part of linearly ramping the Facility unless it is more than 0.1MW different from the last issued Desired MW. AEMO will consult with Market Participants to set the AGC control deadband for the Facility during commissioning.

4.2.2. Actual MW tracking

When the "Facility AGC Control Selection" is set to "On", AEMO's AGC system will be actively using the Desired MW setpoint to linearly ramp the Facility and provide FCESS services.

If the "Facility AGC Control Selection" is set to "Off", it is assumed that the Registered Facility is being controlled locally and AEMO's AGC system will instead update the Desired MW setpoint to equal the Registered Facility's current sent-out MW Injection or Withdrawal, even though it is expected this setpoint will be ignored by the Registered Facility's Distributed Control System. This is to ensure the latest Desired MW setpoint issued by AEMO closely matches the last controlled Injection or Withdrawal of the Registered Facility to provide for a bumpless transfer of control when the "Facility AGC Control Selection" is set back to "On" and the Registered Facility recommences following the Desired MW setpoint again. This logic is summarised in 0.

It is expected that Market Participants implement their own logic to ensure bumpless transfer from AGC control to local control.

Table 3 Actual MW Tracking Logic

Facility status	Facility AGC Control Selection	AEMO AGC Control Selection	Desired MW tracks Actual?
Online	On	Auto, Fixed	No
Online	On	Paused, Suspend	No
Online	Off	Any	Yes
Offline	On or Off	Any	No

4.2.3. AGC Control Mode setpoint

The "Facility AGC Control Mode" setpoint is an indication to the Registered Facility as to what mode AEMO currently has the Registered Facility set to, see Appendix A for more details. This signal is mandatory for a Facility to participate in AGC linear ramping.

This indication can be used by the Market Participant to drive alerts or automation and to show where the Facility is not actively under AGC control even though the "Facility AGC Control Selection" may be set to "On", which can occur from time time including:

- when the Registered Facility's Injection or Withdrawal is not tracking against the Desired MW setpoint for a period of time;
- when there has been a SCADA communications failure; or
- when there has been a problem with AEMO's AGC system and it has been disabled.

4.2.4. Basepoint setpoint

The "Facility Basepoint MW"[7] is an internal number used by AEMO's AGC system to keep track of a Facilities underlying dispatch point. The "Facility Basepoint MW" should generally match the underlying energy dispatch position for the Facility, other than circumstances where:

- the Facility is not actively being dispatched via AGC;
- AGC is actively linearly ramping the Facility from one dispatch point to another (see Appendix C for an example); and/or
- the Facility is actively providing an FCESS service.

This signal is informative for Market Participants (e.g. to support any local alerting), and is optional for a Facility to participate in AGC linear ramping.

4.2.5. Actual MW setpoint

The "Actual MW" setpoint is a copy of the current sent-out level of Injection or Withdrawal as seen by AEMO's SCADA system. This point can be used by Market Participants to identify where there may be an interruption of communications between AEMO and the Registered Facility to support any local automation or alerting.

This signal is optional for Market Participants (e.g. to support any local automation for communications fail).

[7] The current AGC basepoint MW setpoint sent to the Facility for visibility.

4.2.6. AGC Limit setpoints

AEMO can send the current "High AGC Limit" and "Low AGC Limit" to Market Participants from its AGC system. These signals are informative for Market Participants (e.g. to support any local alerting or automation), and are optional for a Facility to participate in AGC linear ramping. AEMO may agree to provide alternetive limits via its SCADA system to enable automation by the Facility.

When not active on AGC, these limits revert to the Facility Basepoint MW (which is typically the last Dispatch Target that AGC was attempting to ramp the Facility to). When actively dispatched via AGC, the limits are as follows (depending on which FCESS are enabled):

- when not cleared to provide Regulation or Contingency services, these limits are equal to the Dispatch Target, unless AGC is actively linearly ramping in response to Dispatch Target changes, in which case the limits will follow the incremental changes being issued to the Desired MW setpoint;
- when cleared to provide Regulation services, these limits are set based on cleared Regulation Raise or Regulation Lower quantities relative to the Facilty's Dispatch Target. Should the Facility receive a change in Dispatch Target while activated for Regulation services, the limit values will change incrementally reflecting the underlying linear ramp to the new Dispatch Target (see Appendix C.2 for an example);
- when cleared to provide Contingency services, these limits are set based on cleared Contingency Raise or Contingency Lower quantities relative to the Facilty's Dispatch Target, noting that these values will only change to reflect the cleared Contingency limits when the SWIS Frequency is outside of the Normal Operating Band and AEMO's AGC system is in Contingency mode; and
- when cleared to provide both Regulation and Contingency services, these limits are set initially based on cleared Regulation Raise or Regulation Lower quantities relative to the Facilty's Dispatch Target, but revised based on cleared Contingency Raise or Contigency Lower quantities if SWIS Frequency is outside of the Normal Operating Band and AEMO's AGC system is in Contingency mode. Per above, they will also ramp incrementally should a Facility's underying Dispatch Target change while cleared for both Regulation and Contingency services.

4.3. Desired MW setpoint for Registered Facilities with multiple components

Where a Registered Facility consists of multiple components (e.g. multiple gas turbines, or a hybrid wind and solar photovoltaic combination), the Registered Facility's logic must be designed to manage the Desired MW setpoint requirement across the available components. The Registered Facility must account for any latency introduced due to this process.

Note that excessive latency may impact the Registered Facility's capability to reliably operate under AGC.

4.4. Communications Failure

4.4.1. Site communications failure

The "DCS Comms Link Fail" point is generated by logic in the connecting RTU using a set of handshaking signals, and will assert when there is a loss of communications identified between AEMO and the Facility. This signal is required in order for a Facility to participate in AEMO linear ramping. Market Participants may also choose to commission a "Masterstation Communications Link Fail" point to identify broader communications issues, this point is optional.

As per section 3.1.3 of the WEM Procedure: Communications and Control Systems, a Registered Facility is expected to revert to local control ("Facility AGC Control Selection" set to "Off") where communication between AEMO and the Facility fails, however this should not be instantaneous to avoid "bouncing" due to short temporary communications issues. Unless otherwise agreed with AEMO, the timout for reverting to local control should set to 10 seconds.

During this time and before the timeout has expired, the Facility should remain operating on the last received Desired MW setpoint from AEMO. Once the timeout has expired, if the communications failure is still present and the Facility has reverted to local control ("Facility AGC Control Selection" set to "Off"), Market Participants should follow Dispatch Instructions as issued in AEMO's Market System or as directed by AEMO.

When the communications issue has been resolved, unless otherwise agreed, Market Participants must contact AEMO's control room for approval before returning "Facility AGC Control Selection" to "On" and resuming active linear dispatch.

See Appendix E.1 for an example.

4.4.2. Internal AGC failure

For an internal failure of AGC, or if there are repeated control or response failures between AGC and a Registered Facility, AEMO will take the Facility out of AGC control (Mode 80 – see Appendix A).

If a Registered Facility's AGC mode changes to Manual (Mode 80), unless otherwise agreed with AEMO, there must be a 40 second delay before the Registered Facility disables the "Facility AGC Control Selection" (sets to "Off") and assumes local control. This prevents the Registered Facility from unnecessarily going into "Local" control due to short communication failures.

During this time and before the timeout has expired, the Facility should remain operating on the last received Desired MW setpoint from AEMO. Once the timeout has expired, if AGC is still disabled (e.g. mode 80) and the Facility has reverted to local control ("Facility AGC Control Selection" set to "Off"), Market Participants may choose to automate linear ramping locally by following their Dispatch Target and Dispatch Ramp Rate setpoints, or instead should follow Dispatch Instructions as issued in AEMO's Market System or as directed by AEMO.

Where a Facility is moving from the Desired MW setpoint to a Dispatch Target setpoint, it should be done in a bumpless manner, moving no faster than the rate specified in the "Desired Ramp Rate" setpoint, where the setpoint is configured.

Unless otherwise agreed with AEMO, Market Participants must contact AEMO's control room for approval before returning "Facility AGC Control Selection" to "On".

See Appendix E.2 for an example.

4.5. Self-Starting Facilities

AEMO's AGC system will not actively send Desired MW setpoints to linearly ramp a Facility until the Facility has reached its minimum dispatchable MW (as specified by the "Facility Min Operating Limit" indication).

Facilities that elect to manage their own starting and stopping (i.e. Registered Facilities not participating as Fast Start Facilities) should ensure that during the start-up sequence the "Facility AGC Control Selection" is set to "Off" until the Facility reaches the point at which it is ready to receive Desired MW setpoints from AEMO, at which time the "Facility AGC Control Selection" should be set to "On"[8].

4.6. Starts and stops with multiple facilities

Where a Registered Facility is made up of multiple, distinct components, the Registered Facility's control system and processes must manage the starts and stops of the distinct components to meet the current and anticipated Dispatch Instructions issued by AEMO.

Registered Facilities may operate with a Dispatch Target MW setpoint, which carries the current end of Dispatch Interval Dispatch Target, or Dispatch Cap. Look-ahead values can also be commissioned to indicate forecast Dispatch Targets or Dispatch Caps for intervals in other look ahead time-horizons. It is the Market Participant's responsibility to ensure that a Registered Facility takes account of the required start times of its component facilities to ensure it is capable of meeting Dispatch Targets or Dispatch Caps as they are issued.

4.7. Facility look-ahead signals

A Registered Facility may choose to implement up to four look-ahead points as per Table 11 of the Technical Specification: Operational Data Points for Registered Facilities.

These signals will be updated by AEMO to feed the forecast Dispatch Target or Dispatch Cap from the Reference Scenario for a fixed period ahead of the current Dispatch Interval, within the Dispatch Schedule Horizon.

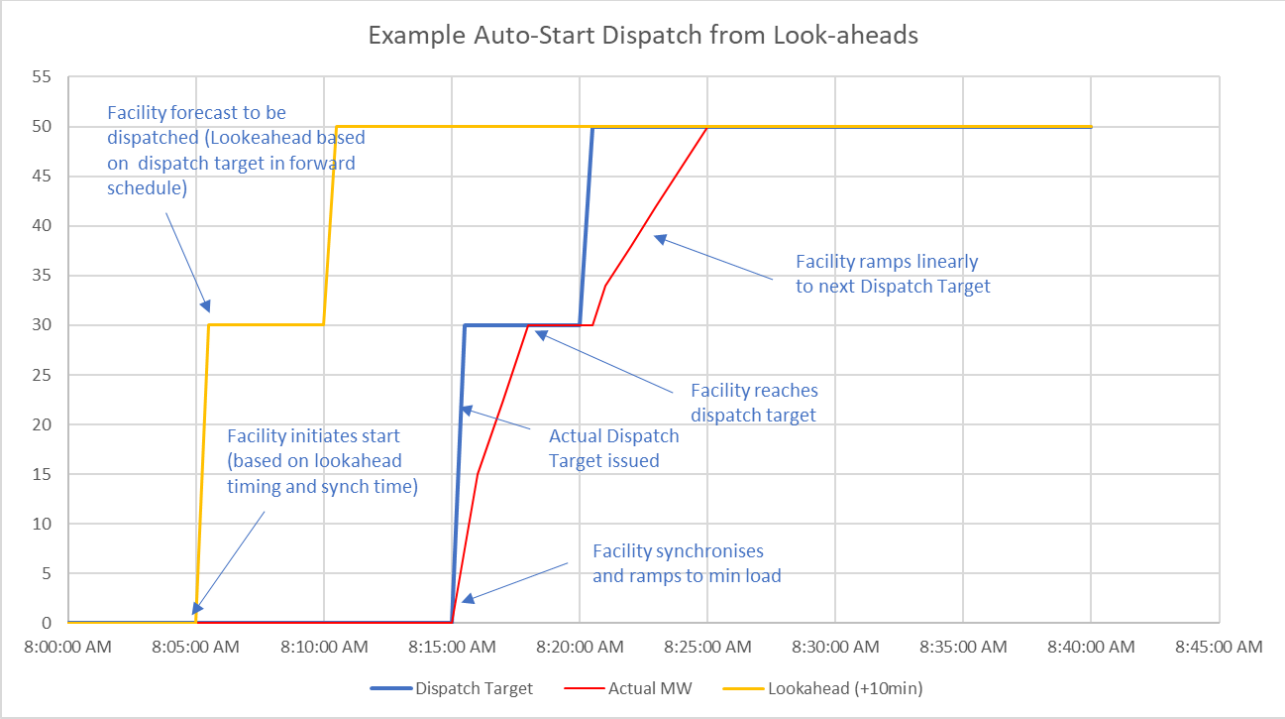
As the data to feed these points must wait until the completion of the solve for the Dispatch Schedule, there may be a delay between the start of a Dispatch Interval, and an update to a look-ahead point. The look-ahead signals are "x" minutes in advance of the relative forecast Dispatch Target (in multiples of 5 minutes), and represent the required end-of-interval value for the relative Dispatch Interval (see example in Figure 1).

[8] If the Facility AGC Control Selection is still set to Off, Participants must control the Injection and Withdrawal of the Registered Facility to meet their Dispatch Targets

AEMO staggers look-ahead setpoints based on a configured time delay after the start of the Dispatch Interval to avoid overloading communications channels. AEMO will consult with Market Participants to set the most appropriate timings for these signals during commissioning.

Look-ahead points are indicative only, and changes in dispatch conditions may result in different outcomes for the Primary Dispatch Interval. However, Market Participants may choose to automate starting and stopping of their Facilities based on these look-ahead signals. Where a Facility is automatically starting or stopping based on these signals, Market Participants need to ensure they take into account the synchronisation time of the Facility when determining appropriate start times based on available look-ahead signals[9]. Market Participants should set the "Facility AGC Control Selection" to "On" when the Facility reaches the point at which it is ready to receive Desired MW setpoints from AEMO in order for it to participate in AGC linear ramping.

Figure 1 Example automated start from look-ahead signals



4.8. Fast Start Facility signals

Where a Market Participant has been approved by AEMO as a Fast Start Facility and has elected to include a Fast Start Dispatch Inflexibility Profile[10], AEMO's Dispatch Engine will take this profile into account when determining Dispatch Targets and look-ahead signals. Dispatch

[9] For example, in **Error! Reference source not found.** the look-ahead is +10 minutes, but if the Facility has an 8 minute start-up t ime then this should be factored into the automation to ensure the Facility is not started too early.

[10] As per WEM Rule 7.4.44 - other information about the behaviour of Fast Start Facilities in dispatch is contained within the WEM Procedure: Dispatch Algorithm Formulation and the WEM Procedure: Facility Dispatch Process.

Targets will be based on the timing and quantities included in the Fast Start Dispatch Inflexibility Profile, see the example in Figure 2.

Figure 2 Example Fast Start Dispatch Inflexibility Profile

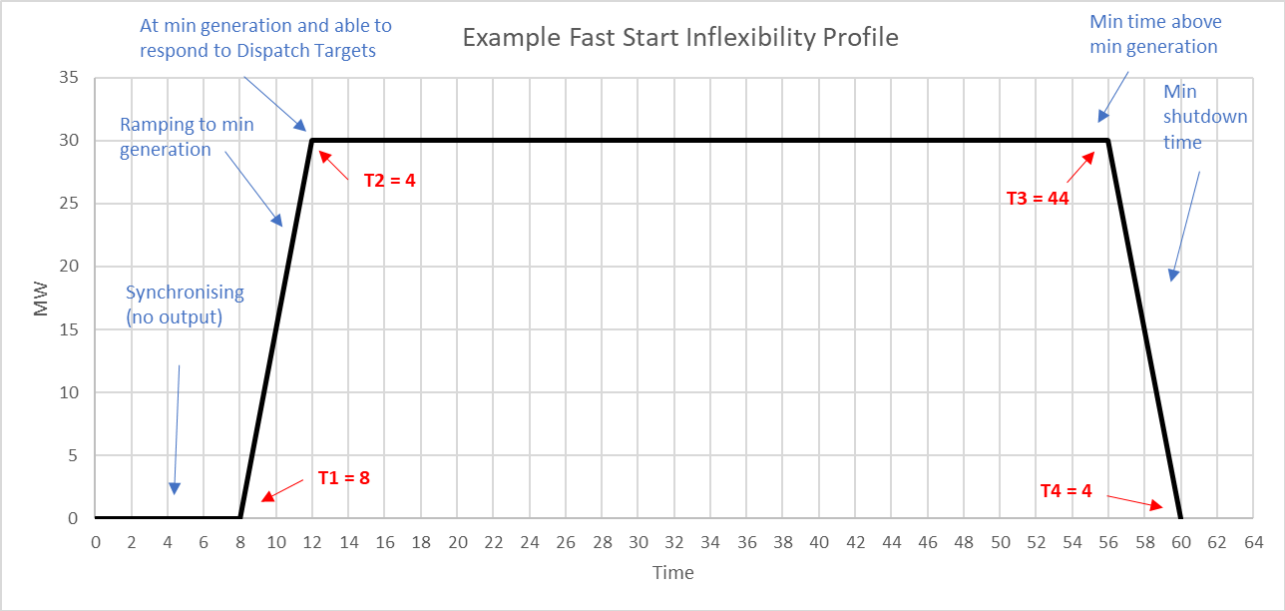
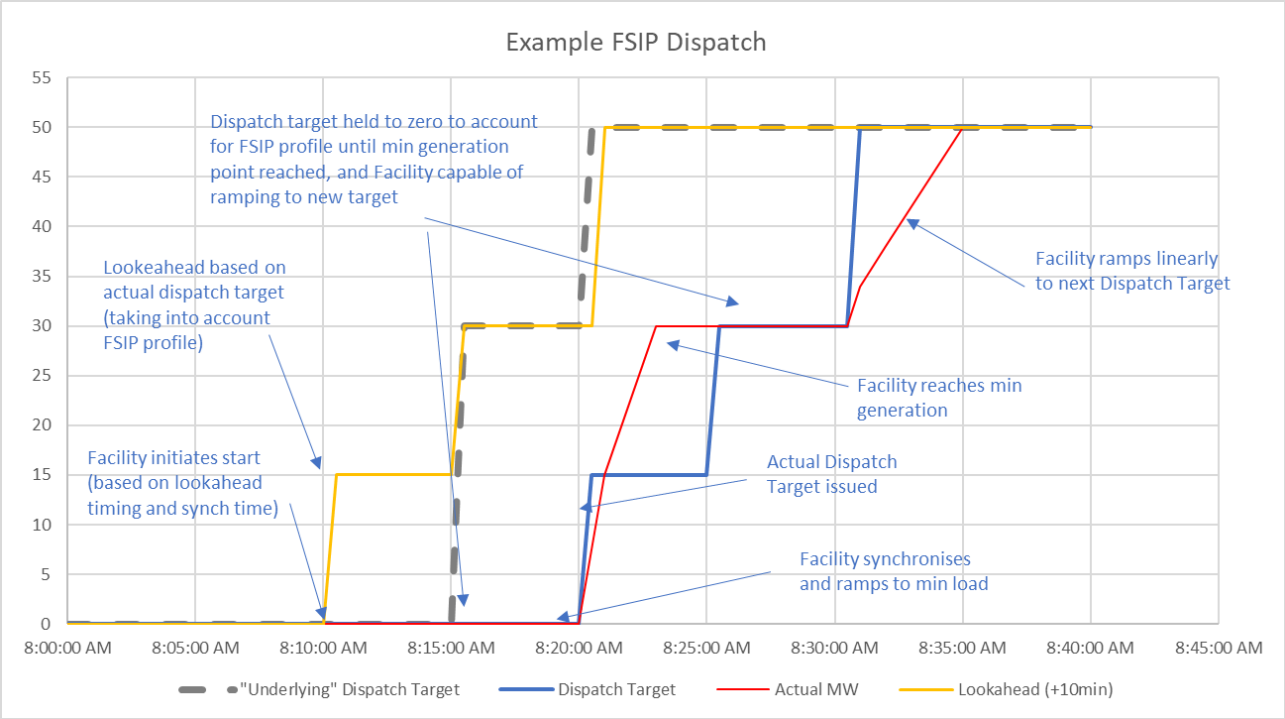


Figure 3 Example FSIP Dispatch



In the example in Figure 3, the "underlying" Dispatch Target is the quantity that the Facility would have been dispatched to if not for its Dispatch Inflexibility Profile. Because the Facility is an active Fast Start Facility, AEMO's Dispatch Engine knows from the Dispatch Inflexibility Profile that the Facility requires 8 minutes to synchronise and a further 4 minutes to reach its minimum dispatchable level.

Therefore the Dispatch Engine delays the Dispatch Targets to commence 5 minutes later with an intermediate target of 15 MW calculated based on a linear interpolation of the Dispatch Inflexibility Profile.

The look-ahead signals also take this into account, being based on the "delayed" Dispatch Targets rather than the "underlying" Dispatch Target[11].

The Fast Start Facility must ensure that it is capable of starting and synchronising in accordance with the timing and values in its Dispatch Inflexibility Profile. To support this, Fast Start Facilities may implement the relevant signals as per Appendix D of the Technical Specification: Operational Data Points for Registered Facilities.

Participants opting to participate in fast start must specify how they wish to receive fast start commands from AEMO. This can be either via a specified start control point, where the start control automatically commences the start-up sequence of the Facility to its specified minimum generation level (note that AEMO may also require an additional "Facility Remote Control" indication per section 4.1). AEMO will only issue the start control signal once, it will not be re-issued periodically or retry upon failure, and it is the Market Participants responsibility to ensure that all necessary conditions are met for the Facility to start correctly and safely.

Alternatively, Market Participants may choose instead to use the look-ahead signals to automatically start/stop the Facility (as described in section 4.7), or manage their starts in another way that is approved by AEMO, instead of commissioning additional control signals and logic.

In addition, AEMO can send the following indications to the Facility to support any local automation or alerting that Market Participants may wish to implement:

- Fast Start Target Mode – an analogue code to indicate what the current fast start status of the Facility is;
- Fast Start Target Mode Time – an analogue value indicating the time (in minutes) that the Fast Start Facility will have been in the relevant Fast Start Target Modes other than modes 0 and 5, as at the end of the Dispatch Interval (reset at each state change);
- Fast Start Enabled Flag – a boolean value indicating whether the Facility has bid in the current Dispatch Interval in such a way that it is eligible to be considered for fast start.

Table 4 Fast Start Target Mode Logic

Mode Description	Fast Start Target Mode	Fast Start Enabled Flag
Not available for fast start	0	False
Offline, but available to fast start	0	True
Start issued, starting in progress	1	True
Synchronised and ramping to minimum loading	2	True
At (or above) minimum loading	3	True
Passed minimum run-time and available to be stopped	4	True
Beyond fast start timeframes and under regular dispatch	5	True

[11] Market Participants should take care to ensure that their submissions reflect these delays when structuring their Real-Time Market Submissions to ensure Facilities start/stop at the expected times.

When offline and prior to synchronisation, the "Facility AGC Control Selection" should be set to "Off". Once the Fast Start Facility has synchronised and reaches its minimum output (as specified in its Dispatch Inflexibility Profile), it can be switched to operate in AGC by setting the "Facility AGC Control Selection" to "On". Fast Start Facilities must ensure that the "Facility Min Operating Limit" and "Facility Max Operating Limit" indications align with the Dispatch Inflexibility Profile once AGC control is enabled to ensure these limits are respected.

4.9. Linear ramping and Frequency Response

When participating in AEMO linear ramping, either via AGC or otherwise, Facilities must still respond to changes in power system frequency in accordance with their specified droop/frequency control characteristics (quantity and ramp)[12], and in accordance with any FCESS requirements where the Facility is cleared for Contingency services.

When active in AGC and not cleared for Contingency services, the Desired MW signal will continue to represent the required Dispatch Target or active linear ramping point for the Facility (i.e. it will not change as a result of frequency). Therefore the Facility's frequency control characteristic should be superimposed on the Desired MW setpoint such that the increase or decrease in output in response to frequency is in respect of the current operating point of the Facility.

Where a Facility that is participating in AGC linear ramping is cleared for Contingency Services, during a frequency event AEMO's AGC system will utilise the additional limits available and may push the Desired MW to these extents. Again, the Facilities frequency control characteristic should be superimposed on the Desired MW setpoint in this case as well, such that the Facility is responding in accordance with its cleared Contingency quantities.

See Appendix F for examples.

[12] As specified in Registered Generator Performance Standards, required as part of an FCESS provision, or otherwise as recorded by AEMO.

5. Testing and Commisioning

AEMO requires Market Participants to demonstrate capability to be dispatched and respond to Dispatch Instructions before allowing full participation in the market. The required tests for a Facility will vary depending on the methods being used for linear dispatch, whether the Facility is a Fast Start Facility, and what FCESS services it will be providing.

This section describes the tests that all Facilities must undertake, and any additional testing that AEMO requires based on the services that the Facility will provide. AEMO may also specify additional tests depending on the specific configuration of the Facility[13].

All tests must be conducted under an approved Commissioning Test Plan. Where possible, the tests should be grouped into a single set of combined activities in sequence. Where a particular test fails, AEMO may agree to continue with the remainder of the tests depending on the significance of the failure.

Where a test fails and must be re-tested, Market Participants must resolve the issue and coordinate a future date for re-testing with AEMO as part of another Commissioning Test Plan.

It is the responsibility of the Market Participant to record the results of the Commissioning Tests such that they can be provided as evidence of successful testing.

5.1. Testing for all Facilities

AEMO requires that all Facilities with SCADA indications and controls first conduct a series of signal end-to-end tests as part of commissioning the Facility. These tests would typically be conducted with the Market Participant following successful signal "pre-commissioning" activities with the Network Operator[14]. The tests involve:

- Proving each indication works correctly by changing each indication at the Facility control system end, and confirming the correct value appears at the AEMO end.
    - Requires testing the full range and sign of the values (where applicable).
    - AEMO will also use this to test automation/calculations are functioning correctly at the AEMO end.
- Where control signals are able to be issued to the Facilty while offline (e.g. setpoints) - proving each control signal is able to be issued by AEMO and appears with the correct value and sign at the Facility control system end.
    - Confirming setpoint back-indications are received within 10 seconds (or as agreed with AEMO).
- Proving SCADA quality by forcing or simulating a communications failure, confirming relevant signals appear as bad quality, and that values remain intact following restoration (e.g. setpoints are not reset, etc).

[13] Market Participants should contact the AEMO Operational Planning team to discuss the specifcs of the required Commissioning Tests prior to submitting the Commissioning Test Plan

[14] It is often helpful to coordinate these tests with the Network Operator on standby to support with any issue resolution that may be required

- Where communications failover functionality has been configured, these tests should also confirm that the failover functions correctly.
    - Signals retain connectivity and values, and that there are no step-changes in Injection or Withdrawal for various failover scenarios where there is multiple redundant equipment installed (e.g. communications link failover, RTU failover).

5.2. Testing for Linear Dispatch

These tests are split into offline and online tests, and will vary depending on whether a Facility is participating in AEMO linear dispatch or is self-dispatching linearly. AEMO will specify the range of ramping and ramp rates that the Facility must demonstrate, which:

- may include various sizes of MW changes over 5-minute periods, up to the largest expected possible movement based on the Maximum Upwards Ramp Rate and/or Maximum Downwards Ramp Rate of the Registered Facility;
- will span at least 1 hour of active operation in order to confirm signal latency and identify potential communications issues; and
- may include testing across different Injection and Withdrawal ranges and operating modes as applicable for the Registered Facility. Market Participants must structure their Real-Time Market Submissions to facilitate online tests wherever possible to do so, in order for AEMO to prove that all the linkages to the Dispatch Engine are configured correctly.

Normal droop/frequency control functionality should remain enabled during these tests, unless specifically required to be disabled by AEMO.

5.2.1. All Facilities

For the offline tests, the following is required:

- Confirm all required signals for AEMO linear dispatch are commissioned and functioning (as relevant).
- Confirm with the Facility offline, that the Facility AGC Control Selection indication and AGC Control Mode setpoint is functioning correctly (as relevant).
- Confirm all limit indications have reasonable values reflecting accurate Facility capability.
- Confirm the Desired Ramp Rate setpoint is set to a value reflective of normal maximum ramping capability (where applicable).

Online testing, “local” control:

- Confirm the Facility is able to be started and ramped locally in response to Dispatch Instructions, across an indicative range of possible operation as specified by AEMO (e.g. between minimum and maximum outputs, varying between minimum and maximum ramp rates):
    - Confirm that ramping is achieved within the Tolerance Range or Facility Tolerance Range as applicable.
    - Confirm Facility AGC Control Selection is set to “Off”.

- Confirm AGC mode is set to 80, and AGC Control Mode setpoint is being received correctly.
- Confirm additional AGC setpoints are being issued and received (e.g. Basepoint MW setpoint, Actual MW setpoint, as relevant).
- Confirm AGC limit setpoints are being issued and received.
- Confirm the Facility recieves, but does not respond to changes in the Desired MW setpoint (and that the Desired MW setpoint is tracking the actual Facility output).
- Confirm the Facility continues to receive other supporting setpoints (e.g. Dispatch Target, Dispatch Ramp Rate, any configured look-ahead setpoints, etc).
- Confirm the Facility does not ramp at a rate greater than that specified in the Desired Ramp Rate setpoint (where applicable).
- Confirm all Facility indications are working correctly, including "Facility Target Net Setpoint" and "Facility Ramp Rate In Use" indications15.
- Confirm all measurement indications are correct, e.g. net/gross MW/MVAr indications, voltage and power factor indication, etc..
- For Semi-Scheduled Facilities, confirm when the Facility is curtailed that any "available MW" or "forecast MW" signals are working correctly.
- Confirm all control system overrides (e.g. ramp limits, maximum/minimum operating limits, etc) are reflected correctly in indications back to AEMO.

- Where the Facility has been configured with automation to respond and ramp to Dispatch Target and Dispatch Ramp Rate setpoints:
  - Confirm the Facility responds and ramps correctly to changes in Dispatch Target and Dispatch Ramp Rate setpoints, across an indicative range of possible operation as specified by AEMO (e.g. between minimum and maximum outputs, varying between minimum and maximum ramp rates).
    - Confirm that ramping is achieved within the Tolerance Range or Facility Tolerance Range as applicable.
  - Confirm the Facility does not ramp at a rate greater than that specified in the Desired Ramp Rate setpoint (where applicable).
  - Confirm all Facility indications are working correctly, including "Facility Target Net Setpoint" and "Facility Ramp Rate In Use" indications.
  - For Semi-Scheduled Facilities, confirm when the Facility is curtailed that any "available MW" or "forecast MW" signals are working correctly.

5.2.2. Facilities participating in AEMO linear dispatch

Online tests:

- Confirm following successful start and reaching minimum dispatch, that the Facility AGC Control Selection point changes to "On" and that AGC Control Mode changes to 90.

[15] Reflecting what internal control setpoints the Facility is using.

- AEMO may need to conduct a short series of linear ramps for the purposes of AGC tuning, and to configure the necessary AGC timing parameters.
- Confirm the Facility is able to be ramped by AEMO linearly in response to Dispatch Instructions, across an indicative range of possible operation as specified by AEMO (e.g. between minimum and maximum outputs, varying between minimum and maximum ramp rates):
    - Confirm that ramping is achieved within the Tolerance Range or Facility Tolerance Range as applicable.
    - Confirm the Facility does not ramp at a rate greater than that specified in the Desired Ramp Rate setpoint (where applicable).
    - Confirm all Facility indications are working correctly, including "Facility Target Net Setpoint" and "Facility Ramp Rate In Use" indications.
    - For Semi-Scheduled Facilities, confirm when the Facility is curtailed that any "available MW" or "forecast MW" signals are working correctly.
- Simulate a communication failure on site such that the Communications Fail logic is initated:
    - Confirm AGC Mode is set to 80, and that on site that the Facility remains operating at the last received Desired MW setpoint.
    - Restore the communications path prior to the specified timeout in section 4.4 and confirm that the Facility AGC Control Selection point is still set to "On", confirm that AGC Control Mode switches back to 90 and that the Facility continues to follow Desired MW setpoints.
    - With the communications failure persisting longer than the specified timeout in section 4.4, confirm on site that the Facility AGC Control Selection point has been set to "Off". Restore communications and confirm that the AGC Control Mode remains in 80 and that the Facility is able to ramp locally (adhering to the maximum Desired Ramp Rate setpoint).
    - Confirm all Facility indications are working correctly, including "Facility Target Net Setpoint" and "Facility Ramp Rate In Use" indications.
- With AGC disabled by AEMO:
    - Confirm AGC Mode is set to 80, and that on site that the Facility remains operating at the last received Desired MW setpoint.
    - Restore to active AGC prior to the specified timeout in section 4.4 and confirm that the Facility AGC Control Selection point is still set to "On", confirm that AGC Control Mode switches back to 90 and that the Facility continues to follow Desired MW setpoints.
    - With AGC Mode 80 persisting longer than the specified timeout in section 4.4, confirm on site that the Facility AGC Control Selection point changes to "Off" and that the Facility is able to be ramped locally. Restore communications and confirm that the AGC Control Mode remains in 80 and that the Facility is able to ramp locally (adhering to the maximum Desired Ramp Rate setpoint).
    - Confirm all Facility indications are working correctly, including "Facility Target Net Setpoint" and "Facility Ramp Rate In Use" indications.

- Where the Facility has also been configured with automation to respond and ramp to Dispatch Target and Dispatch Ramp Rate setpoints:
    - When being linearly dispatched by AEMO, confirm that the Dispatch Target and Dispatch Ramp Rate setpoints continue to be received, but are not responded to by the Facility.
    - When AEMO disable AGC, confirm that AGC Control Mode changes to 80 and that after the specified timeout in section 4.4, confirm the Facility switches the Facility AGC Control Selection point to "Off" and commences following the Disaptch Target and Dispatch Target Ramp Rate setpoints (confirming that there is no step-change greater than the Dispatch Target Ramp Rate).
    - Confirm the Facility does not ramp at a rate greater than that specified in the Desired Ramp Rate setpoint (where applicable).
    - Confirm all Facility indications are working correctly, including "Facility Target Net Setpoint" and "Facility Ramp Rate In Use" indications.

5.3. Testing for automated start/stop, and Fast Start Facilities

If the Registered Facility is intending to participate as a Fast Start Facility, AEMO may require testing to confirm that any fast start logic is working correctly (both for start and stop conditions). This may require Market Participants to structure their Real-Time Market Submissions to meet the following requirements:

- Testing may include: Demonstrating that the Facility is able to respond to a look-ahead signal and automatically start the Facility.
    - Confirming the behaviour of the Facility AGC Control Selection point, and subsequent automated ramping.
- Testing may include: Demonstrating that the Facility is able to respond to a look-ahead signal and automatically stop the Facility.
    - Confirming the behaviour of the Facility AGC Control Selection point.
- Testing of any start controls commissioned for the purpose of Fast Start (where applicable).
- Testing of any additional logic implemented by Market Participants using signals issued by AEMO (e.g. Fast Start signals).

5.4. Testing for Facilities providing FCESS

- Where intending to participate in Regulation services, the tests must include those identified in the Guideline: Frequency Co-optimised Essential System Service Testing[16].

[16] Available here: https://www.aemo.com.au/energy-systems/electricity/wholesale-electricity-market-wem/system-operations/essential-system-services

Appendix A. AGC Control and Participation Modes

Table 5 shows the various possible AGC participation modes for a Facility, as well as the analogue values that are sent to the Facility using the AGC Control Mode point. The list below highlights the key values for Energy and Regulation participation:

- A Registered Facility participating in Energy, and receiving Dispatch Targets via AGC, but not participating in Regulation or Contingency Reserve will be in mode 90.
- A Registered Facility participating in Energy and Regulation will be in mode 120.
- A Registered Facility Participating in Energy, Regulation, and Contingency Reserve will be in mode 130[17].
- A Registered Facility participating in Energy and Contingency Reserve will be in mode 110 unless otherwise exempt from AGC control by AEMO as per the WEM Procedure: Frequency Co-optimised Essential System Services Accreditation.
- A Registered Facility not participating in AGC will be in mode 80 (“Manual”).

Other values are not actively used for the communication of Dispatch Targets or Essential System Service provision, but are included for completeness.

Table 5 AGC control and participation modes

Facility status	Facility AGC Control Selection	AEMO AGC Control	Not cleared for FCESS	Cleared for Regulation	Cleared for Contingency Reserve	Cleared for both Regulation and Contingency Reserve
Online	On	Enabled (Auto)	90 (Energy only)	120 (Energy and Regulation)	110 (Energy and Contingency Reserve)	130 (Energy, Regulation, and Contingency Reserve [18])
Online	On/Off	Disabled (not Auto)	80 (Manual)	N.A.	N.A.	N.A.
Offline	On	Disabled (not Auto)	40 (Available)	N.A.	N.A.	N.A.
Offline	Off	Disabled (not Auto)	20 (Unavailable)	N.A.	N.A.	N.A.

[17] This will be enabled when AEMO has confirmed that it will not impact existing Facilities that are currently configured to receive this as a value of 120.

[18] Where the ACE leaves the Normal Region, AEMO will adjust the AGC limits for the Registered Facility to reflect the required Contingency Reserve Provision.

Appendix B. AGC Dispatch Examples

Figure 4 AGC Dispatch Examples

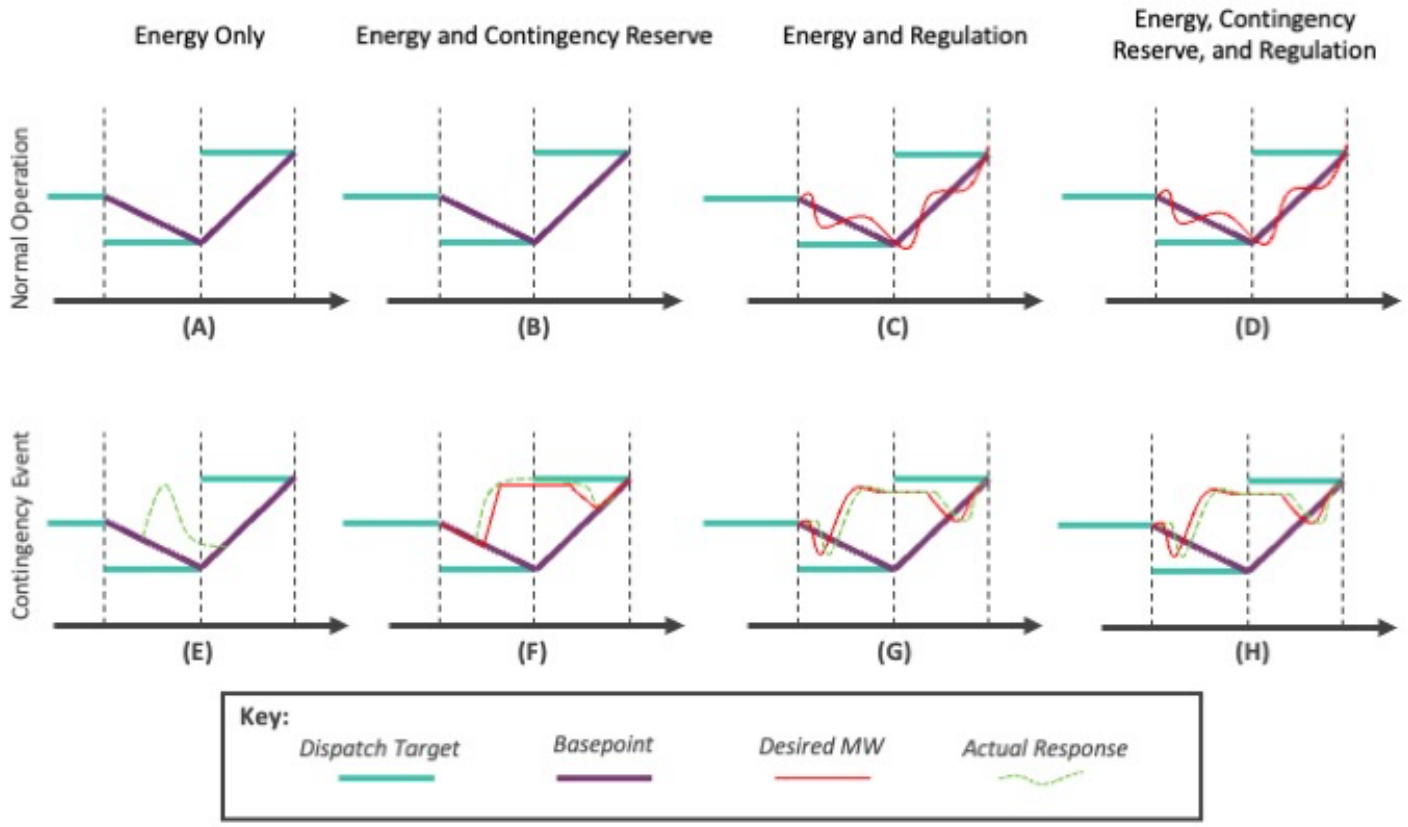


Figure 4 shows eight examples of scenarios of AGC dispatch in normal operation, and during and immediately after a Contingency Event. Note that these example are not exhaustive, and do not override any requirements of the WEM Rules, Generator Performance Standards, or directions or other instructions from AEMO. They are provided for informational purposes only.

B.1 Normal Operation (A): Energy Only

In normal dispatch, while active in AGC (AGC Control mode 90), AEMO will linearly ramp the Registered Facility's Basepoint between its Initial MW, and its Dispatch Target. This will result in regular updates to the Desired MW setpoint for the Registered Facility which will follow an approximately linear trajectory. For simplicity, this diagram assumes that the Registered Facility perfectly follows a linear trajectory. At the start of each Dispatch Interval, the look-ahead Dispatch Target MW setpoint is updated with the new Dispatch Target once produced by WEMDE, and the Desired MW setpoint begins ramping linearly towards this target.

B.2 Normal Operation (B): Energy and Contingency Reserve

In normal dispatch, a Registered Facility will behave as per section Appendix C of this Appendix. While the SWIS Frequency is inside the Normal Operating Band, and ACE remains within the ACE Normal Region, no MW will be assigned to the Registered Facility for frequency control, and so the behaviour remains the same as in the Energy only example.

B.3 Normal Operation (C): Energy and Regulation

In normal dispatch, a Registered Facility will be moved off its Basepoint by AGC to maintain SWIS Frequency close to the nominal frequency (50 Hz). This will occur except when SWIS Frequency is within a narrow deadband close to the nominal frequency. The limits of this enablement upwards and downwards will be set by the Essential System Service Enablement Quantities for Regulation Raise and Regulation Lower respectively. Simultaneously, a Registered Facility's Basepoint can be incrementally ramped as per Appendix C. The Desired MW Setpoint for the Registered Facility will combine these movements. In this particular example, the general trend of the Desired MW Setpoint follows the Basepoint, but can move above or below to help manage SWIS Frequency. Any quantity within the range set by the Basepoint and the Essential System Service Enablement Quantities for Regulation Raise and Regulation Lower is possible in practice.

B.4 Normal Operation (D): Energy, Contingency Reserve, and Regulation

In normal dispatch, the dispatch outcomes resulting from this configuration are the same as section B.3 of this Appendix. While the ACE remains within the ACE Normal Region, no MW will be assigned to the Registered Facility beyond the Essential System Service Enablement Quantities for Regulation Raise and Regulation Lower.

B.5 Contingency Event (E): Energy Only

If a Contingency Event occurs while a Registered Facility is in Mode 90, the Registered Facility is expected to respond as per its droop settings in its Generator Performance Standards. The Desired MW Setpoint will not change from the Basepoint during this time. Once the required duration of response is met, the Facility should return to its Desired MW target, which will continue as before the Contingency Event.

B.6 Contingency Event (F): Energy and Contingency Reserve

If a Contingency Event occurs while a Registered Facility is in Mode 110, the Registered Facility is expected to respond as per its droop settings in its Generator Performance Standards, and the requirements of its accreditation for Contingency Reserve Raise and/or Contingency Reserve Lower. In the seconds following the Contingency Event, the Desired MW Setpoint will move up to the limits set by the Registered Facility's Essential System Service Enablement Quantities for Contingency Reserve, and will continue to vary until the ACE returns to the ACE Normal Region. At this time, the Desired MW Setpoint will begin to return to its Basepoint.

B.7 Contingency Event (G): Energy and Regulation

If a Contingency Event occurs while a Registered Facility is in Mode 120, but not enabled for Contingency Reserve, the Registered Facility is expected to respond as per its droop settings in its Generator Performance Standards. In the seconds following the Contingency Event, the Desired MW Setpoint may move up to its Essential System Service Enablement Quantities for Regulation Raise and Regulation Lower, and continue to vary within those limits until the ACE returns to the ACE Normal Region. At this time the Registered Facility may again be dispatched within the range set by its Essential System Service Enablement Quantities for Regulation Raise and Regulation Lower.

B.8 Contingency Event (H): Energy, Contingency Reserve, and Regulation

If a Contingency Event occurs while a Registered Facility is in Mode 120, and is enabled for Contingency Reserve, the Registered Facility is expected to respond as per its droop settings in its Generator Performance Standards. In the seconds following the Contingency Event, the Desired MW Setpoint will move up to its combined Essential System Service Enablement limit, which would be the sum of its Essential System Service Enablement Quantity for Regulation and Contingency Reserve (Raise or Lower depending on the nature of the Contingency Event), and continue to vary until the ACE returns to the ACE Normal Region. At this time the Registered Facility may again be dispatched within the range set by its Essential System Service Enablement Quantities for Regulation Raise and Regulation Lower.

Appendix C. Linear Ramping Examples

The examples in this appendix intend to show how AEMO Linear Ramping works in more detail. These examples do not depict behaviour that includes changes in Injection or Withdrawal due to delivery of a Contingency Reserve service, or as a result of Droop Response, which are considered in Appendix B.

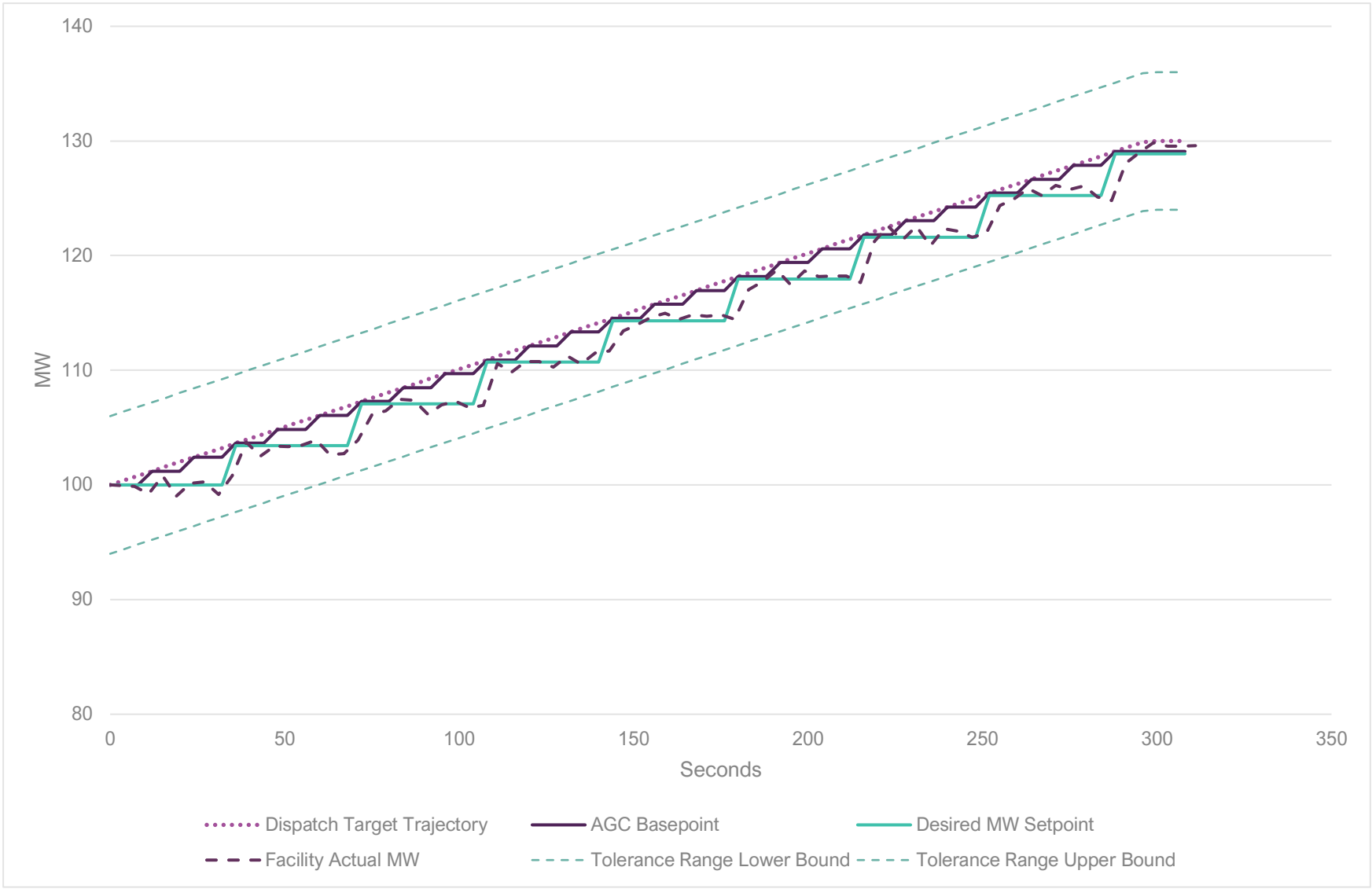
C.1 Scheduled Facility Linear ramping without Regulation enablement

In this example (see Figure 5), a Scheduled Facility without any Essential System Service Enablement Quantities reaches its new target of 130 MW, from an Initial MW value of 100 MW. Due to the Facility Deadband of 3 MW, the Scheduled Facility receives eight discrete updates to its Facility Desired MW setpoint, not including its initial position. The Scheduled Facility stays within its Tolerance Range for the entire Dispatch Interval.

Table 6 Example values for linear ramping without Regulation enablement

Item	Value	Units
Initial MW	100	MW
Dispatch Target	130	MW
Ramp Rate Limit	15	MW/min
Minimum Basepoint Delta	1	MW
Facility Lag	3	s
Facility Deadband	3	MW
Essential System Service Enablement Quantity for Regulation Raise	0	MW
Essential System Service Enablement Quantity for Regulation Lower	0	MW
Tolerance Range	6	MW
Calculated Linear Ramp Rate	$6.\overline{06}$	MW/min

Figure 5 Linear Ramping Example – Energy Only



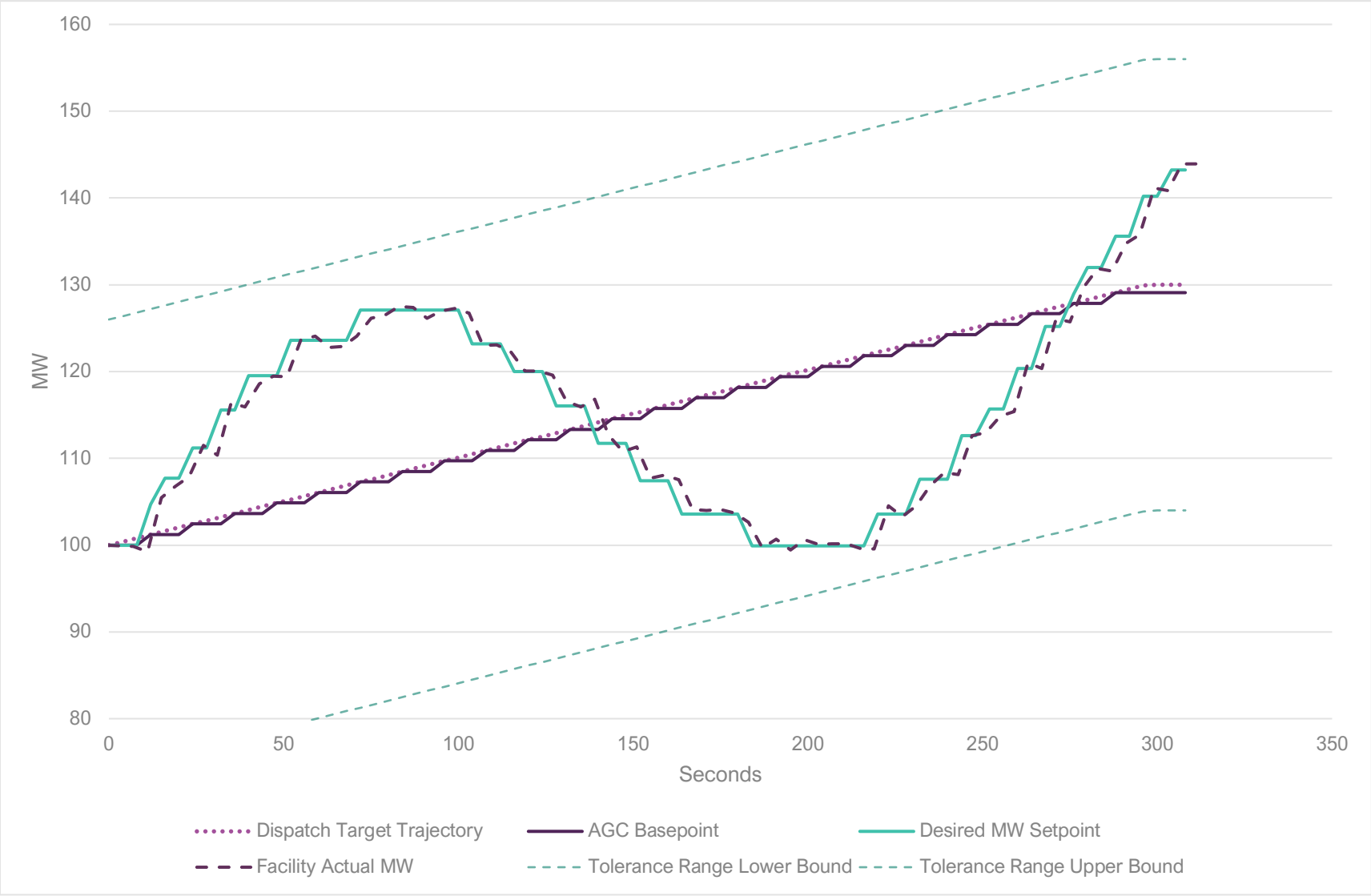
C.2 Scheduled Facility Linear ramping with Regulation enablement

In this example (see Figure 6), a Scheduled Facility with symmetrical Essential System Service Enablement Quantities for Regulation Raise and Regulation Lower of 20 MW each is dispatched to its new target of 130 MW, from an Initial MW value of 100 MW. The Scheduled Facility is required to increase and decrease its Injection from its Basepoint due as part of its Regulation Raise and Regulation Lower provision. As per the previous example, the Scheduled Facility receives updates to its Desired MW setpoint when the change from the current value exceeds the Facility Deadband. The Scheduled Facility stays within its Tolerance Range for the entire Dispatch Interval, which is wider due to the provision of Regulation Raise and Regulation Lower.

Table 7 Example values for linear ramping with Regulation enablement

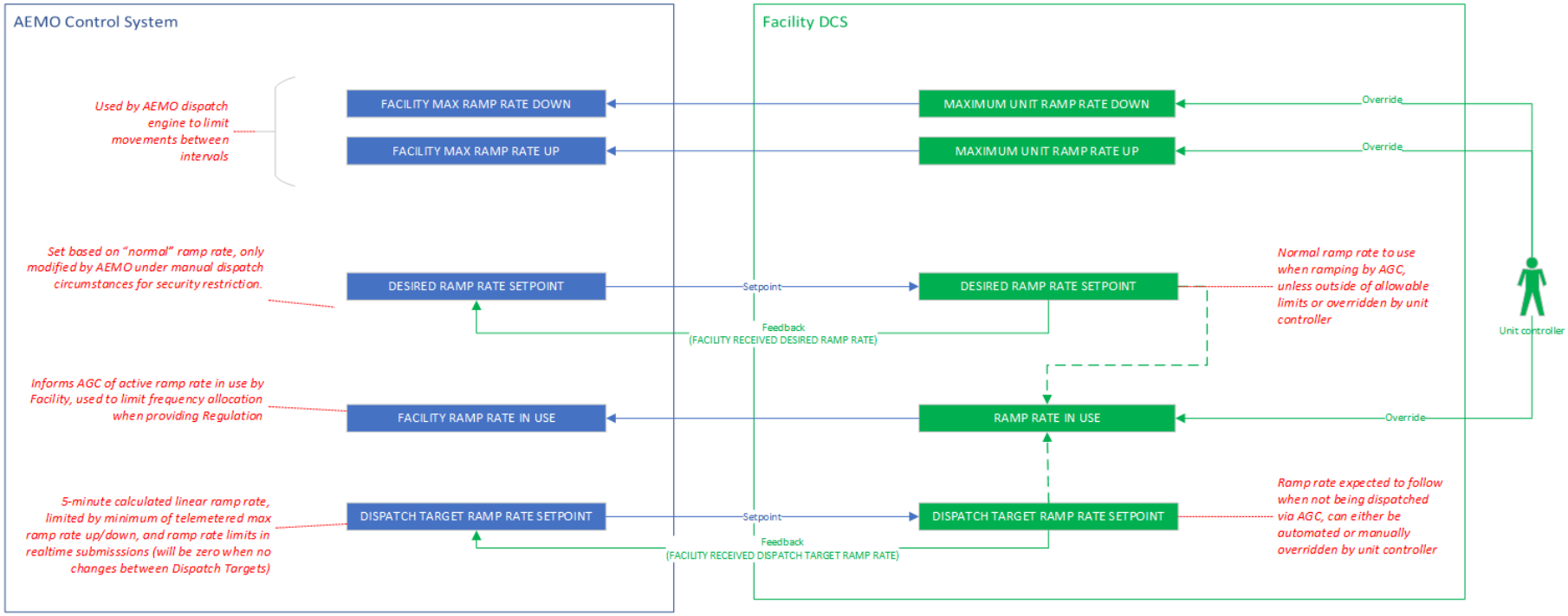
Item	Value	Units
Initial MW	100	MW
Dispatch Target	130	MW
Ramp Rate Limit	15	MW/min
Minimum Basepoint Delta	1	MW
Facility Lag	3	s
Facility Deadband	3	MW
Essential System Service Enablement Quantity for Regulation Raise	20	MW
Essential System Service Enablement Quantity for Regulation Lower	20	MW
Tolerance Range	6	MW
Calculated Linear Ramp Rate	$6.\overline{06}$	MW/min

Figure 6 Linear Ramping Example – Energy and Regulation



Appendix D. Facility Ramp Rate Signals

Figure 7 Illustrates the usage of the different ramp rate setpoints



Appendix E. Communications Failure Examples

This appendix contains some examples of control handover sequences for AGC and communication fail scenarios.

E.1 Loss of Communications between RTU and Facility Control System

This example shows how the Facility should behave during an intermittent or persistent communications failure event.

Figure 8 Intermittent or persistent communications failure event

E.2 AGC Disabled

This example shows how the Facility should behave when AGC is disabled by AEMO, either temporarily or for a longer period.

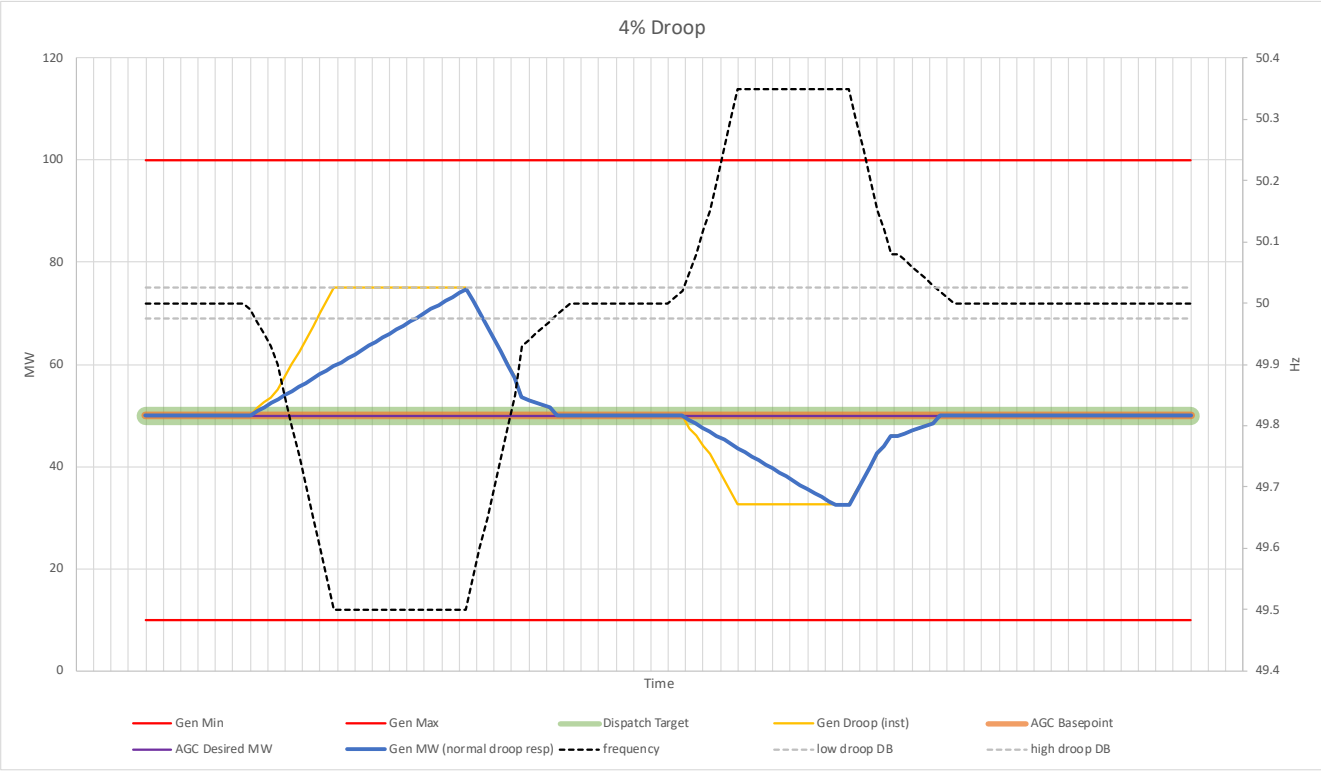
Figure 9 AGC is disabled by AEMO, either temporarily or for a longer period

Appendix F. AGC and Frequency Response

This appendix contains some examples of Facility frequency response when active on AGC. Note that these are intended for illustration and do not represent all the characteristics of a Facility's real frequency response.

F.1 Frequency response when not cleared for Contingency Services

In this example, a Facility is participating in AGC Linear Ramping and has a Dispatch Target of 50 MW. The instantaneous droop response is shown in yellow to indicate the ideal response to frequency, with the actual response of the Facility in blue based on its droop ramp rate.



F.2 Frequency response when cleared for Contingency services

In this example, the same Facility is cleared for +35 MW and -30 MW of Contingency services. The Desired MW increases during the frequency event and the revised instantaneous droop response is shown in yellow, with the actual response of the Facility in blue based on its droop ramp rate (note the difference from the previous example in that the response is extended to support restoring system frequency as part of providing Contingency services).