AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

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.”

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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) from New WEM Commencement Day.

1.1.3. This document is being published in advance to indicate the expected SCADA and communication requirements for AGC operation from New WEM Commenement Day. This document will be updated as implementation of the necessary systems and processes progresses.

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

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

1.1.6. 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 for frequency in the AGC system's control model.
Automatic Generation Control (AGC)	As defined in the Communications and Control Systems Procedure, which at the time this document was published read:

Term	Definition
	"Equipment operated by AEMO, which sends signals to facilities participating in the AGC scheme to automatically adjust their output so as to maintain frequency or restore frequency within the SWIS Operating Standards."
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.
Calculated Linear Ramp Rate	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.
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.
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 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: Communicatiosns 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.
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.
SCADA-telemetered Dispatch Instruction	A Dispatch Instruction sent to a Registered Facility via the SCADA system.
Supervisory Control and Data Acquisition (SCADA)	As defined in the Communications and Control Systems Procedure, 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 paragraph refers to a paragraph 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 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 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 Reserve[1] 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 Point Requirements for Registered Facilities, available on the WEM Website.

3. AGC Control and Linear Ramping

The below paragraphs detail the various forms of SCADA-telemetered Dispatch Instruction and AGC participation, and the expected response from Registered Facilities.

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

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 realtime capability of a Facility. The following telemetered limits are used in AGC where provided by Market Participants:

- "Facility Max Operating Limit"
- "Facility Min Operating Limit"
- "Facility Max Ramp Rate Up"[2]
- "Facility Max Ramp Rate Down"

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. 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 paragraph 3.2.2 and paragraph 3.2.3 below. 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 below.

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, and its effective Dispatch Target.

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

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

nominated ramp rates when following their "Facility Desired MW Setpoint", unless directed otherwise by AEMO.

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.

Semi-Scheduled Facilties 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 regular updates to the "Facility Desired MW Setpoint" which reflects the expected linear ramping profile of the SSF between its Initial MW, and its effective Dispatch Cap (similar to AGC-based linear ramping).

A SSF must participate in linear ramping when providing Regulation (which would be via AEMO's AGC system as per section 3.2.2 of this Technical Specification).

3.2.4. Self-Ramping

Where a Registered Facility is not participating in AGC dispatch, it will be 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 Setpoint (or Dispatch Cap MW Setpoint) – the current required Dispatch Target (or Dispatch Cap); and
- Dispatch Ramp Rate Setpoint – 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.

3.3. Dispatch Caps

A 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.

Dispatch Cap setpoints which are non-negative indicate a limitation in the quantity of Injection (i.e. inject no more than that quantity). Dispatch Cap setpoints which are negative indicate a limitation in the quantity of Withdrawal (i.e. withdraw no more than the absolute value of that quantity).

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 indications are 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 provide FCESS via AGC or respond to any linear ramping setpoints from its SCADA system. When in this mode Market Participants are responsible for implementing any linear ramping requirements.
  - A status of "Remote" indicates that the Facility is able to respond to setpoints from AEMO.
- "Facility AGC Control Selection" – for Facilities being controlled via AEMO's AGC system
  - 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 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.

Regardless of whether the Facility is being controlled by AEMO or by the 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"[3] – the active ramp rate being used by the facility.

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

4.2. Additional AGC Indications

4.2.1. 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 DCS. This is to ensure that 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 Table 3.

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

4.2.2. AGC Control Mode Setpoint

The "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 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.

4.2.3. Basepoint Setpoint

The "AGC Basepoint Setpoint" is an internal number used by AEMO's AGC system to keep track of a Facilities underlying dispatch point. The "AGC Basepoint Setpoint" 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 linearly ramping the Facility (see Appendix C for an example); and/or
- the Facility is actively providing an FCESS service.

4.2.4. 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.

4.2.5. AGC Limit Setpoints

AEMO can send the current "High AGC Limit" and "Low AGC Limit" to Market Participants from its AGC system. When not active on AGC, these limits revert to the Basepoint. 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;
- 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;
- when cleared to provide Contingency Services, these limits are set based on cleared Contingency Raise or Contigency Lower quantities relative to the Facilty's Dispatch Target; 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 the ACE is outside of the ACE Normal Region.

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. Dispatch Instruction acknowledgement

Registered Facilities can acknowledge that they have received a Dispatch Instruction via the back-indication for the "Dispatch Target MW" point. Refer to the Facility Dispatch Process WEM Procedure for considerations around the use of this point as a method to acknowledge Dispatch Instructions.

4.5. Communications Failure

4.5.1. Registered Facility – AEMO Comms Failure

As per section 3.1.3 of the Communications and Control Systems WEM Procedure, a Registered Facility is expected to revert to local control where communication between AEMO's EMS and the Registered Facility fails.

4.5.2. 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), 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 going back into "Local" control due to short communication failures.

4.6. Self-Starting Facilities

Facilities that elect to manage their own starting and stopping (i.e. Registered Facilities not participating as Fast Start Facilities) must 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" must be set to "On"[4].

4.7. 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 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.

4.8. Facility Look-Ahead signals

A Registered Facility may choose to implement up to three 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

[4] 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

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 several minutes delay between the start of a Dispatch Interval, and an update to a Look-Ahead point.

Look-Ahead points are indicative only, and changes in dispatch conditions may result in different outcomes for the Primary Dispatch Interval.

4.9. Fast Start Facility signals

A Fast Start Facility must implement the relevant signals as per Appendix D of the Technical Specification: Operational Data Points for Registered Facilities. The Fast Start Facility must ensure that it is capable of starting and synchronising in accordance with the T1 value in its effective Dispatch Inflexibility Profile. During start-up and shut-down sequences, the “Facility AGC Control Selection” must be set to “Off”. Other information about the behaviour of Fast Start Facilities in dispatch is contained within the WEM Procedure: Dispatch Algorithm Formulation and the Facility Dispatch Process WEM Procedure.

Once a Fast Start Facility has synchronised and reaches the quantity provided under 7.4.44(e) in its effective Dispatch Inflexibility Profile, it can be switched to operate in AGC by setting the “Facility AGC Control Selection” to “On”. A Fast Start Facility must ensure that its telemetered high and low limits align with the Dispatch Inflexibility Profile once AGC control is enabled to ensure these limits are respected.

Participants opting to participate in fast start must specify how they wish to receive fast start commands from AEMO. This can be either via specified start/stop control points, or via the following reserved values in the Desired MW Setpoint:

Table 4 Desired MW Setpoint reserved values for Fast Start

Signal Description	Reserved Value
Facility Start	1001
Facility Starting	1002
Faciltiy Stop	1003
Facility Stopping	1004

In addition, AEMO can send the following indications to the Facility to support any local automation or alerting that 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 6, 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 5 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

5. Testing and Commisioning

All tests must be conducted under an approved Commissioning Test Plan. To commission a Registered Facility to participate with AGC, the following tests are required:

- Signals implemented by the Registered Facility are functioning and scanning correctly, and that updates to setpoints are acknowledged by the relevant feedback point within 10 seconds.
- Where a Registered Facility is participating in AEMO Linear Ramping, the Registered Facility can follow the updated Desired MW Setpoint values as issued by AEMO, and that the relevant delays and deadbands associated with the ramping process ensure Linear Ramping is achieved within the Tolerance Range or Facility Tolerance Range as applicable. Testing:
    - should 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;
    - should span at least 1 hour of active operation in order to confirm signal latency and identify potential communications issues; and
    - may require testing of AEMO Linear Ramping across different Injection and Withdrawal ranges and operating modes as applicable for the Registered Facility.
- Where a Registered Facility is not participating in AEMO Linear Ramping, when an updated Dispatch Target MW Setpoint is issued, the Registered Facility is able to reach the new target following a linear or near-linear trajectory within Tolerance Range or Facility Tolerance Range as applicable. This may require confirmation across different Injection and Withdrawal ranges and operating modes as applicable for the Registered Facility.
- When the AGC Control Mode is set to Manual (Mode 80 – see Appendix A), the Registered Facility ignores its Desired MW Setpoint values, and can be controlled locally, also confirming that the “Facility Target Net Setpoint” and “Facility Ramp Rate In Use” indications accurately reflect the local operation of the Facility.
- When a communication failure occurs, the Registered Facility moves to local control within timeframes as required in paragraph 4.5 of this document.
- Confirming that there are no step-changes in Injection or Withdrawal for various failover scenarios where there is redundant equipment installed (e.g. communications link failover, RTU failover).

- If the Registered Facility is intending to participate as a Fast Start Facility, confirmation that any fast start logic is working correctly (both for start and stop conditions). This may require AEMO to manually simulate fast start control signals.
- Where intending to participate in Regulation services, the tests must include those identified in the Guideline: Frequency Co-optimised Essential System Service Testing[5].
- Any other tests required by AEMO to ensure that the Registered Facility behaves appropriately in general operation.

Tests may include testing any additional logic implemented by Market Participants using signals issued by AEMO (e.g. lookahead signals).

[5] 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 6 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 (“Base None”).
- A Registered Facility participating in Energy and Regulation will be in mode 120 (“Base Full”).
- A Registered Facility Participating in Energy, Regulation, and Contingency Reserve will be in mode 120 (“Base Full”).
- A Registered Facility participating in Energy and Contingency Reserve will be in mode 110 (“Base Assist”) 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.

Note that for the purposes of Table 6 the mode names (e.g. “Base Full”) are a legacy from the previous XA/21 EMS, and reference to them is intended to be phased out over time.

Table 6 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 (Base None)	120 (Base Full)	110 (Base Assist)	120 (Base Full[6])
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.

[6] 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 1 AGC Dispatch Examples

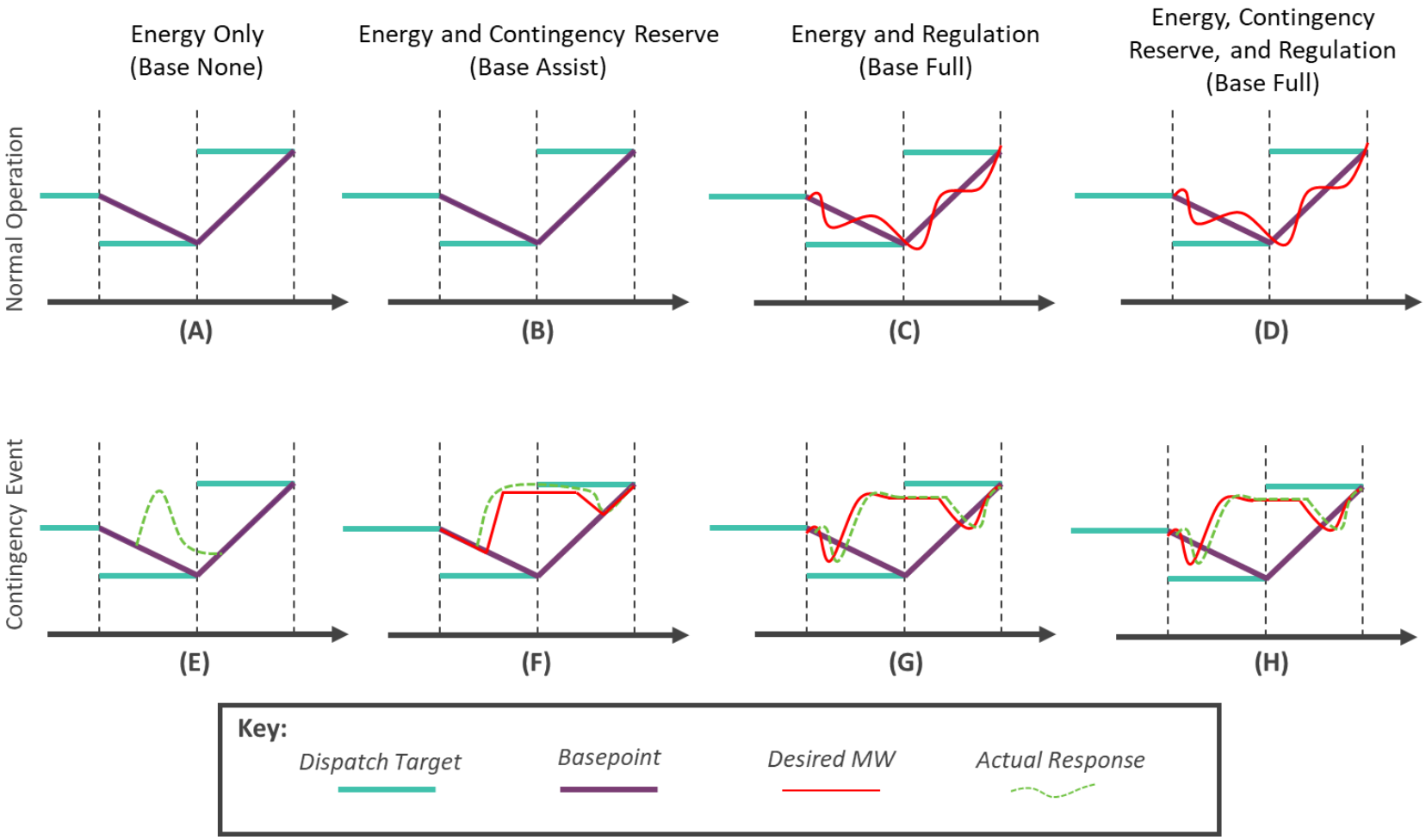


Figure 1 shows eight examples of scenarios of AGC dispatch in normal operation, and during and immediately after a Contingency Event. Note that these example are not exhaustive, and do not override any requirements of the WEM Rules, Generator Performance Standards, or directions or other instructions from AEMO. They are provided for informational purposes only.

B.1 Normal Operation (A): Energy Only – Base None

In normal dispatch, while in Base None (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 – Base Assist

In normal dispatch, while in Base Assist, a Registered Facility will behave as per section Appendix C of this Appendix. While the 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 – Base Full

In normal dispatch, while in Base Full, 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 – Base Full

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 – Base None

If a Contingency Event occurs while a Registered Facility is in Base None (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 – Base Assist

If a Contingency Event occurs while a Registered Facility is in Base Assist (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 – Base Full

If a Contingency Event occurs while a Registered Facility is in Base Full (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 – Base Full

If a Contingency Event occurs while a Registered Facility is in Base Full (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.

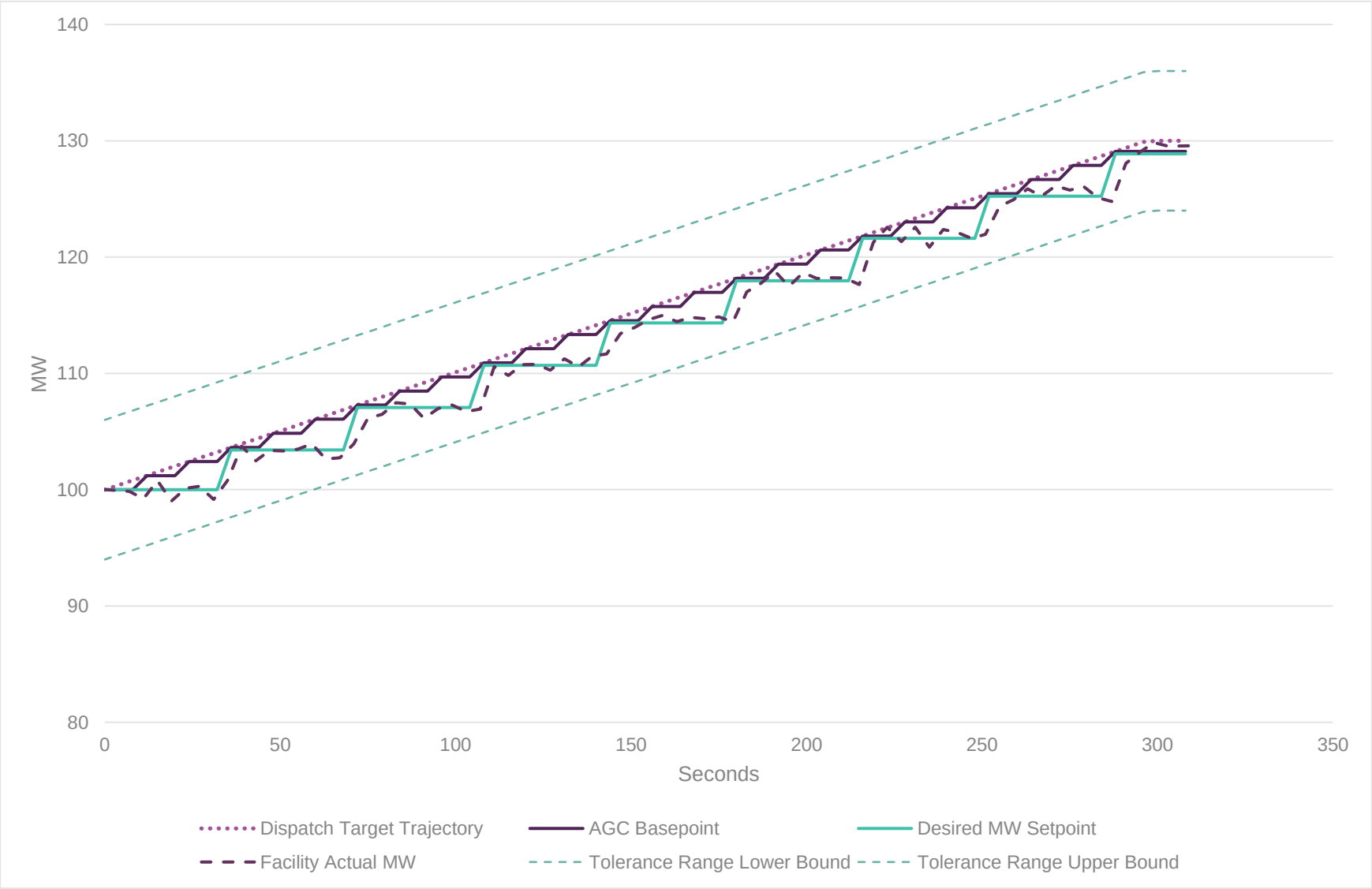
C.1 Scheduled Facility Linear ramping without Regulation enablement

In this example (see Figure 2), 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 7 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 2 Linear Ramping Example – Energy Only



C.2 Scheduled Facility Linear ramping with Regulation enablement

In this example (see Figure 3), 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 8 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 3 Linear Ramping Example – Energy and Regulation