Battery ESPS Grid Code Implementation Note

Version 3.0 – December 2021

Version History

Version	Date	Comment
1.0	June 2019	Initial Publication
2.0	June 2020	Updated to include further clarity on Grid Code Variations
3.0	December 2021	Updated in response to industry feedback, process for charging of battery ESPS units added, Black Start Shutdown section added.

Contents

Introduction

Battery Energy Storage Power Stations (ESPS) are classified as Power Park Modules (PPM) in the EirGrid and SONI Grid Codes. Battery ESPS with a registered capacity greater than 1 MW (EirGrid) / 5 MW (SONI) must be controllable and dispatchable.

At present, Grid Code requirements for PPMs are based on the Grid Code requirements developed for wind farms (WFPS). Version 1.0 of this Implementation Note on the integration of battery energy storage was published in June 2019 and examined the applicability or implementation of a subset of Grid Code clauses which are not suited to Battery ESPS.

Version 2.0 of this document superseded the original version published in June 2019. This document has been updated (version 3.0) to address industry feedback and include current information on the process for charging of battery units. This document aims to provide definitive guidance on the technical requirements for Battery ESPS and further elaborate on the applicability of specific clauses in both the SONI and EirGrid Grid Codes.

Further industry engagement regarding the treatment of energy storage (including Batteries) will take place via the FlexTech initiative. The European Network Code RfG is being revised to include requirements for energy storage, which will result in Grid Code modifications specific to Battery ESPS. EirGrid and SONI intend to support the derogations outlined herein until such a time as the SONI and EirGrid Grid Codes are modified to reflect requirements specific to Battery ESPS.

Units which are not Battery ESPS, but believe this implementation note should apply to them, should contact the TSOs to confirm.

Part A of this document lists the technical requirements published in the relevant jurisdictional Grid Code as applied to transmission-connected PPMs, and states the extent to which they apply to Battery ESPS. Where a Grid Code requirement is modified in order to be applied to Battery ESPS, the modified form of that requirement specific to Battery ESPS is detailed in Part B.

Note that in Part B, formatting is used to help the reader identify key variations when applying the SONI or EirGrid Grid Code, this is as follows:

- Normal font is used to describe characteristics that are required for both the SONI and EirGrid Grid Code
- Italics font is used to highlight specific characteristics that apply to either the SONI or EirGrid Grid Code.

Part A: Applicability of Grid Code Technical Requirements

Part A of this Implementation Note provides a summary view of the existing SONI and EirGrid Grid Code clauses that apply to PPMs and outlines how EirGrid and SONI intend for them to be applied to Battery ESPS, subject to further developments under FlexTech and EU Network Codes.

Tables A1 and Table A2 provide a reference to the General and Connection Condition clauses for PPMs connecting in Northern Ireland as identified in the SONI Grid Code[1].

Table A3 provides a reference to the PPM clauses of the EirGrid Grid Code version 8[2].

To assist the users of this Implementation Note, each table lists the requirements by Grid Code section and identifies the corresponding theme or technical area to which that section relates.

The applicability of each Grid Code section and sub-section is indicated in one of three ways:

- <u>Applies</u>
  Indicates that this section or sub-section of the Grid Code applies to Battery ESPS.

- <u>Does not apply</u>
  Indicates that this section or sub-section of the Grid Code should not apply (derogation applies) in respect of Battery ESPS (accompanied by a note to indicate why this section or sub-section should not apply).

- <u>Variation applies</u>
  Indicates that this section or sub-section of the Grid Code as written should not apply to Battery ESPS, but that a new or modified requirement applies in its place. The new or modified requirements to apply are contained in Part B of this document.

In the EirGrid and SONI Grid Codes, energy storage units are considered to be non-RfG, and as such when interpreting any sections stated to apply to Battery ESPS, any sub-sections or clauses marked with the RfG symbol  do not apply.

[1] http://www.soni.ltd.uk/media/documents/SONI-GridCode-Version-Feb2020.pdf
[2] http://www.eirgridgroup.com/site-files/library/EirGrid/Grid-Code.pdf

Table A1: SONI Grid Code General Connection Conditions

Grid Code Section	Theme	Grid Code Sub-Section	Applicability to Battery ESPS
CC1	Introduction	CC1.1	Applies
		CC1.2	Applies
		CC1.3	Applies
		CC1.4	Applies
		CC1.5	Applies
CC2	Objectives	CC2.1	Applies
CC3	Scope	CC3.1	Applies
		CC3.2	Applies
		CC3.3	Applies
CC4	Connection Principles	CC4.1	Applies
		CC4.2	Applies
		CC4.3	Applies
CC5	Supply Standards	CC5.1	Applies
		CC5.2	Applies
		CC5.3	Applies
		CC5.4	Applies
		CC5.5	Applies
		CC5.6	Applies
CC6	Technical Criteria	CC6.1	Applies
		CC6.2	Applies
		CC6.3	Applies
		CC6.4	Applies
		CC6.5	Applies
		CC6.6	Applies
		CC6.7	Applies
		CC6.8	Applies
		CC6.9	Applies
		CC6.10	Applies

CC7	Technical Criteria	CC7.1	Applies
		CC7.2	Applies
		CC7.3	Applies

CC8	Technical Criteria	CC8.1	Applies
		CC8.2	Applies
		CC8.3	Applies
		CC8.4	Applies
		CC8.5	Applies
		CC8.6	Applies
		CC8.7	Applies
		CC8.8	Does not apply. Distribution Connections only

CC9	Site Related Conditions	CC9.1	Applies
		CC9.2	Applies
		CC9.3	Applies
		CC9.4	Applies
		CC9.5	Applies

CC10	Approval To Connect	CC10.1	Applies
		CC10.2	Applies
		CC10.3	Applies

CC11	Distribution Connections	-	Does not apply. Distribution connections only

CC12	Generator Aggregators	CC12.1	Does not apply. Aggregators only

CC13	Demand Side Units	-	Does not apply. Demand Side Units only

CC14	Fuel Security Code	CC14.1	Applies

Table A2: SONI Grid Code Connection Conditions Schedule 2 Part 1

Grid Code Section	Theme	Grid Code Sub-Section	Applicability to Battery ESPS
CC.S2.1.1	Applicability		Applies
CC.S2.1.2	PPM Connections		Applies
CC.S2.1.3	PPM Performance Requirements	CC.S2.1.3.1	Applies
		CC.S2.1.3.2	Variation applies. See sections B.4 & B.5
		CC.S2.1.3.3	Does not apply. RfG plant only
		CC.S2.1.3.4	Does not apply. RfG plant only
		CC.S2.1.3.5	Does not apply. RfG plant only
		CC.S2.1.3.6	Applies
		CC.S2.1.3.7	Does not apply. Resource-dependent PPM only
		CC.S2.1.3.8	Applies
		CC.S2.1.3.9	Applies
CC.S2.1.4	PPM Performance Requirements (RfG)	CC.S2.1.4	Does not apply. RfG plant only
		CC.S2.1.4.1	Does not apply. RfG plant only
		CC.S2.1.4.2	Does not apply. RfG plant only
		CC.S2.1.4.3	Does not apply. RfG plant only
		CC.S2.1.4.4	Does not apply. RfG plant only
		CC.S2.1.4.5	Does not apply. RfG plant only
		CC.S2.1.4.6	Does not apply. RfG plant only
CC.S2.1.5	Ramp Rates		Variation applies. See section B.2
CC.S2.1.6	Black Start		Applies
CC.S2.1.7	Control Arrangements	CC.S2.1.7.1	Applies
		CC.S2.1.7.2	Variation applies. See section B.3
		CC.S2.1.7.3	Applies
		CC.S2.1.7.4	Applies
CC.S2.1.8	Protection	CC.S2.1.8.1	Applies
		CC.S2.1.8.2	Applies
		CC.S2.1.8.3	Applies
		CC.S2.1.8.4	Applies
		CC.S2.1.8.5	Applies
		CC.S2.1.8.6	Applies

		CC.S2.1.8.7	Applies

CC.S2.1.9	Negative Phase Sequence Loadings		Applies

CC.S2.1.10	Neutral Earthing	CC.S2.1.10.1	Applies

CC.S2.1.11	Automatic Load Shedding	CC.S2.1.11.1	Applies
		CC.S2.1.11.2	Applies
		CC.S2.1.11.3	Applies

CC.S2.1.12	Additional Information	CC.S2.1.12.1	Does not apply. WFPS only
		CC.S2.1.12.2	Applies
		CC.S2.1.12.3	Applies

Table A3: EirGrid Grid Code PPM Section

Grid Code Section	Subject/Topic	EirGrid Grid Code Clause	Applicability to Battery ESPS
PPM1.1	Introduction	PPM1.1	Applies
PPM1.2	Objective	PPM1.2	Applies
PPM1.3	Scope	PPM1.3.1	Applies
	Scope	PPM1.3.2	Applies (Note: in the list of applicable OC clauses identified in PPM1.3.2 OC6.7 should refer to OC7)
PPM1.4	Fault Ride Through Requirements	PPM1.4.1	Applies
		PPM1.4.2	Applies
PPM1.5	Transmission System Frequency Ranges	PPM 1.5.1	Applies
	Active Power Management	PPM 1.5.2	Applies
	Active Power Control	PPM1.5.2.1	Variation applies – see Section B.1
	Frequency Response	PPM1.5.3.1	Variation applies – see Section B.2 and B.3
		PPM1.5.3.2	Variation applies – see Section B.1 and B.3
		PPM1.5.3.3	Variation applies - see section B.2 and B.3)
		PPM1.5.3.4	Does not apply
		PPM1.5.3.5	Does not apply
		PPM1.5.3.6	Variation applies – see Section B.3
		PPM1.5.3.7	Variation applies – see Section B.3
		PPM1.5.3.8	Applies
		PPM1.5.3.9	Applies
		PPM1.5.3.10	Does not apply
		PPM1.5.3.11, PPM1.5.3.12, PPM1.5.3.13, PPM1.5.3.14	RfG clauses – do not apply
	Procedure for setting and changing curve parameters	PPM1.5.3.15	Variation applies – See Section B.3
	Ramp rates	PPM1.5.4.1	Variation applies – See Section B.2
	Ramp rates	PPM1.5.4.2	Variation applies – See Section B.2
	Procedure for setting and changing the ramp rate control	PPM1.5.4.3	Applies
PPM1.6	Transmission System Voltage Range	PPM1.6.1	Variation applies – see Section B.4
	Automatic Voltage Regulation	PPM1.6.2.1	Applies
	Reactive Power Control Modes	PPM1.6.2.2	Variation applies – see Section B.4
	Voltage Regulation System Slope Setting	PPM1.6.2.3	Applies
	Speed of response	PPM1.6.2.4	Applies

	Reactive Power Capability	PPM1.6.3.1	Variation – See section B.4 & B.5
		PPM1.6.3.2	Applies
		PPM1.6.3.3	Applies
		PPM1.6.3.4	RfG clauses – do not apply
	Voltage step emissions	PPM1.6.4	Applies
	Grid connected transformer	PPM1.6.5.1 & PPM1.6.5.2	Applies
PPM1.7	Signals, Communication & Control	PPM1.7.1	Applies – reference to Signal List #2 does not apply (see PPM1.7.1.2)
	Signal List #1	PPM1.7.1.1	Applies
	Signal List #2	PPM 1.7.1.2 -All subsections	Does not apply
	Signal List #3	PPM1.7.1.3.1 & PPM1.7.1.3.2	Does not apply
	Signal List #3	PPM1.7.1.3.3 & PPM1.7.1.3.4	Variation applies PPM resource related signals – refer to unit specific signal list
	Signal List #4	PPM1.7.1.4	Applies
	Signal List #5	PPM1.7.1.5	Variation applies – see unit specific signal list and Section B.3 and B.6
	Time delays and data quality	PPM1.7.1.6	Applies - References to meteorological signals does not apply- see PPM1.7.1.2
	Control signals	PPM1.7.2.1	Applies
	APC signals	PPM1.7.2.2	Applies
	Frequency response signals	PPM1.7.2.3	Variation – see Section B.3, B.6 and unit specific signal list
	Voltage regulation signals	PPM1.7.2.4	Applies
	Black Start Shutdown	PPM1.7.2.5	Does not apply for battery only projects – see Section B.7.
	Time Delays and Data Quality	PPM1.7.2.6	Applies
	Responsible operator	PPM1.7.3	Applies
	Data and Communications Specifications	PPM1.7.4.1, PPM1.7.4.2, PPM1.7.4.3, PPM1.7.4.4, & PPM1.7.4.5	Applies
	Resource forecasts	PPM1.7.5.1 PPM1.7.5.2	Applies
	MW availability declarations	PPM1.7.6	Applies

Part B: New and Modified Requirements

B.1 Active Power Control (APC)

SONI Grid Code derogations for CC.S2.1.5
EirGrid Grid Code derogations for PPM1.5.2.1, PPM1.5.3.2

A Battery ESPS will be required to achieve any MW set point instructed by the TSO within its Operating Range, assuming that it has sufficient energy or capacity to do so. The Operating Range of a Battery ESPS is the region between its maximum active power export capability and maximum active power import capability. Maximum active power export and import capabilities may be determined by a number of technical and contractual factors.

Battery ESPS control system shall be capable of adjusting the MW import/export of the Battery ESPS on receipt of an input. That input may be either;

- a MW set point issued by the TSO via SCADA; or
- an operator input, following receipt of a dispatch instruction via EDIL (Electronic Dispatch Instruction Logger)

The TSO may use SCADA *(APC in Ireland or Emergency Action in Northern Ireland)* to issue instructions directly to the Battery ESPS control system.

EDIL is an interface between TSO and a responsible operator for the Battery ESPS. The Battery ESPS Operator must be capable of interacting with the TSO via EDIL to declare availability and receive/acknowledge Dispatch Instructions.

If Active Power Control (APC) or Emergency Action is turned ON, the set-point issued via that control scheme should take precedent over an instruction issued via EDIL.

When APC or Emergency Action is turned off, the unit should ramp to 0 MW output[3] at the Active Power Control Set-Point Ramp Rate, unless subsequently instructed otherwise by the TSO (via EDIL).

In addition to the above guidance, there is currently a MW level of Pre-Agreed charging that is acceptable as instructed by the TSO (via EDIL). Please note the below reflects the arrangements at time of publication and are subject to change. This arrangement may be superseded in future publications. The Pre-Agreed MW load level that a Battery unit can charge at must be within the following range;

From zero MW up to the lower of

- 5MW or
- 20% of MEC or
- MIC (MW level is import level)

[3] The TSO accepts that there may be some level of import required to manage house load in this scenario. The battery should not be discharging or charging while APC/EA is OFF, but may import due to house load.

The charging MW level can vary as deemed appropriate by the battery unit within the above range. Any charging required by the battery outside that range should only be by explicit MW instruction from the TSO.

Any MW instruction from control centre (via EDIL) should override the pre-agreed charging as requested. The Pre-Agreed charging should also be over-ridden by the Active Power Control (APC) or Emergency Action as applicable.

In cases where the TSO believes the Pre-Agreed charging MW would affect the system security, the TSO will issue a zero MW instruction[4] to battery units to notify that Pre-Agreed charging is temporarily unavailable (via EDIL message appended to a MW instruction). Once the system security event has passed the TSO will notify the battery units (via EDIL) with another message that Pre-Agreed charging is available again.

EirGrid: *PPM.1.5.3.2 states that, when APC is ON, PPMs should operate with a deadband of +/-15mHz, unless otherwise agreed with the TSO. For Battery ESPS, there should be no change to deadband or trigger settings when APC is switched on, the settings should remain as per the current active Mode settings, see Section B.3 below.*

[4] The TSO accepts that there may be some level of import required to manage house load in this scenario. The battery should not be discharging or charging while APC/EA is OFF, but may import due to house load.

B.2 Ramp Rates

SONI Grid Code derogations for CC.S2.1.5
EirGrid Grid Code derogations for PPM1.5.3.1, PPM1.5.3.3, PPM1.5.4.1, PPM1.5.4.2

Battery ESPS are required to be capable of operating to three separate active power ramp rates:

- Active Power Control Set-Point Ramp Rate
- Frequency Response Ramp Rate
- Capacity Limited Ramp Rate

Active Power Control Set-Point Ramp Rate and Frequency Response Ramp Rate are established concepts for PPMs, but Capacity Limited Ramp Rate is a new requirement specific to Battery ESPS, necessitated by the capacity-limited nature of storage. For the avoidance of doubt, Resource Following Ramp Rate as defined in the current SONI and EirGrid Grid Codes does not apply to Battery ESPS.

Active Power Control Set-Point Ramp Rate

Active Power Control Set-Point Ramp Rate describes the rate of change of active power which must be achieved by a Battery ESPS in response to an active power set point (via SCADA) or EDIL instruction as issued by the TSO.

A Battery ESPS must be capable of implementing an Active Power Control Set-Point Ramp Rate anywhere in a range between 1% and 100% of Registered Capacity per minute.

This requirement of a 1-100% Registered Capacity per minute range is as per existing PPM Grid Code requirements. The TSOs do not anticipate setting ESPS units to ramp rates as low as 1%. Further consultation on an appropriate range for battery units may be carried out when implementing future Grid Code modifications.

SONI: *The Active Power Control Set-Point Ramp Rate which applies at any given time shall be issued by the TSO via a SCADA signal.*

EirGrid: *The ramp rate settings shall be specified by the TSO in the unit specific signal list.*

Frequency Response Ramp Rate

Frequency Response Ramp Rate is a Battery ESPSs rate of change of active power when providing a frequency response.

Battery ESPS are required to be compliant with the frequency response ramp rates outlined in the SONI and EirGrid Grid Codes for both over and under frequency events, over the Battery ESPS operating range. This is a minimum ramp rate requirement and it is acknowledged that batteries will be likely to far exceed this minimum requirement.

EirGrid:

- *As per PPM 1.5.3.3: When acting to control Transmission System Frequency, the Controllable PPM shall provide at least 60% of its expected additional Active Power response within 5 seconds, and 100% of its expected additional Active Power response within 15 seconds of the start of the Transmission System Frequency excursion outside the deadband or trigger frequency setting.*

SONI:

In the SONI Grid Code, Frequency Response Ramp Rate is defined in terms of a primary and secondary response capability:

- *Primary Response capability of the Battery ESPS (Available by 5s and sustained to 15s): 60% of expected MW Output change value based on droop characteristic. (This is an absolute minimum and if Battery ESPS can offer a larger response within 5 seconds they should do so).*
- *Secondary Response capability of the Battery ESPS (Available by 15s and sustained to 90s): 100% of expected MW Output change value based on droop characteristic. (This is an absolute minimum and if Battery ESPS can offer a larger response within 15 seconds they should do so).*

<u>Capacity Limited Ramp Rate</u>

Capacity Limited Ramp Rate describes the manner in which a Battery ESPS must control its active power import/export as it approaches the limits of its energy capacity.

It is recognised that a Battery ESPS is a storage device with finite energy capacity, and as such, cannot continue to import or export energy indefinitely. It is therefore important to put in place requirements to govern the behaviour of a Battery ESPS in the following conditions:

1. When a Battery ESPS is exporting (discharging) to the system, either in response to an active power set-point or frequency, and is running low on remaining stored energy, and;
2. When a Battery ESPS is importing (charging) from the system, either in response to an active power set-point or frequency, and is approaching full energy capacity.

For a Battery ESPS to respond to either of the above conditions by stepping or ramping sharply to zero active power is undesirable due to the potential effect on power system stability. The required behaviour is a controlled and predictable reduction in MW response as defined by this Capacity Limited Ramp Rate.

On approach to either of the limits described above, a Battery ESPS is required to be capable of ramping to zero MW in a linear fashion at a specified rate between 1% and 100% per minute of Registered Capacity as applicable.

A Battery ESPS control system must be capable of taking into account the prevailing Capacity Limited Ramp Rate and calculating, based on the current import or export MW set-point, the energy volume required to ramp to zero from that set-point. As the Battery ESPS ramps in response to a fully charged or fully depleted state, it is also expected that the unit will provide Frequency Response in the direction at which there is ‘capacity available’.

SONI: *The Capacity Limited Ramp Rate which applies at any given time shall be specified by the TSO in the PPM Settings Schedule.*

EirGrid: *The Capacity Limited Ramp Rate settings shall be specified by the TSO in the unit specific signal list.*

Example 1 – Battery ESPS Exporting:

Figure 1 below shows a Battery ESPS exporting at a constant rate and approaching a fully depleted state.

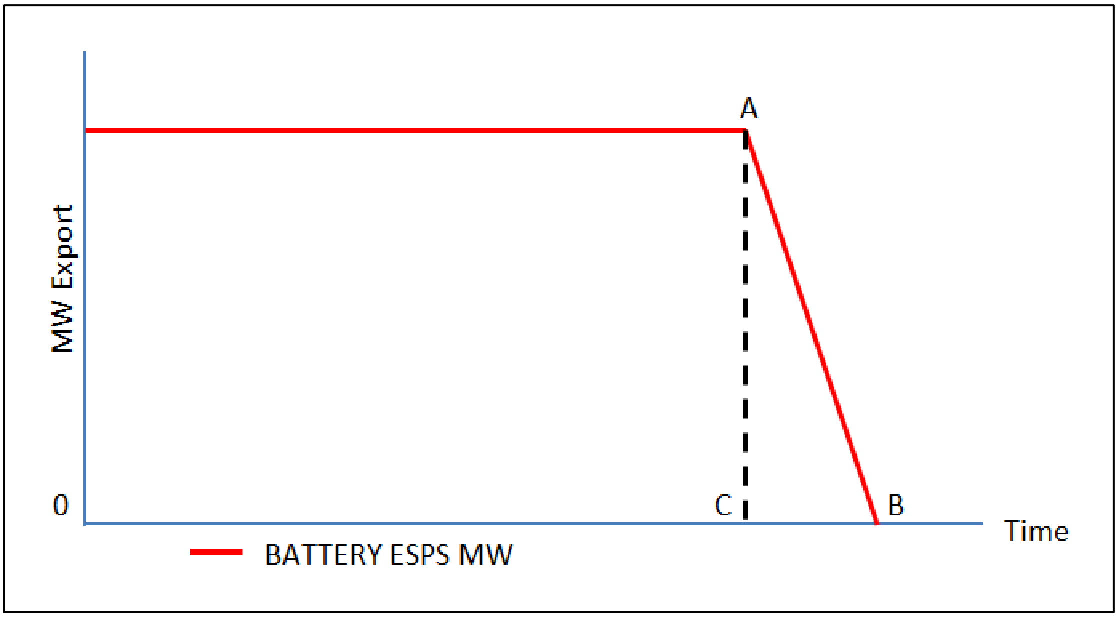


Figure 1 Capacity Limited Ramp Rate from Export

The Battery ESPS controller will be required to calculate ‘Point A’, the point at which it has just enough remaining stored energy to ramp to zero MW at the pre-defined Capacity Limited Ramp Rate. I.e. the energy volume represented by the area bounded by the triangle A-B-C is equal to the remaining stored energy and the gradient of line A-B represents the Capacity Limited Ramp Rate in effect as specified by the TSO.

On reaching ‘Point A’ the Battery is required to commence a ramp to zero at the Capacity Limited Ramp Rate. In this case, the line A-B represents a cap on the active power exported by the Battery ESPS. During the ramp down from A to B, the Battery ESPS MW export must not exceed line A-B in response to an active power set point or in response to frequency. The Battery ESPS MW response may however, reduce below line A-B (and enter an import state) in response to an active power set-point or in response to an increase in system frequency.

Example 2 – Battery ESPS Importing:

Figure 2 below shows a Battery ESPS importing at a constant rate and approaching a fully charged state.

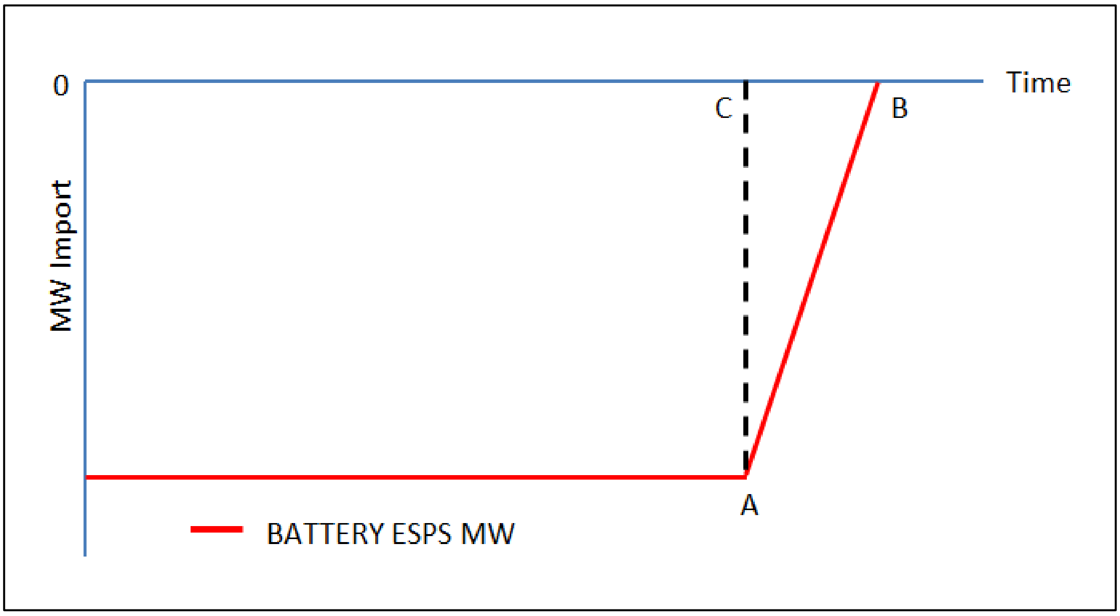


Figure 2 Capacity Limited Ramp Rate from Import

The gradient of line A-B represents the Capacity Limited Ramp Rate in effect as specified by the TSO. The Battery ESPS controller will be required to calculate 'Point A', the point at which it has just enough remaining storage capacity to ramp to zero MW at the pre-defined Capacity Limited Ramp Rate (i.e. the energy volume represented by the area bounded by the triangle A-B-C). On reaching 'Point A' the Battery is required to commence ramping to zero at the Capacity Limited Ramp Rate.

In this case, the line A-B represents a cap on the active power imported by the Battery ESPS. During the ramp down from A to B, the Battery ESPS MW import must not exceed line A-B in response to an active power set point or in response to frequency. The Battery ESPS MW response may however, rise above line A-B (and enter an export state) in response to an active power set-point or in response to a decrease in system frequency.

<u>Ramp Rate Priority</u>

All three ramp rates co-exist and a Battery ESPS control system must prioritise the ramp rates in the following order;

1. Capacity Limited Ramp Rate
2. Frequency Response Ramp Rate
3. Active Power Control Set-Point Ramp Rate

The ESPS should calculate and apply a delta MW response, based on system frequency and MW/Hz slope as per active mode setting.

Note the MW output should not be latched to this initial response value. It is expected that the PPM controller continuously recalculates its expected response during the frequency excursion.

If the ESPS has entered Capacity Limited Ramp, it should continue to respond to frequency from a base MW value which is equal to the lesser* of:

a) the current MW set-point**, taking into account the applicable APC ramp rate if a new MW set point has been issued, and;
b) The instantaneous point on the line A-B

In doing so, the MW export/import of the ESPS must not exceed*** the line A-B.

If a frequency response is required while the ESPS is not limited in terms of energy or storage capacity, the delta MW should be applied to the current MW set-point** taking into account the applicable APC ramp rate if a new MW set point has been issued. If ramping at APC ramp rate in this scenario, the delta MW should be applied as an offset to the ramp.

*Lesser meaning closer to zero in both export and import
** APC/EA set-point or EDIL Dispatch Instruction. This includes a pre-agreed charging level not implemented via APC or an EDIL Dispatch Instruction
***Exceed meaning move further from zero in both export and import

B.3 Frequency Response

SONI Grid Code derogations for CC.S2.1.7.2
EirGrid Grid Code derogations for PPM1.5.3.1, PPM1.5.3.2, PPM1.5.3.3, PPM1.5.3.6, PPM1.5.3.7, PPM1.5.3.15 (also PPM1.7.1.5, PPM1.7.2.3)

Battery ESPS must be capable of;

- contributing to the control of system frequency by modulation of active power.
- responding to both high and low frequency conditions from a baseline active power output anywhere within their Operating Range, including at zero MW output. Frequency response is not expected to extend beyond the limits of Operating Range.
- accommodating five separate programmable Frequency Response Modes. Each mode shall be represented by a response curve described in terms of the parameters listed below (see 'Response Characteristics and Performance').

The TSO will have the functionality to;

- toggle between the Frequency Response Modes via SCADA signals
- turn Frequency Response on and off via a SCADA signal

When Frequency Response is 'ON', the battery ESPS shall respond to system frequency in line with the specified frequency response settings for the active frequency mode. When Frequency Response is turned 'OFF', the Battery ESPS shall not respond to any changes in system frequency.

The selected Frequency Response Mode (and feedback) shall not be affected by the Frequency Response status (ON / OFF) i.e. the Frequency Response Mode does not change, nor should the feedback signal go suspect.

Note on Frequency Response ON/OFF control

RES ON / RES OFF instructions can be automatically generated within EDIL when NCC/CHCC issues dispatch instructions. The TSOs manage frequency response modes as well as frequency response on/off using SCADA (via EMS). Therefore if a battery operator receives a dispatch instruction via EDIL, together with RES ON or RES OFF, they should not interpret this as an instruction to (and hence should not) turn frequency response on or off.

For the avoidance of doubt, Frequency Response status will be under control of CHCC/NCC during normal operation, the ESPS should not turn Frequency Response ON or OFF during normal operation, unless instructed to do so by the TSO.

Response Characteristic & Parameters

A Battery ESPS frequency response characteristic and the parameters used to describe it are shown in Figure 3.

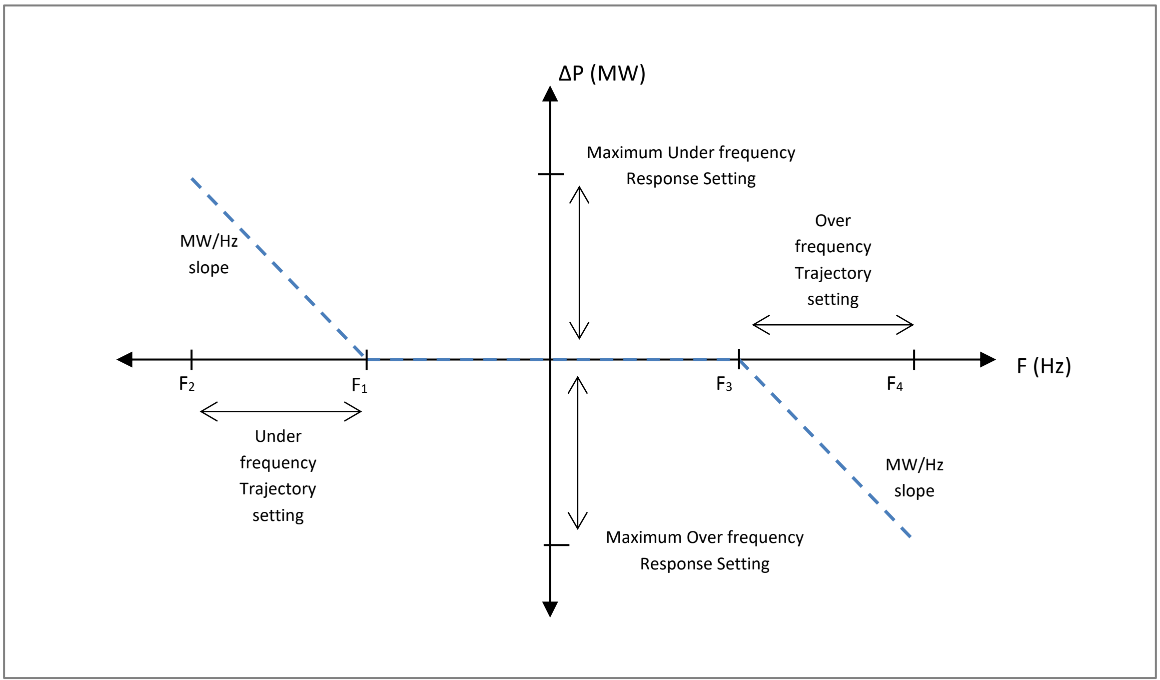


Figure 3 Battery ESPS Frequency Response Characteristic & Parameters

Where the characteristics are defined as follows:

No.	Characteristic	Description
1	F	System frequency at any given time
2	ΔP	Change in active power output, due to change in system frequency
3*	Under frequency trigger frequency (F_1)	Frequency at which the unit begins to provide under frequency response
4	F_2	Frequency at which the unit would achieve its maximum under frequency response setting (F1 - Under frequency trajectory setting)
5*	Over frequency trigger frequency (F_3)	Frequency at which the unit begins to provide over frequency response
6	F_4	Frequency at which the unit would achieve its maximum over frequency response setting (F3 + Over frequency trajectory setting)
7*	Under frequency trajectory	The magnitude of the change in Frequency over which the unit would deliver its Maximum Under frequency Response Setting (if it was not limited by capacity or availability)
8*	Over frequency trajectory	The magnitude of the change in Frequency over which the unit would deliver its Maximum Over frequency Response Setting (if it was not limited by capacity or availability)
9*	Maximum Under frequency Response	Maximum increase in active power which the unit will provide in response to under frequency
10*	Maximum Over frequency Response	Maximum reduction in active power which the unit will provide in response to over frequency

* Settings accompanied with an astrix are the settable parameters which define frequency response in modes 1-5.

The slope in terms of MW/Hz is defined only by the Maximum Response setting and the trajectory, as defined for each Mode.

The under frequency settings defined in frequency response modes 1-5 shall be implemented as follows:

- ∆P is applied as a deviation from the Battery ESPS set-point at any given time. It is important to note that this ∆P may move the Battery ESPS from a nominal import set-point to an export position
- In line with the System Services Protocol, the slope of MW/Hz characteristic (or droop) is defined by a combination of the Maximum Under frequency Response setting (MW) and Trajectory setting (Hz). e.g. settings of 10 MW and 0.5 Hz, respectively would give a characteristic of 20 MW/Hz.
- When the frequency drops below the Trigger Frequency setting (F1), the Battery ESPS will immediately increase its export (and/or reduce its import) in line with this characteristic. (As the frequency changes, the Battery ESPS will continue to adjust the ∆P in line with that characteristic.)
- Under frequency Response (∆P) will be limited by the lesser of availability, Maximum Under frequency Response setting, maximum capacity (accounting for MEC), and application of the Capacity Limited Ramp Rate.

The over frequency settings defined in frequency response modes 1-5 shall be implemented as follows:

- ∆P is applied as a deviation from the Battery ESPS set-point at any given time. It is important to note that this ∆P may move the Battery ESPS from a nominal export set-point to an import position
- In line with the System Services Protocol, the slope of MW/Hz characteristic (or droop) is defined by a combination of the Maximum Over frequency Response setting (MW) and Trajectory setting (Hz). e.g. settings of 10 MW and 0.5 Hz, respectively would give a characteristic of 20 MW/Hz.
- When the frequency increases above the Trigger Frequency setting (F3), the Battery ESPS will immediately reduce its export (and/or increase its import) in line with this characteristic. (As the frequency changes, the Battery ESPS will continue to adjust the ∆P in line with that characteristic.)
- Over frequency Response (∆P) will be limited by the lesser of availability, Maximum Over frequency Response setting, maximum capacity (accounting for MIC[5]), and application of the Capacity Limited Ramp Rate.

[5] For IE TSO units: MIC to be converted from MVA to MW (as defined in Connection Agreement) using fixed 0.95 Power Factor and MW limiter to be applied.
This is to be confirmed for IE DSO units, and for SONI units.

Appendix 1 provides a number of examples to further demonstrate how frequency response should be provided by Battery ESPS in various states of charge and at different points within the operating range of the unit.

As a minimum requirement, Battery ESPS must be capable of operating with parameters set anywhere in the following ranges:

EirGrid:	*Under frequency Trigger F1:*	*49.5Hz – 50Hz*
	Under frequency Trajectory F1-F2:	*1Hz – 5Hz*
	Maximum Under frequency Response:	*0MW – Operating Range*
	Over frequency Trigger F3:	*50Hz – 50.5Hz*
	Over frequency Trajectory F3-F4:	*1Hz – 5Hz*
	Maximum Over frequency Response:	*0MW – Operating Range*

(Equivalent to a droop range of 2%-10% with deadbands between 49.5Hz and 50Hz under frequency and 50Hz and 50.5Hz over frequency)

SONI:	*Under frequency Trigger F1:*	*49Hz – 50Hz*
	Under frequency Trajectory F1-F2:	*1Hz – 10Hz*
	Maximum Under frequency Response:	*0MW – Operating Range*
	Over frequency Trigger F3:	*50Hz – 51Hz*
	Over frequency Trajectory F3-F4:	*1Hz – 10Hz*
	Maximum Over frequency Response:	*0MW – Operating Range*

(Equivalent to a droop range of 2%-20% with deadbands between 49Hz and 50Hz under frequency and 50Hz and 51Hz over frequency)

The ranges above represent the Grid Code requirements and are reflective of the current PPM requirements. The TSOs do not intend to specify settings for a battery ESPS unit that are more onerous than the settings reflected in their System Services contract. These mode settings will be discussed and provided in advance of energisation.

Further consultation on appropriate minimum requirements for battery units may be carried out when implementing future Grid Code modifications.

Clarification of terms

It is noted that terms such as “trajectory” are used elsewhere in DS3 System Services documentation. The terms above refer to the operational performance characteristics of the unit and will be specified in such a way to cover the full operating range of the unit. There may be a scenario where a unit may choose to contract for a lesser volume than the max response setting value. In this case the contracted trajectory value will be calculated in relation to the contracted volume, such that the MW/Hz slope remains the same as defined by the mode settings. The unit would still be expected to provide frequency response as per the active mode settings, over the full operating range, but only the contracted value would be assessed in terms of System Services performance monitoring.

Please see Appendix 2 for further examples.

Volume Capped Units

The above examples assume a symmetric deadband and MW/Hz slope for under-frequency and over-frequency. The TSOs are aware that there are some units with fixed Volume Capped contracts that may require specific frequency response curves to meet the pre-defined contracted volumes and parameters for these contracts. This will be accommodated in the Mode settings when issued. Please note it is still expected that a unit has the capability to comply with the settings as per Section B3.

EirGrid:

Figure 3 replaces Figure PPM1.2 in the Grid Code. This response curve will replace references to Frequency Response Curves 1 and 2 in the PPM sections of the Grid Code. Points F1, F2, F3 and F4 will replace references to points A, B, C, D, E in the Grid Code. Requirements for deadband setting range and droop response will remain as per the Grid Code.

PPM1.5.3.2 refers to operation in a frequency sensitive mode when APC is on. For Battery ESPS turning APC on or off will not impact the Battery ESPS sensitivity to frequency. If Frequency Response is on, the Battery ESPS shall operate as per enabled mode (1-5), regardless of APC status.

PPM1.5.3.5 refers to the expected PPM response when the frequency exceeds Fd and Fe. The battery ESPS should follow the curve as outlined above for F3 and F4.

The unit specific signal list sets out five settings for these parameters corresponding to the five frequency modes. The process for setting and changing the settings for these mode parameters is as outlined in PPM1.5.3.15.

SONI:

The parameter settings required by the Grid Code will be specified in the PPM Settings Schedule.

B.4 Reactive Power Control

SONI Grid Code derogations for CC.S2.1.3.2
EirGrid Grid Code derogations for PPM1.6.1, PPM1.6.2.2, PPM1.6.3.1

A Battery ESPS is required to have a continuously variable and continuously acting voltage regulation system, capable of maintaining power factor and reactive power set-points at the connection point, and capable of receiving a voltage regulation set-point for the voltage at the connection point.

There are three Reactive Power Control modes:

- Voltage Control mode
- Power factor control mode
- Reactive Power Dispatch (reactive power control mode in IE)

All of these voltage control modes are established requirements for PPMs.

Reactive Power Dispatch / control modes

The Battery ESPS controller will be required to maintain the effective MVAr set-point during changes to active power export or import, including through zero MW.

Regarding power factor control mode, the convention shall be that export of MVArs from the Battery ESPS is always positive, and absorption of MVArs is always negative. For example; at 50MW export, an 18 degree power factor set-point will result in a reactive power export of 16.25 MVAr, and a -18 degree set-point will give -16.25MVAr. At 50MW import, an 18 degree power factor set-point will result in a reactive power export of 16.25 MVAr, and a -18 degree set-point will give -16.25MVAr.

SONI: *A Battery ESPS shall continuously control voltage at the Connection Point within its Reactive Power capability limits. For Battery ESPS, the minimum Reactive Power capability is defined in the characteristic in Figure 4 of section B.5, within the voltage limits specified under CC5.4.*

There are three Voltage Control modes:

(i) Voltage Control mode
(ii) Power Factor Control mode
(iii) Reactive Power Dispatch

In all three modes, the reactive capability of the Battery ESPS is defined by the envelope ABCD in Figure 4. For the avoidance of doubt, all measurements refer to the Connection Point. Battery ESPS must be capable of responding to variations in the voltage of the NI System in accordance with CC5.4

EirGrid: *PPM 1.6.1 states that PPMs shall remain continuously connected to the transmission System over a specified range of voltages and conditions. The Grid Code states PPMs should remain connected at max Available Active Power or controlled Active power output. Battery ESPs should remain connected at controlled active power output or frequency response output.*

B.5 Reactive Power Capability

SONI Grid Code derogations for CC.S2.1.3.2
EirGrid Grid Code derogations for PPM1.6.1, PPM1.6.3.1

The minimum required reactive capability characteristic of a Battery ESPS is described in Figure 4, where P represents active power, and Q represents reactive power.

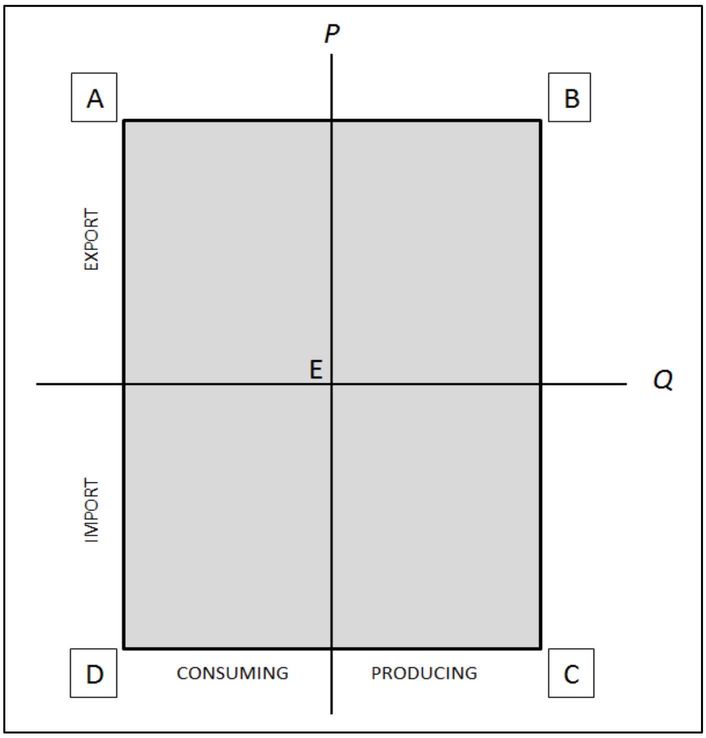


Figure 4 Minimum Reactive Capability Characteristic of Battery ESPS at Connection Point

- Point A represents the Registered Capacity of the battery and a Q/P ratio of -0.33, equivalent to a leading power factor of -0.95. This is the minimum MVAr absorption capability required at 100% Registered Capacity.
- Point B represents the Registered Capacity of the battery and a Q/P ratio of 0.33, equivalent to a lagging power factor of 0.95. This is the minimum MVAr production capability required at 100% Registered Capacity.
- Point C represents the minimum MVAr production capability required at MIC[6] of the battery and a Q capability equal to that at point B.
- Point D represents the minimum MVAr absorption capability required at MIC[7] of the battery and a Q capability equal to that at point A.
- Point E is the intersection of the P and Q axes and represents zero active or reactive power flow.

[6] For IE TSO units: MIC to be converted from MVA to MW (as defined in Connection Agreement) using fixed 0.95 Power Factor and MW limiter to be applied.
This is to be confirmed for IE DSO units, and for SONI units.
[7] See footnote above

For the avoidance of doubt, Figure 4 describes a Battery ESPS whose Operating Range is symmetric about zero. In cases where the Operating Range is not symmetric, the minimum reactive power export and import capabilities (the Q values of the lines AD and BC) shall be defined based on a Q/P ratio of 0.33 at Registered Capacity.

Figure 4 also assumes 100% mechanical availability of the PPM.

EirGrid:

Figure 4 replaces Figure PPM1.4 in the Grid Code. Figure 4 represents the minimum expected reactive power capability of the battery ESPS. The Battery ESPS is obliged to tell the TSO if it can exceed these capabilities and submit an actual P-Q diagram. The Battery ESPS shall be capable of operating in Power Factor, Voltage Control and Reactive Power mode at any point within the P-Q capability, as measured at the connection point, over the normal and disturbed transmission system voltage ranges as specified in the Grid Code.

SONI:

When operating in any of the three reactive power control modes the minimum reactive capability of a Battery ESPS is defined by the envelope ABCD.

B.6 Signalling Requirements

SONI Grid Code derogations for N/A
EirGrid Grid Code derogations for PPM1.7.1.3.3, PPM1.7.1.3.4, PPM1.7.1.5, PPM1.7.2.3

EirGrid:

EirGrid issues a unit specific signal list for each controllable PPM. For multiple market units, there shall be one set of Voltage related signals/measurands per connection point. There shall be one set of all other signals/measurands per market unit.

SONI:

SONI's signal list for Battery ESPS will be published in the PPM Settings Schedule.

B.7 Black Start Shutdown

SONI Grid Code derogations for N/A
EirGrid Grid Code derogations for PPM1.7.2.5

EirGrid:

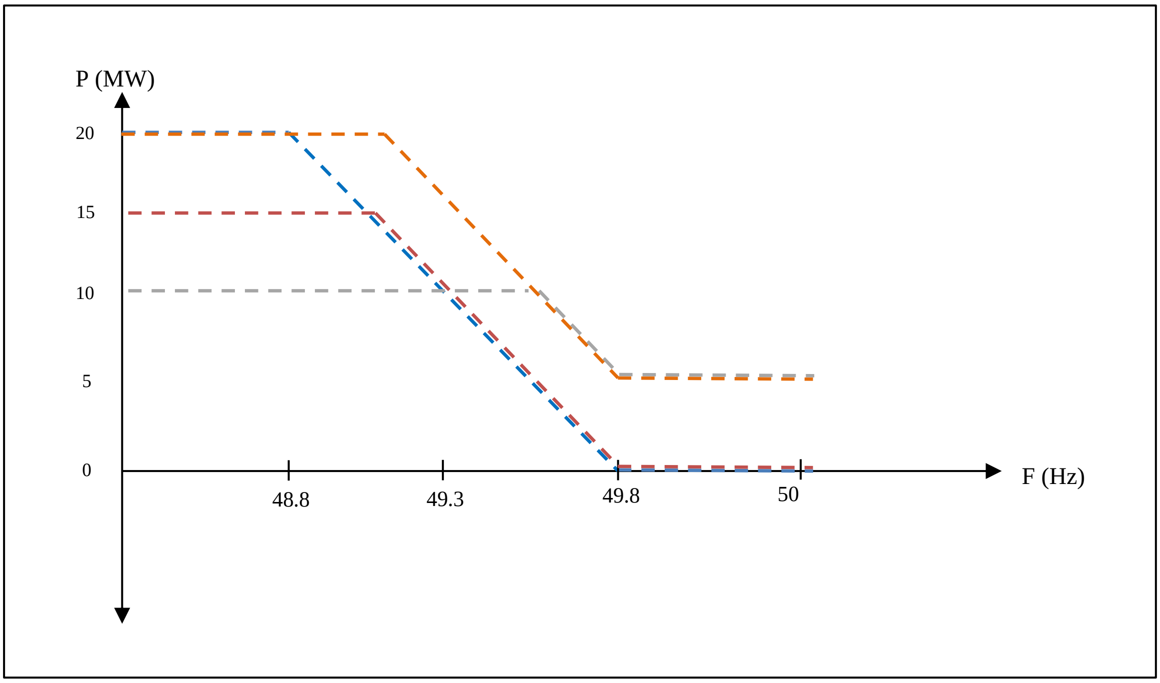
Note there is no operational requirement for Black Start Shutdown scheme for Battery Energy Storage Power Stations. For hybrid sites e.g. WFPS and Battery, Black Start Shutdown will be required due to the presence of the WFPS.

For avoidance of doubt this extends to Dispatch Fail Lamp (DFL) and Blue Alert Lamp (BAL) for distribution connected batteries. There is no operational requirement for DFL and BAL for distribution connected Battery ESPS. For hybrid sites e.g. WFPS and Battery, DFL and BAL will be required due to the presence of the WFPS.

Appendix 1: Frequency Response Mode Definition Examples

Case 1: Impact of availability and pre-event MW output

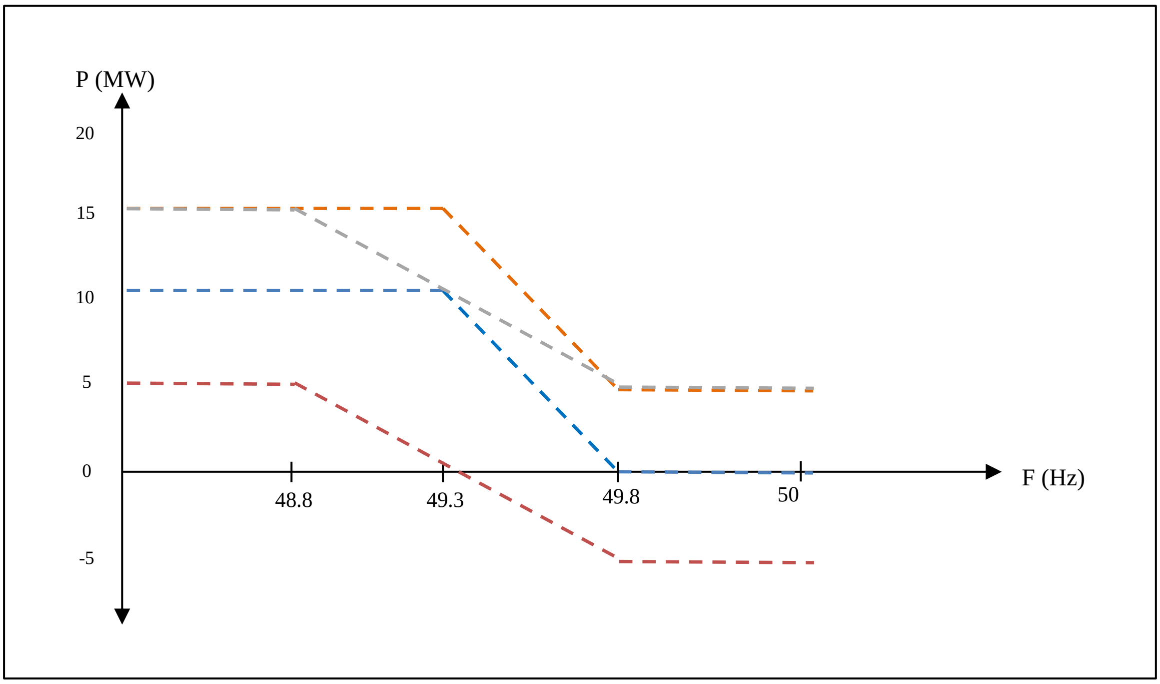
The following case examine the under frequency response of a Battery ESPS with an operating range from +20MW to -20MW and a Maximum Under frequency Response Setting of 40 MW. Over frequency response is excluded for simplicity, but is treated in the same way.



Case 1 Example:	Blue	Red	Orange	Grey
Maximum Under frequency Response setting	40 MW	40 MW	40 MW	40 MW
Trajectory setting	2 Hz	2 Hz	2 Hz	2 Hz
Under frequency Trigger setting	49.8 Hz	49.8 Hz	49.8 Hz	49.8 Hz
Available Active Power	20 MW	15 MW	20 MW	10 MW
Set-point	0 MW	0 MW	5 MW	5 MW

Case 2: Impact of Maximum Under frequency Response Setting

The following cases examine the under frequency response of a Battery ESPS with an operating range from +20MW to -20MW and a Maximum Under frequency Response Setting of 10 MW (less than the operating range). Over frequency response is excluded for simplicity, but is treated in the same way.

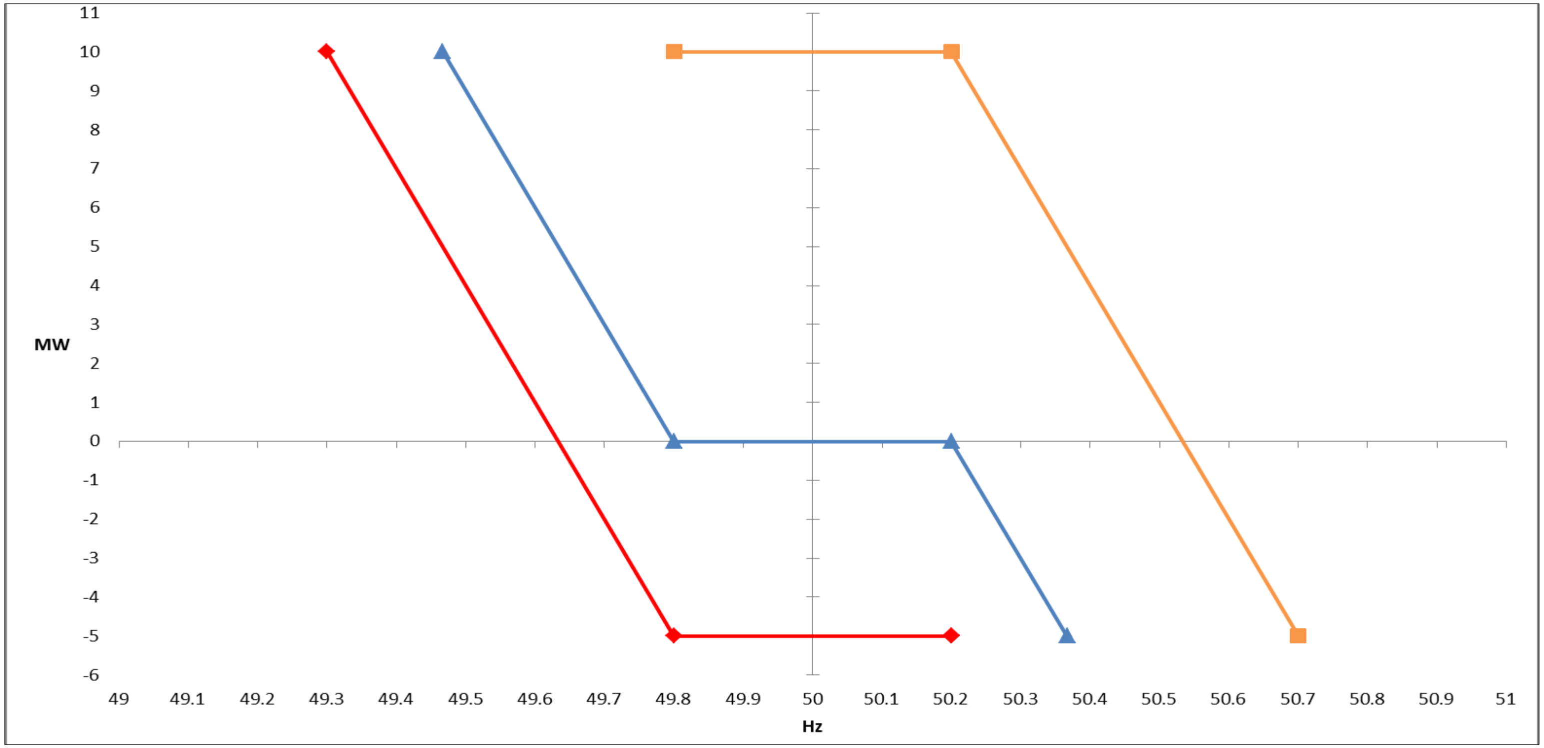


Case 2 Example:	Blue	Orange	Red	Grey
Maximum Under frequency Response setting	10 MW	10 MW	10 MW	10 MW
Trajectory setting	0.5 Hz	0.5 Hz	1 Hz	1 Hz
Under frequency Trigger setting	49.8 Hz	49.8 Hz	49.8 Hz	49.8 Hz
Available Active Power	20 MW	20 MW	20 MW	20 MW
Set-point	0 MW	5 MW	-5 MW	5 MW

Case 3: Battery ESPS with non-symmetric MEC and MIC

The following example examines the frequency response curve for a Battery ESPS with an operating range from +10MW to -5MW. The below assumes the battery has full availability.

Case 3 Example:	Blue	Orange	Red
Maximum Under frequency & Over Frequency Response setting	15 MW	15 MW	15 MW
Under Frequency & Over Frequency Trajectory setting	0.5 Hz	0.5 Hz	0.5 Hz
Under frequency trigger setting	49.8 Hz	49.8 Hz	49.8 Hz
Over frequency trigger setting	50.2Hz	50.2Hz	50.2Hz
Set-point	0 MW	10 MW	-5 MW

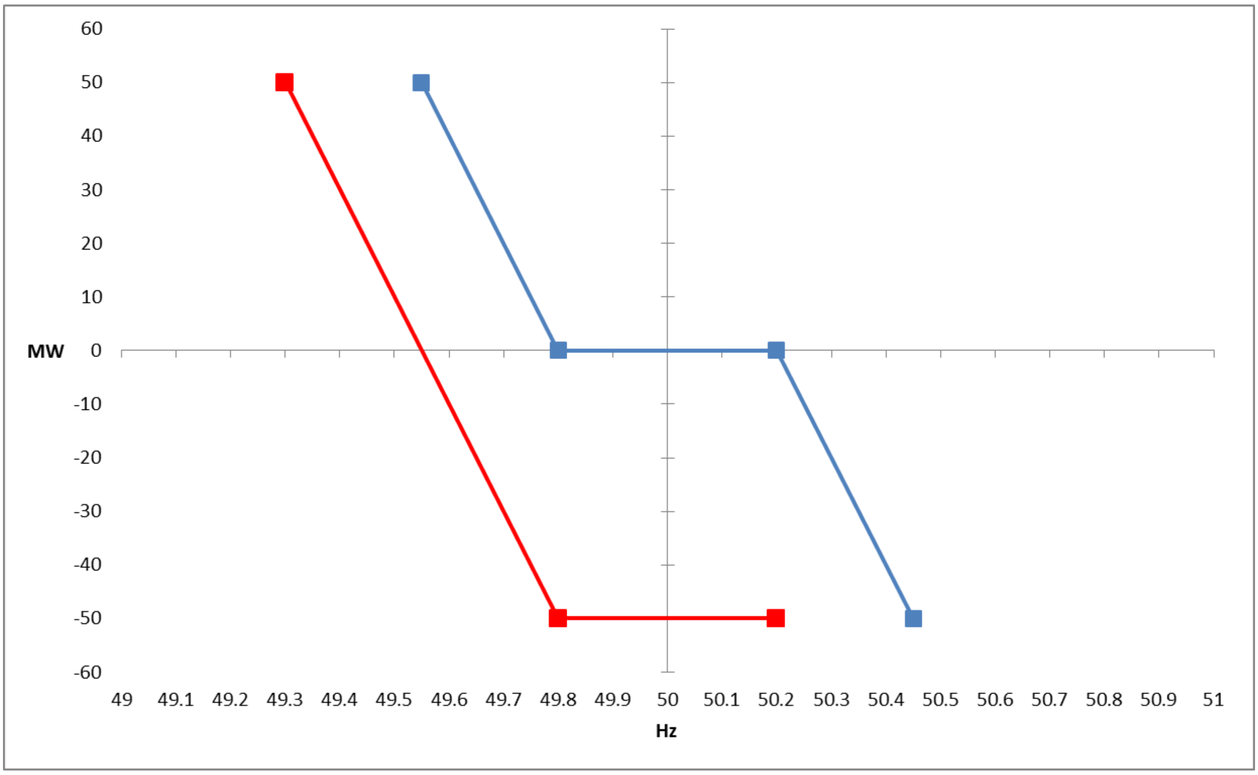


Appendix 2: Operational and Contractual Parameters

For example, a unit with a 50MW registered capacity and 50MW MIC with operational trajectory and max response settings as per below, covering the full operating range.

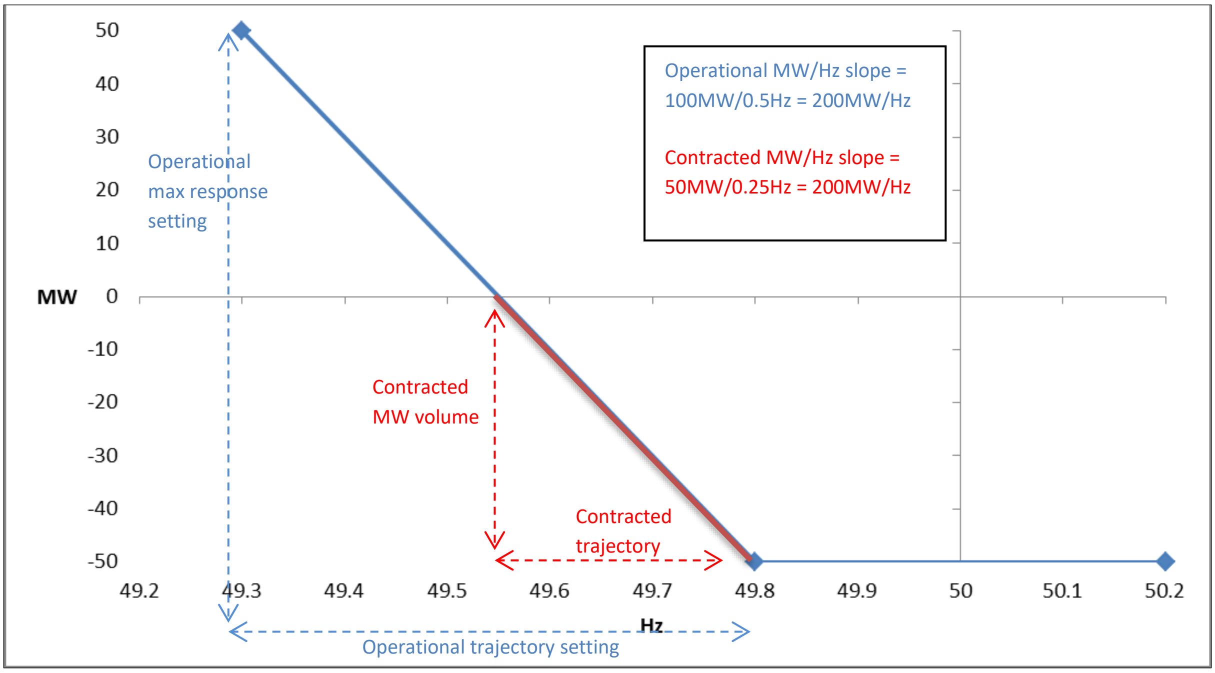
Under frequency trigger frequency	49.8 Hz
Over frequency trigger frequency	50.2 Hz
Under frequency trajectory	0.5Hz
Over frequency trajectory	0.5Hz
Maximum Under frequency Response	100MW
Maximum Over frequency Response	100MW

The MW/Hz slope of the frequency response curve defined by these settings is 200MW/Hz. The graph below shows the frequency curve from two pre-event outputs; the blue curve is with respect to a 0MW pre-event output, and the red curve is with respect to a -50MW pre-event output.



If this unit chose to contract for only 50MW FFR, the MW/Hz slope would remain the same and the contracted trajectory value would be 0.25Hz for a 50MW FFR contract volume. The unit should not apply limiters to the frequency response volume if contracting for less than full operating range.

The intended contractual parameters will be discussed with the unit prior to the TSOs specifying the five frequency mode settings.



END