# SONI Consultation Paper: Grid Code and PPM Setting Schedule Changes Facilitating Incorporation of Battery ESPS Implementation Note

Consultation Paper
November 25th 2022

# 1. Introduction

1.1 A programme of work capture experience in the connection, compliance testing and operation of batteries, and thereby compile the changes required to incorporate battery energy storage into the Grid Code and PPM Setting Schedule has been undertaken.

1.2 This consultation paper details the output of that work in the form of “red line” changes.

1.3 This consultation period is proposed to be four weeks; the deadline for submission of comments is close of business on 23rd December 2022. SONI will submit a copy of all responses to the Utility Regulator alongside its report on this consultation. If a response is required to remain confidential this should clearly be stated. The intention is to publish all non-confidential responses. Please note that, in any event, all responses will be shared with the Regulatory Authority.

# 2. Background and Overview

2.1 An “implementation note”[1] capturing operational guidance and views as to the applicability of Grid Code clauses was first published in June 2019 and has been updated in the intervening years.

2.2 Testing of transmission-connected batteries for Grid Code compliance based on adapted PPM test procedures[2] has since been completed by SONI, and operational experience has been gained. A signals list[3] for operators of battery energy storage installations has also been compiled and made available based on existing PPM requirements.

2.3 SONI engaged the services of an external consultant and embarked on a programme of work to compile the changes necessary to incorporate battery energy storage. A companion workstream in the Other Jurisdiction ran in parallel; sections of the Grid Code under shared governance were jointly reviewed.

2.4 The approach was to minimise amendments where appropriate. Such amendments were deemed to be necessary considered the current situation with respect to Network Codes, whereby batteries are considered to be non-RfG. Further and befitting the nature of the Grid Code, operational guidance will not be incorporated but instead made available separately.

# 3. Changes to the Grid Code – Incorporating RoCoF Modification and Related Housekeeping

3.1 Glossary and Definitions

[1] https://www.soni.ltd.uk/media/documents/Integration-of-Batteries-Implementation-Note.pdf

[2] https://www.soni.ltd.uk/media/documents/Battery-ESPS-Compliance-Procedures.pdf

[3] https://www.soni.ltd.uk/media/documents/Battery-ESPS-Signal-List.pdf

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| **Energy Storage Power Station (ESPS)** | A collection of one or more ~~storage devices~~ **ESU**(s) that can automatically act upon a remote signal from the TSO to change its **Active Power** output ~~owned and/or operated by the same **Generator**, as, or as part of a **PPM**~~. |
| **Energy Storage Unit (ESU)** | A **Generating Unit**(s) using storage devices to generate and consume electricity as, or as part of, a **PPM**. |
| **Capacity Limited Ramp Rate** | The rate of increase or decrease of **Active Power** of an **ESPS** in response to reaching the **Capacity Limit**. The **Capacity Limited Ramp Rate** settings shall be specified by the **TSO** in the **PPM Settings Schedule**. |
| **Capacity Limit** | The point calculated by the **PPM** control system where there is just enough energy storage or generation capacity, calculated in MWh, for the **ESPS** to change the **Active Power** to zero MW at the **Capacity Limited Ramp Rate**. |

3.2 Connection Conditions

*New version of CC.S2.1.3.2 to apply to both existing PPMs and for ESPSs (non-RfG Generating Units)*

CC.S2.1.3.2 A **PPM** shall continuously control voltage at the **Connection Point** within its **Reactive Power** capability limits. For **PPMs**, the minimum **Reactive Power** capability is defined in the characteristic below, within the voltage limits specified under CC5.4.

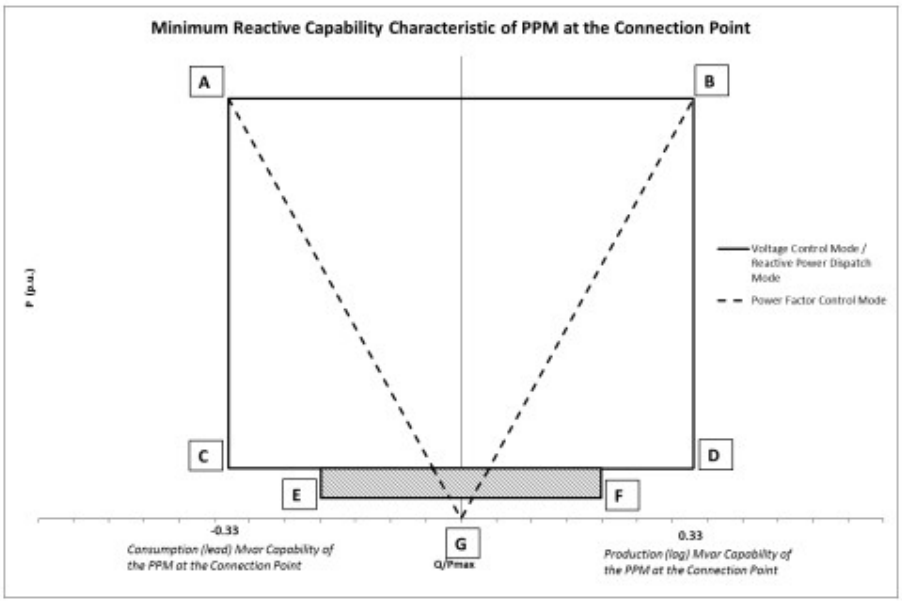
There are three **Voltage Control** modes:

(i) **Voltage Control** mode
(ii) power factor control mode
**(iii) Reactive Power Dispatch**

Whilst the **PPM** with the exception of an **ESPS** is operating in **Voltage Control** mode the minimum reactive capability is defined by the envelope ABCDEF in the **Voltage Control** characteristic shown below. Points E and F will be defined by the **Generator** six weeks prior to energisation and confirmed by the **TSO** through Compliance testing. Whilst the **PPM** with the exception of an **ESPS** is operating in power factor control mode the reactive capability is defined by the envelope AGB in the power factor control mode characteristic shown below. Whilst the **PPM** with the exception of an **ESPS** is operating in **Reactive Power Dispatch** control mode, the **PPM**, as a minimum, must be capable of exporting or importing **Mvars** within the envelope ABCDEF.

For the avoidance of doubt, all measurements refer to the **Connection Point**.

**PPMs** with the exception of an **ESPS** must be capable of responding to variations in the voltage of the **NI System** in accordance with the following diagram.

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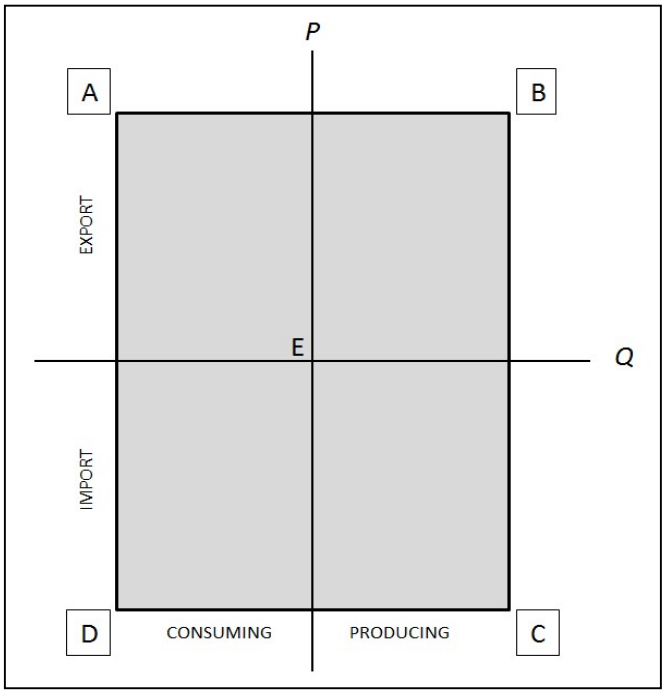
| Point A | **Mvar** consumption (lead) capability of the **PPM** at **Registered Capacity** at the **Connection Point** |
| Point B | **Mvar** production (lag) capability of the **PPM** at **Registered Capacity** at the **Connection Point** |
| Point C | **Mvar** consumption (lead) capability of the **PPM** when **Output** is 12% of **Registered Capacity** at the **Connection Point** |
| Point D | **Mvar** production (lag) capability of the **PPM** when **Output** is 12% of **Registered Capacity** at the **Connection Point** |
| Point E | **Mvar** consumption (lead) capability when any of the **Generating Units** begins to export **Active Power** at the **Connection Point** (to be defined by **Generator**) |
| Point F | **Mvar** production (lag) capability when any of the **Generating Units** begins to export **Active Power** at the **Connection Point** (to be defined by **Generator**) |

Diagram and Table showing the minimum Reactive Capability characteristic for non **ESPS PPMs**

Whilst the **PPM** consisting of an **ESPS** is operating in **Voltage Control** mode the minimum reactive capability is defined by the envelope ABCD in the **Voltage Control** characteristic shown below. Whilst the **PPM** consisting of an **ESPS** is operating in power factor control mode the reactive capability is enclosed by the envelope AEBA and DECD in the power factor control mode characteristic shown below. Whilst the **PPM** consisting of an **ESPS** is operating in **Reactive Power Dispatch** control mode, the **PPM**, as a minimum, must be capable of exporting or importing **Mvars** within the envelope ABCD.

For the avoidance of doubt, all measurements refer to the **Connection Point**.

**PPMs** consisting of **ESPSs** must be capable of responding to variations in the voltage of the **NI System** in accordance with the following diagram.

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| Point A | **Mvar** consumption (lead) capability of the **PPM** at **Registered Capacity** at the **Connection Point** and a Q/P ratio of -0.33 is equivalent to a leading power factor of -0.95. |
| Point B | **Mvar** production (lag) capability of the **PPM** at **Registered Capacity** at the **Connection Point** and a Q/P ratio of 0.33 is equivalent to a lagging power factor of 0.95 |
| Point C | **Mvar** production (lag) capability of the **PPM** when **Output** is at **Maximum Import Capacity** and a Q capability equal to that of Point B at the **Connection Point** |
| Point D | **Mvar** consumption (lead) capability of the **PPM** when **Output** is at **Maximum Import Capacity** and a Q capability equal to that of Point A at the **Connection Point** |
| Point E | Is the intersection of the P and Q axes and represents zero active or reactive power flow. |

Diagram and Table showing the minimum Reactive Capability characteristic for **ESPS PPMs**

All **PPMs** must be capable of responding to variations in the voltage of the **NI System** in accordance with CC5.4

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*New version of CC.S2.1.5 to apply to both existing PPMs and for ESPSs (non-RfG Generating Units) as indicated.*

CC.S2.1.5 Ramp Rates

For PPMs with the exception of ESPSs:

(a) The **PPM** control system shall be capable of controlling the ramp rate of its **Active Power Output**. There shall be three ramp rate capabilities designated, **Resource Following Ramp Rate, Active Power Control Set-Point Ramp Rate** and **Frequency Response Ramp Rate**. The **PPM** control system shall operate the ramp rates with the following order of priority (high to low): **Frequency Response Ramp Rate; Active Power Control Set-Point Ramp Rate; Resource Following Ramp Rate**. It shall be possible to vary the **Resource Following Ramp Rate** over a range between 1% and 100% of **Registered Capacity** per minute. The ramp rate is the average rate of change in **Output** measured over any 10 minute period. The ramp rate averaged over 1 minute should not exceed 3 times the average ramp rate over 10 minutes.

(b) A **Controllable PPM** or a **Dispatchable PPM** shall have a ramp **Frequency** controller, which on **Start-Up** and during normal operation of any **Controllable PPM** or **Dispatchable PPM** shall only allow an increase in **Active Power Output** when the **System Frequency** is below a set value. This set value in the ramp **Frequency** controller should be capable of being set in the range 50.0 Hz to 52.0 Hz in steps of 0.1 Hz.

(c) During operation the **TSO** may send to the **Generator** a positive ramp blocking signal if the **NI System** would otherwise be at risk from excess **Frequency** movements. This signal is designed to restrain **PPMs** from ramping above the previous 10 minute average level at the time of receiving the signal. The **PPM** may continue to supply **Output** up to this level until the signal is removed. The **TSO** will remove the ramp blocking signal as soon as stable conditions on the **NI System** are restored, as determined by the **TSO**.

(d) Unless the **Controllable PPM** or **Dispatchable PPM** has a continually manned control point the **TSO** shall send SCADA signals indicating that a process of increasing/decreasing maximum **Output** is to be initiated and the time interval over which the increase/decrease of **Output** is to be achieved. A **Controllable PPM** or **Dispatchable PPM** receiving such a signal shall send a SCADA signal in response confirming that it has received the SCADA signal from the **TSO**. The increase/decrease in **Active Power Output** of the **Controllable PPM** or **Dispatchable PPM** shall be at the **Active Power Control Set-Point Ramp Rate**. For the avoidance of doubt nothing in this CC.S2.1.~~3.8~~5(d) shall be construed as requiring a **Controllable PPM** or **Dispatchable PPM** to operate beyond its technical limits.

(e) Upon removal of an **Active Power Dispatch Instruction** sent by the **TSO** via SCADA when the **PPM** is operating in an **Active Power** control mode and under normal operational conditions, the **PPM** shall ramp at the **Resource Following Ramp Rate**.

(f) The ramp rate requirements for **PPMs** need not be met in the case of the resource availability falling at a greater rate than that which would be required to control the **Output** to be within the ramp rate.

(g) In the absence of a **TSO Dispatch Instruction**, each **Generating Unit** comprising a **Controllable PPM** or **Dispatchable PPM** must operate as per the power curve submitted to the **TSO** and remain connected to the **NI System** between the upper and lower limit of resource level needed for a **Generating Unit** to generate **Active Power**.

**For PPMs consisting of ESPSs:**

(h) The **PPM** control system shall be capable of controlling the ramp rate of its **Active Power**. There shall be three ramp rate capabilities designated, **Capacity Limited Ramp Rate, Active Power Control Set-Point Ramp Rate** and **Frequency Response Ramp Rate**. These ramp rates co-exist and the **PPM** control system shall operate the ramp rates with the following order of priority (high to low): **Capacity Limited Ramp Rate**; **Frequency Response Ramp Rate; Active Power Control Set-Point Ramp Rate**. It shall be possible to vary the **Active Power Control Set-Point Ramp Rate** over a range between 1% and 100% of **Registered Capacity** per minute. The ramp rate is the average rate of change in **Active Power** measured over any 10 minute period. The ramp rate averaged over 1 minute should not exceed 3 times the average ramp rate over 10 minutes.

(i) Unless the **Controllable PPM** or **Dispatchable PPM** has a continually manned control point the **TSO** shall send SCADA signals indicating that a process of increasing/decreasing Active Power is to be initiated. A **Controllable PPM** or **Dispatchable PPM** receiving such a signal shall send a SCADA signal in response confirming that it has received the SCADA signal from the **TSO**. The increase/decrease in **Active Power Output** of the **Controllable PPM** or **Dispatchable PPM** shall be at the **Active Power Control Set-Point Ramp Rate**. For the avoidance of doubt nothing in this CC.S2.1.5(i) shall be construed as requiring a **Controllable PPM** or **Dispatchable PPM** to operate beyond its technical limits.

(j) The ramp rate requirements for **PPMs** need not be met in the case of the **ESPSs** import/export energy capacity becoming limited. Under these conditions the **ESPS** shall ramp at the **Capacity Limited Ramp Rate**.

*The following section of CC.S2 Part II requires a housekeeping modification to correct the numbering of CCS2.2.3.4, which is repeated, and clauses dealing with Ramp Rates must be modified as follows.*

CC.S2.2.3.~~4~~11 Ramp Rates

For PPMs with the exception of ESPSs:

(a) The **PPM** control system shall be capable of controlling the ramp rate of its **Active Power Output**. There shall be three ramp rate capabilities designated, **Resource Following Ramp Rate, Active Power Control Set-Point Ramp Rate** and **Frequency Response Ramp Rate**. The **PPM** control system shall operate the ramp rates with the following order of priority (high to low): **Frequency Response Ramp Rate; Active Power Control Set-Point Ramp Rate; Resource Following Ramp Rate**. It shall be possible to vary the **Resource Following Ramp Rate** over a range between 1% and 100% of **Registered Capacity** per minute. The ramp rate is the average rate of change in **Output** measured over any 10 minute period. The ramp rate averaged over 1 minute should not exceed 3 times the average ramp rate over 10 minutes.

(b) A **Controllable PPM** or a **Dispatchable PPM** shall have a ramp **Frequency** controller, which on **Start-Up** and during normal operation of any **Controllable PPM** or **Dispatchable PPM** shall only allow an increase in **Active Power Output** when the **System Frequency** is below a set value. This set value in the ramp **Frequency** controller should be capable of being set in the range 50.0 Hz to 52.0 Hz in steps of 0.1 Hz.

(c) During operation the **TSO** may send to the **Generator** a positive ramp blocking signal if the **NI System** would otherwise be at risk from excess **Frequency** movements. This signal is designed to restrain **PPMs** from ramping above the previous 10 minute average level at the time of receiving the signal. The **PPM** may continue to supply **Output** up to this level until the signal is removed. The **TSO** will remove the ramp blocking signal as soon as stable conditions on the **NI System** are restored, as determined by the **TSO**.

(d) Unless the **Controllable PPM** or **Dispatchable PPM** has a continually manned control point the **TSO** shall send SCADA signals indicating that a process of increasing/decreasing maximum **Output** is to be initiated and the time interval over which the increase/decrease of **Output** is to be achieved. A **Controllable PPM** or **Dispatchable PPM** receiving such a signal shall send a SCADA signal in response confirming that it has received the SCADA signal from the **TSO**. The increase/decrease in **Active Power Output** of the **Controllable PPM** or **Dispatchable PPM** shall be at the **Active Power Control Set-Point Ramp Rate**. For the avoidance of doubt nothing in this CC.S2.2.3.4(d) shall be construed as requiring a **Controllable PPM** or **Dispatchable PPM** to operate beyond its technical limits.

(e) Upon removal of an **Active Power Dispatch Instruction** sent by the **TSO** via SCADA when the **PPM** is operating in an **Active Power** control mode and under normal operational conditions, the **PPM** shall ramp at the **Resource Following Ramp Rate**.

(f) The ramp rate requirements for **PPMs** need not be met in the case of the resource availability falling at a greater rate than that which would be required to control the **Output** to be within the ramp rate.

(g) In the absence of a **TSO Dispatch Instruction**, each **Generating Unit** comprising a **Controllable PPM** or **Dispatchable PPM** must operate as per the power curve submitted to the **TSO** and remain connected to the **NI System** between the upper and lower limit of resource level needed for a **Generating Unit** to generate **Active Power**.

**For PPMs consisting of ESPSs:**

(h) The **PPM** control system shall be capable of controlling the ramp rate of its **Active Power**. There shall be three ramp rate capabilities designated, **Capacity Limited Ramp Rate, Active Power Control Set-Point Ramp Rate** and **Frequency Response Ramp Rate**. These ramp rates co-exist and the **PPM** control system shall operate the ramp rates with the following order of priority (high to low): **Capacity Limited Ramp Rate**; **Frequency Response Ramp Rate; Active Power Control Set-Point Ramp Rate**. It shall be possible to vary the **Active Power Control Set-Point Ramp Rate** over a range between 1% and 100% of **Registered Capacity** per minute. The ramp rate is the average rate of change in **Active Power** measured over any 10 minute period. The ramp rate averaged over 1 minute should not exceed 3 times the average ramp rate over 10 minutes.

(i) Unless the **Controllable PPM** or **Dispatchable PPM** has a continually manned control point the **TSO** shall send SCADA signals indicating that a process of increasing/decreasing Active Power is to be initiated. A **Controllable PPM** or **Dispatchable PPM** receiving such a signal shall send a SCADA signal in response confirming that it has received the SCADA signal from the **TSO**. The

increase/decrease in **Active Power Output** of the **Controllable PPM** or **Dispatchable PPM** shall be at the **Active Power Control Set-Point Ramp Rate**. For the avoidance of doubt nothing in this CC.S2.2.3.4(i) shall be construed as requiring a **Controllable PPM** or **Dispatchable PPM** to operate beyond its technical limits.

(j) The ramp rate requirements for **PPMs** need not be met in the case of the **ESPSs** import/export energy capacity becoming limited. Under these conditions the **ESPS** shall ramp at the **Capacity Limited Ramp Rate**.

*CC.S2.1.7.2 and CC.S2.2.5.2 require minor edits for ESPS as Droop is not an applicable term and not to exclude import scenarios.*

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CC.S2.1.7.2

(a) Each **Controllable PPM** or **Dispatchable PPM** must be fitted with a **Fast Acting** proportional power governor to provide **Frequency Control** under normal operational conditions. This **Fast Acting** proportional governor should be equipped with controls which allow the droop or equivalent for **PPMs** consisting of **ESPSs** to be set independently in the range 2% to 20% above and below 50.0 Hz. A deadband within which no control will be exercised must be capable of being set with a lower limit between 49.0 Hz and 50.0 Hz in steps of 0.05 Hz and an upper limit between 50.0 Hz and 51.0 Hz in steps of 0.05 Hz. Whilst responding to **Frequency** excursions on the **System** the change in **Active Power** ~~**Output**~~ of the **Controllable PPM** or **Dispatchable PPM** shall be at the **Frequency Response Ramp Rate**. In addition a high **Frequency** trip facility must be provided capable of being set in the range 51.0 Hz to 52.0 Hz in steps of 0.1 Hz. Where a **Controllable PPM** or **Dispatchable PPM** becomes isolated from the rest of the **Transmission System** the **Controllable PPM** or **Dispatchable PPM** must immediately detect the condition and shut itself down.

(b) Under certain **System** conditions the **TSO** may require a **Controllable PPM** or a **Dispatchable PPM** to operate below its maximum instantaneous **Output** on a droop or equivalent for **PPMs** consisting of **ESPSs** setting to be set in the range 2% to 20%. In this mode of operation the **Controllable PPM** or **Dispatchable PPM** will be providing some of the **System** reserve. The **Controllable PPM** or **Dispatchable PPM** controller must be capable of being set to operate in a constrained manner within the range of at least 50% to 100% of maximum instantaneous Output

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CC.S2.2.5.2

(a) Each **Controllable PPM** or **Dispatchable PPM** must be fitted with a **Fast Acting** proportional power governor to provide **Frequency Control** under normal operational conditions. This **Fast Acting** proportional governor should be equipped with controls which allow the droop or equivalent for **PPMs** consisting of **ESPSs** to be set independently in the range 2% to 20% above and below 50.0 Hz. A deadband within which no control will be exercised must be capable of being set with a lower limit between 49.0 Hz and 50.0 Hz in steps of 0.05 Hz and an upper limit between 50.0 Hz and 51.0 Hz in steps of 0.05 Hz. Whilst responding to **Frequency** excursions on the **System** the change in **Active Power** ~~**Output**~~ of the **Controllable PPM** or **Dispatchable PPM** shall be at the **Frequency Response Ramp Rate**. In addition a high **Frequency** trip facility must be provided capable of being set in the range 51.0 Hz to 52.0 Hz in steps of 0.1 Hz. Where a **Controllable PPM** or **Dispatchable PPM** becomes isolated from the rest of the **Transmission System** the **Controllable PPM** or **Dispatchable PPM** must immediately detect the condition and shut itself down.

(b) Under certain **System** conditions the **TSO** may require a **Controllable PPM** or a **Dispatchable PPM** to operate below its maximum instantaneous **Output** on a droop or equivalent for **PPMs** consisting of **ESPSs** setting to be set in the range 2% to 20%. In this mode of operation the **Controllable PPM** or **Dispatchable PPM** will be providing some of the **System** reserve. The **Controllable PPM** or **Dispatchable PPM** controller must be capable of being set to operate in a constrained manner within the range of at least 50% to 100% of maximum instantaneous Output

## 3.3 PPM Setting Schedule Glossary of Terms

*Definitions have been introduced and/or modified to incorporate battery energy storage.*

| Term | Definition |
|---|---|
| **Active Power (or MW)** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Active Power Control Set-Point Ramp Rate** | As per **Grid Code** or **Distribution Code** as applicable |
| **Available Active Power** | The amount of **Active Power** that the **Controllable PPM** could produce based on current resource conditions. The **Available Active Power** shall only differ from the actual **Active Power** if the **Controllable PPM** has been curtailed, constrained or is operating in a restrictive **Frequency Response** mode. |
| **Commissioning / Acceptance Test Panel** | The panel made up of representatives from SONI and NIE Networks that will agree the **Compliance** testing program, provide direction on technical requirements, assess the test results and decide if **Compliance** has been achieved by the **PPM**. |
| **Compliance** | **Compliance** with the **Grid Code** and/or the **Distribution Code** as applicable |
| **Connection Agreement** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |

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| **Connection Point** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Controllable Power Park Module** | As per **Grid Code** or **Distribution Code** as applicable |
| **Designed Minimum Operating Level (DMOL)** | The **Output** below which a **Power Park Module** cannot operate without shutting down<br>**Generating Units**. |
| **Distribution Code** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Distribution Network Owner (DNO)** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Distribution System** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Energisation Operational Notification (EON)** | A notification issued by the **DNO** to a **Generator** prior to energisation of its internal network. Also defined in EREC G99/NI |
| **Energy Storage Generator** | As per **Grid Code** or **Distribution Code** as applicable |
| **Energy Storage Power Station** (or **ESPS**) | As per **Grid Code** or **Distribution Code** as applicable |
| **Final Operational Notification (FON)** | The **Final Operational Notification** as may be issued by SONI in accordance with CC15.2.3 (for a **Transmission System** connected **Power Park Module**) or CC16.2.3 (for a distribution-**System** connected **Power Park Module**). Also defined in EREC G99/NI |
| **Frequency** | As per **Grid Code** or **Distribution Code** as applicable |
| **Frequency Control** | As per **Grid Code** or **Distribution Code** as applicable |
| **Frequency Sensitive Mode (FSM)** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Generating Unit** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Generator** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Generator Performance Chart** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Grid Code** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Interim Operational Notification (ION)** | **Interim Operational Notification** as may be issued by SONI in accordance with CC15.2.2 (for a **Transmission System** connected **PPM**) or CC16.2.2 (for a distribution-**System** connected **PPM**). Also defined in EREC G99/NI |
| **Limited Frequency Sensitive Mode – Over frequency (LFSM-O)** | As per **Grid Code** or **Distribution Code** as applicable |
| **Limited Frequency Sensitive Mode – Under frequency (LFSM-U)** | As per **Grid Code** or **Distribution Code** as applicable |
| **Limited Operational Notification (LON)** | If a non-**Compliance** arises at any point from synchronisation throughout the full operational life of the **Power Park Module**, SONI/NIE Networks may issue the **Generator** with a **Limited Operational Notification**, which will detail the level of non-**Compliance** of the |

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| | **Power Park Module**, the time frame to rectify the non-**Compliance** and the MVA restriction to which the **Power Park Module** will be capped until the non-**Compliance** is resolved. Also defined in EREC G99/NI |
| **Maximum Export Capacity** | As per **Grid Code** or **Distribution Code** as applicable |
| **Maximum Import Capacity** | As per **Grid Code** or **Distribution Code** as applicable |
| **Maximum Instantaneous Output (MIO)** | The **MW** figure a **Power Park Module** is capable of generating at any instant if there is no SONI action present. |
| **Minimum Stable Operating Level** | The minimum **Active Power** output which a **PPM** can reasonably generate as registered with the **DNO or the TSO**. Also defined in EREC G99/NI |
| **MW Availability** | The amount of **Active Power** that the **Controllable PPM** could produce based on current generation resource conditions, network conditions and **System** conditions. |
| **Operating Range** | The **Active Power** range over which an **ESPS** can operate, in **MW**, taking into account **MIC**, **MEC**, **User's Plant** and **Registered Capacity**. |
| **Operational Readiness Confirmation** | Issued by SONI to the **Generator** when a **Power Park Module** passes the SONI **MW Availability** standard and successfully completes the operational readiness dispatch test. |
| **Output** | As per **Grid Code** or **Distribution Code** as applicable |
| **Power Generating Facility (PGF)** | A facility that converts primary energy into electrical energy and which consists of one or more **PPMs** connected to a **System** at one or more **Connection Points**. Also defined in EREC G99/NI. Also defined in the **Grid Code** (Power Station) |
| **Power Park Module (PPM)** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Reactive Power (MVAr)** | As per **Grid Code** or **Distribution Code** as applicable |
| **Registered Capacity** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Resource Following Ramp Rate** | The maximum rate of increase of **Active Power Output** of a **PPM** upon removal of any **TSO** actions via SCADA which limits **Active Power Output** of the **PPM**, as specified by the **TSO** from time to time in the **PPM Setting Schedule** (or such other place or by such other means as may be notified to the **Generator** from time to time. |
| **Setting Schedule** | A document that sets out certain technical criteria and **Compliance** requirements that the **Generator** must comply with. |
| **System** | As per **Grid Code** or **Distribution Code** as applicable |
| **Transmission System** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI |
| **Transmission System Operator (TSO)** | As per **Grid Code** or **Distribution Code** as applicable. Also defined in EREC G99/NI. |
| **Type C** | A **PPM** with a **Connection Point** below 110 kV and a **Registered Capacity** of 5 **MW** or greater but less than 10 **MW**. Also defined in EREC G99/NI. |

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| **Type D** | A **PPM** with a **Connection Point** at, or greater than, 110 kV and/or with a **Registered Capacity** of 10 **MW** or greater. Also defined in EREC G99/NI. |
| **User Data Library (UDL)** | A common directory structure for information in support of **Compliance** statements and technical data. The structure of **UDL** is given in Appendix A of this document. |
| **Voltage Control** | As per **Grid Code** or **Distribution Code** as applicable |

Acronyms

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|---|---|
| **AAP** | **Available Active Power** |
| CC | Connection Conditions (**Grid Code**) |
| CHCC | Castlereagh House Control Centre |
| DCC | Distribution Control Centre |
| DLR | Dynamic Line Rating |
| **DNO** | **Distribution Network Operator** |
| **DMOL** | **Designed Minimum Operating Level** |
| DRC | Data Registration Code (**Grid Code**) |
| FRT | Fault Ride Through |
| FSM | **Frequency Sensitive Mode** |
| GCCA | Grid Code Compliance Agreement |
| HV | High Voltage |
| ~~SEM~~ | ~~Single Electricity Market~~ |
| ~~SEMO~~ | ~~Integrated Single Electricity Market Operator~~ |
| LV | Low Voltage |
| **MEC** | **Maximum Export Capacity** |
| **MIC** | **Maximum Import Capacity** |
| MIO | **Maximum Instantaneous Output** |
| NIE Networks | Northern Ireland Electricity Networks |
| NRMSD | Normalised Root Mean Square Deviation |
| OHL | Over Head Line |
| **ORC** | **Operational Readiness Confirmation** |
| PF | Power Factor |
| PGF | **Power Generating Facility** |

| **PPM** | **Power Park Module** |
|---|---|
| pu | per unit |
| SEM | Single Electricity Market |
| SEMO | Integrated Single Electricity Market Operator |
| SONI | **System** Operator of Northern Ireland |
| T&D | Transmission and Distribution |
| TDLR | Temperature Dependent Dynamic Line Rating |
| TUOS | Transmission Use of **System** |
| TUOSA | Transmission Use of **System** Agreement |
| **UDL** | **User Data Library** |
| VPT | Variable Price Taker |

3.4 PPM Setting Schedule Introduction

*In the introductory sections, appropriate distinction is drawn between PPMs which consist of battery energy storage, and those that do not.*

## 2.0 INTRODUCTION

### 2.1 ALL POWER PARK MODULES *EXCEPT* ENERGY STORAGE POWER STATIONS (ESPS)

This **Power Park Module Setting Schedule** comes into effect on 27 April 2019 for **Type C** and **Type D Power Park Modules** first installed on or after that date. This **Power Park Module Setting Schedule** should be used in conjunction with the SONI **Grid Code** (CC7.2, CC7.3, CC.S2.1.1 and CC.S2.2.1) which is available from the SONI website[4], the **Distribution Code** (CC1.1, CC1.2, CC1.3, CC11.1, CC11.2) and EREC G99/NI which are available on the NIE Networks website. This **Power Park Module Setting Schedule** is a subsidiary document to both the **Grid Code** and **Distribution Code** and will be under the governance of the respective Review Panels. It will provide **Power Generating Facilities** containing **Type C** and **Type D Power Park Modules** clarity with regard to the **Compliance** requirements of the Codes, where certain aspects of the Codes are not detailed.

This **Setting Schedule** contains specific **Compliance** requirements for **Type C** and **Type D Power Park Modules** and explains a process to manage crucial interactions and data exchange. The process involves plant testing and reporting to demonstrate **Compliance** with the SONI **Grid Code** and the NIE Networks **Distribution Code** and the Commission Regulation (EU) 2016/631, Network Code Requirements for all Generators. Where the **Connection Agreement** specifically requires additional conditions or tests, a schedule shall be agreed between the parties. The technical requirements, general compliance and commissioning requirements for **Type C** and **Type D Power Park Modules** connecting to the **Distribution System** are given in EREC G99/NI.

It is intended to inform the **Generator** of the necessary process and reference should be made to the **Grid Code**, **Distribution Code**, EREC G99/NI, the **Connection Agreement** and the

[4] System Operators Northern Ireland (SONI) Website

**Connection Agreement** application process for a complete set of provisions relating to connection of generation.

**Type C** and **Type D Power Park Modules** connecting to the NIE Networks **Distribution System** are required to comply with the NIE Networks **Distribution Code**. **Power Park Modules** with a capacity greater than 5 **MW** will be required to comply with the SONI **Grid Code**, in particular the Connection Conditions. It is recommended that a **Generator** make contact with SONI and NIE Networks at an early stage of the project, prior to signing a contract with **Generating Unit** manufacturers. SONI and NIE Networks will provide guidance on technical issues and plant performance requirements.

SONI and NIE Networks' role will be to facilitate the compliance for the **Power Park Module**. SONI and NIE Networks' licence obligation is to ensure that the connection of **Power Park Module** does not conflict with its responsibilities mentioned in the foreword of this document.

## 2.2 ALL ESPS POWER PARK MODULES

This **Power Park Module Setting Schedule** has been updated to integrate the Battery **ESPS** Compliance Procedures and Battery **ESPS** Signal List, which were both documents previously available on the SONI **Grid Code** website. This most recent update is part of the **Grid Code** amendment to integrate the Battery Implementation Note into the **Grid Code** and came into effect in December 2021..

It is important to note that currently all storage devices except for pump-storage are explicitly excluded from the EU Network Code Requirements for Generators (RfG) (Commission Regulation (EU) 2016 / 631), therefore the changes to the **Grid Code** from 2019 including a major part of this **Power Park Module Setting Schedule** do not apply to storage devices. To inform the **Energy Storage Generator** of the necessary compliance process and to keep a clear partition between RfG and non RfG, a separate Section 7 (**ESPS** Compliance Test procedures) and new Appendix E (**ESPS** Signal List) have been added confirming the requirements.

*The decision to update the PPM Setting Schedule with non RfG battery storage was taken as the existing non RfG WFPS Setting Schedule has not been updated since 2015 and is no longer applicable to new connections. In addition, storage devices will be included in the next update to the RfG in the near future and at that time, SONI expect to bring forward further **Grid Code** amendments to this document.*

3.5 PPM Setting Schedule Compliance Procedures

*In the compliance test procedures sections, appropriate distinction is drawn between PPMs which consist of battery energy storage, and those that do not.*

### 5.0.1 OPERATIONAL READINESS CONFIRMATION (EXCEPT FOR ESPS)

As per Step No.6 of Section 5.0 of this **PPM Setting Schedule**, when the **PPM** is capable of full **Active Power** export and the **Generator** confirms to SONI that the **MW Availability** is of an accuracy level which, will pass the SONI **MW Availability** standard (detailed in Appendix C), SONI will begin continuous monitoring of the **MW Availability** signal that the **PPM** is submitting via SCADA. If the **PPM** passes the SONI **MW Availability** standard continuously for two weeks, then when resource conditions allow (**PPM Output** ≥ 50% **Registered Capacity**) SONI will carry out a dispatch Test to verify that the **PPM** is remotely controllable via SCADA. The

**Generator** will not be informed of when this test is taking place. The format of the dispatch Test conducted by SONI will be as follows:

## 7.0 ESPS COMPLIANCE TEST PROCEDURES

The following section details the Compliance procedures and tests for **Transmission System** connected **ESPS's**.

## 7.1 ENERGISATION AND DISPATCH TESTING

*Energisation and First Export*

An **ESPS** shall complete all pre-energisation requirements and will be issued an **Energisation Operational Notification (EON)** prior to energization and an **Interim Operational Notification (ION)** prior to first export.

On energisation, the following limits / requirements apply: A limit of +/-10 **MW** (import and export) is applied by the **ESPS** independent of **Active Power** Control System used by SONI.

**Frequency** Response will remain OFF except as required during commissioning activities, or as instructed by SONI. Such commissioning activities will be agreed with SONI through load profiles, as noted below. The **ESPS** shall submit load profiles to SONI for approval of commissioning and internal testing activities.

*First **Active Power** Dispatch Test (+/- 10MW)*

The **ESPS** shall inform SONI when the **ESPS** is available for an **Active Power** Dispatch Test (also providing information on the available **Reactive Power**).

SONI will carry out a Dispatch Test, not exceeding the +/-10 MW limit applied within the **ESPS** controller (this may include a combination of EDIL dispatch and Emergency Action controls)

Providing there is **Reactive Power** capability available, SONI will also carry out a brief **Reactive Power** control test, which may include issuing **MVAr** set points. (Note this will apply for transmission connected units where SONI has control over reactive power output)

SONI will review the results from the first **Active Power** Dispatch Test and will advise whether the **ESPS** has passed or failed

If the test is passed – SONI will advise that the cap can be lifted to full **MEC** and **MIC**

If the test is failed – the 10MW cap on import and export will remain in place, with the **ESPS** to resolve any issues identified and notify SONI when a repeat 10MW dispatch test can be carried out.

*Completing Commissioning*

The **ESPS** will continue to progress the project through the commissioning programme, submitting load profiles to SONI for approval as necessary. The **ESPS** shall also submit internal test results to demonstrate that commissioning of **Frequency** response and reactive power control and capability is completed. Following review of commissioning results, SONI may turn on frequency response and use reactive power control if required.

## ***Operational Readiness Confirmation (ORC)*** *Dispatch Test*

The **ESPS** informs SONI that commissioning is complete and requests the final dispatch test for **Operational Readiness Confirmation**.

This test will consist of **Active Power** dispatch instructions across the full **Operating Range** of the **ESPS**. This may include a combination of EDIL dispatch instructions and direct Emergency Action SCADA set points.

For transmission connected units where SONI has control of **Reactive Power** output, this test will also include **Reactive Power** set points.

SONI will review the results from the **ORC** Dispatch Test and will advise whether the **ESPS** has passed or failed

If the test is passed, SONI will issue an **ORC**. On issuing the **ORC**, SONI will advise its Real-Time Operations department that the unit is now considered controllable and available for dispatch

If the test is failed – the **ESPS** must resolve any issues identified and notify SONI when a repeat **ORC** dispatch test can be carried out.

## *Grid Code Compliance Testing and System Services Testing*

Following receipt of **Operational Readiness Confirmation**, the **ESPS** can progress to scheduling dates for **Grid Code Compliance** testing, and **System** Services testing.

### *Dispatch Test Procedure*

The **ESPS** should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day. Before each test section, the state of charge of the **ESPS** should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected **MW** output is 0MW. It is understood that there may be small **MW** imports at the connection point to account for house load, unless otherwise instructed by SONI.

It should be noted that the terms permissible import and permissible export in this procedure are defined as a maximum of 10MW in the case of the first **Active Power** Dispatch Test and or **MIC** and **MEC** in the case of the **ORC** Dispatch Test.

| Step No. | Action | Comments |
|---|---|---|
| 1 | If SONI has control of the **ESPS Reactive Power**, ensure the **ESPS** is close to 0 **MVAr** at the connection point. | |
| 2 | Confirm market PNs have been submitted and notify **ESPS** EDIL operator (if required) | |
| 3 | Ensure frequency response is **OFF** | |
| 4 | In EMS, turn Emergency Action **ON** | |
| 5 | Send **Active Power** Set-point of 50% permissible export (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 6 | Send **Active Power** Set-point of 20% permissible export (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |

| | | |
|---|---|---|
| 7 | Send **Active Power** Set-point of 30% permissible import (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 8 | Send **Active Power** Set-point of 70% permissible import (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 9 | Send **Active Power** Set-point of 40% permissible import (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 10 | In EMS, turn Emergency Action OFF (allow **ESPS** to return to 0MW and wait 1 minute). | |
| 11 | Send **Active Power** Set-point of 20% permissible export and wait 1 minute. (**ESPS** should not respond with Emergency Action OFF) | |
| 12 | Turn Emergency Action ON (allow the **ESPS** to achieve the current Set-point and wait 1 minute). | |
| 13 | Send **Active Power** Set-point of 0 MW (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 14 | Send **Active Power** Set-point of 20% permissible export (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 15 | Turn Emergency Action OFF (allow **ESPS** to return to 0MW and wait 1 minute). | |
| 16 | Send **MVAr** Set-point no.1 (allow the **ESPS** to achieve this Set-point and wait 1 minute). *Timing and magnitude of change in **MVAr** dependent on system conditions on day of* | |
| 17 | Send **MVAr** Set-point no.2 (allow the **ESPS** to achieve this Set-point and wait 1 minute). *Timing and magnitude of change in **MVAr** dependent on system conditions on day of* | |
| 18 | Send **MVAr** Set-point no.3 (allow the **ESPS** to achieve this Set-point and wait 1 minute). *Timing and magnitude of change in **MVAr** dependent on system conditions on day of* | |
| 19 | Send **MVAr** Set-point no.4 (allow the **ESPS** to achieve this Set-point and wait 1 minute). *Timing and magnitude of change in **MVAr** dependent on system conditions on day of* | |
| 20 | Send **MVAr** Set-point of 0 **MVAr** (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 21 | Ensure **Frequency** Response status is returned to pre-test condition | |
| 22 | Ensure Emergency Action is OFF and **MW** set-point is 0MW | |
| THE FOLLOWING TEST STEPS WILL ONLY BE PERFORMED IF EDIL DISPATCH IS OPERATIONAL | | |
| 23 | In EDIL, SONI/CHCC to issue DI for 40% permissible export (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 24 | In EDIL, SONI/CHCC to issue DI for 10% permissible export (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 25 | In EDIL, SONI/CHCC to issue DI for 40% permissible import (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 26 | In EDIL, SONI/CHCC to issue DI for 20% permissible import (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 27 | In EDIL, SONI/CHCC to issue DI for 0MW (allow the **ESPS** to achieve this Set-point and wait 1 minute). | |
| 28 | Ensure frequency status is returned to pre-test positon as noted in step 3 | |
| 29 | In EMS, ensure EMERGENCY ACTION is OFF and **MW** set-point is 0MW | |

| | | |
|---|---|---|
| 30 | Notify **ESPS** EDIL operator that the dispatch test has been completed and unit is returned to normal operation | |

## 7.2 ACTIVE POWER CONTROL TESTS

Compliance Testing/monitoring

Title of Test: **Active Power** Control

*Purpose of Tests*:

To establish that the **Active Power** control capability of the **ESPS** is in compliance with the requirements of CC.s2.1.5 of the Grid Code.

The purpose of this test is to demonstrate the **Active Power** Control functions of the **ESPS**, including ramp rates applied. This test procedure also includes verification of house load and battery capacity. Availability signals are recorded during this test and should be assessed in the test report.

*Results Required*:

The following data must be captured by the ESPS at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:

- **ESPS** Available **Active Power** Export (**MW**)
- **ESPS** Available **Active Power** Import (MW**)**
- **ESPS** Useable Energy Remaining (MWhr)
- **ESPS** Total Useable Storage Capacity (MWhr)
- Actual active power to/from the **ESPS** (**MW**)
- Emergency Action ON/OFF
- Emergency Action set-point from SONI
- **Frequency** Response ON/OFF
- Number of modules online

*Test Assessment*:

This test is required to show **Compliance** with CC.S2.1.5 for Transmission Connected **PPMs** consisting of **ESPSs**

*Criteria of Assessment*:

Active Power Control

- **Active Power** export and import is limited to the **MEC** and **MIC** of the **ESPS** respectively
- **ESPS** Control System receives all online Emergency Action set-points, commences
- implementation of all set-points within 10 seconds of receipt and provides the correct set-point feedback
- When Emergency Action is ON, **ESPS** regulates its active power output to within the greater of (±0.5 **MW** or ±3% of **Registered Capacity**) of the **Active Power** Control Set-point
- **ESPS** does not respond to any set-points sent while Emergency Action is OFF

Ramp Rates

- Rate of change of output is equal to the **Active Power** Control set-point Ramp Rate when ramping to **Active Power** Control Set-points, with temporary deviations not exceeding ±3% of Registered Capacity
- **ESPS** output ramps to 0MW at the **Active Power Control Set-point Ramp Rate** when Emergency Action is turned OFF (unless acting under **Frequency** Response Ramp Rate or Capacity Limited Ramp Rate)
- Demonstration that the **Active Power Control Set-point Ramp Rate** can be set by SONI over a range between 1% and 100% of **Registered Capacity** per minute

Battery Signals

- Available **Active Power** export and import signals are limited to the **MEC** and **MIC** of the **ESPS** respectively
- Available **Active Power** export and import signals behave correctly when the unit is issued an Emergency Action set-point or is providing a **Frequency** response

- Useable Energy Remaining signal provides real time quantity of energy (MWhr) that the unit is capable of exporting, based on current state of charge.
- Total Useable Storage Capacity signal provides real-time quantity of energy (MWhr) that the unit is capable of importing, based on current state of charge.
- **ESPS** Charging and Discharging Signals correctly determine if the **ESPS** is charging or discharging

Capacity/Max On Time

- **ESPS** Demonstration of Capacity ( Registered Characteristic / Technical Offer Data value)

### 7.2.1 ACTIVE POWER CONTROL TEST PROCEDURE

The **ESPS** should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the **ESPS** should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected **MW** output is 0MW. It is understood that there may be small **MW** imports at the connection point to account for house load, unless otherwise instructed by SONI.

*Demonstration of Limiters*

The ability of the **ESPS** to limit its Active Power flow (and the **AAP**) to **MEC** and **MIC** is demonstrated by sending Emergency Action set-points above **MEC** and below **MIC**.

| **Demonstration of Limiters Test Sequence for Test No.1** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the Demonstration of Limiters test and confirms the following with SONI:<br>1. AAP of the **ESPS**<br>2. **Frequency** Response is OFF<br>3. Emergency Action is ON<br>4. Emergency Action set-point [0MW]<br>5. **MW** output of the **ESPS**<br>6. **ESPS** Useable Energy Remaining (MWhr) |
| 2 | **ESPS** requests SONI to issue a **MW** set-point greater than **MEC** and waits until 1 minute after export has stabilised |
| *Note: intermediate steps may be added to avoid large MW changes during between Step 2 and 3, particularly if the difference between MEC and MIC is greater than 20MW.* | |
| 3 | **ESPS** requests SONI to issue a **MW** set-point less than **MIC** and waits until 1 minute after import has stabilised |
| 4 | **ESPS** informs SONI that the Demonstration of Limiters test is complete. If further testing is not being completed, go to 5: Return to Standard Settings |

*Ramp Rate Settings*

**Active Power Control Set-point Ramp Rate** is adjusted to values between 1%[5] and 100% of **Registered Capacity** per minute, with ramps carried out at each ramp rate setting.

Note: **Capacity Limited Ramp Rate** settings are changed during the **Frequency** Response Test procedure during the Ramp Rate Priority test. To avoid duplication of testing, it is suggested that data from the Ramp Rate test could be used to demonstrate the **ESPS** ability to change **Capacity Limited Ramp Rate** setting.

*A selection of ramp rate settings have been proposed here, as it is not practical to test all values with the requirements. In the test report, please include a statement outlining the ranges that these parameters can be set within.*

| **Ramp Rate Settings Test Sequence - Test No.2** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the Ramp Rate Settings test and confirms the following with SONI:<br>1. Emergency Action is OFF<br>2. **MW** output of the ESPS<br>3. **Frequency** Response is OFF<br>4. **ESPS** Useable Energy Remaining (MWhr)<br>5. **ESPS** Total Useable Storage Capacity (MWhr) |
| 2 | **ESPS** requests SONI to turn Emergency Action ON and issue a **MW** set-point of 30% of **MEC** and waits until 1 minute after the set-point has been achieved |
| 3 | SONI sets the **Active Power Control Set-point Ramp Rate** to 1% of **Registered Capacity** per minute |
| 4 | **ESPS** requests SONI to issue a **MW** set-point of 35% of **Registered Capacity** and waits until 1 minute after the set-point has been achieved |
| 5 | SONI sets the **Active Power Control Set-point Ramp Rate** to 100% of **Registered Capacity** per minute |
| 6 | **ESPS** requests SONI to issue a **MW** set-point of 20% of **Registered Capacity** and waits until 1 minute after the set-point has been achieved |
| 7 | SONI sets the **Active Power Control Set-point Ramp Rate** to 50% of **Registered Capacity** per minute |
| 8 | **ESPS** requests SONI to issue a set-point of 0MW then turn Emergency Action OFF and waits until 1 minute after the **MW** output has reached zero |
| 9 | **ESPS** ends data recording |
| 10 | **ESPS** informs SONI that the Ramp Rate Settings test is complete. If further testing is not being completed, go to 5: Return to Standard Settings |

[5] SONI do not anticipate setting ESUs to ramp rates as low as 1%. Ramp Rrate setting to be agreed with the **Energy Storage Generator** and SONI.

*Active Power Control (Emergency Action OFF)*

The following test is intended to provide data to demonstrate that the **ESPS** responds correctly when Emergency Action is turned OFF, and that the **ESPS** does not respond to any set-points sent while Emergency Action is OFF.

*Please also refer to test steps in **Frequency** Response and **Reactive Power** Test Procedures where APC set-points are issued. Data from these tests can be used to assess many of the APC pass criteria.*

| **Active Power Control (Emergency Action OFF) Test Sequence - Test No.3** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the **Active Power** Control test and confirms the following with SONI:<br>1. **Frequency** Response is OFF<br>2. Emergency Action is OFF<br>3. AAP export of the **ESPS**<br>4. AAP import of the **ESPS**<br>5. **MW** output of the **ESPS**<br>6. **ESPS** Useable Energy Remaining (MWhr) |
| 2 | **ESPS** requests SONI to turn Emergency Action ON and issue a **MW** set-point of 50% of **Registered Capacity** and waits until 1 minute after the set-point has been achieved |
| 3 | **ESPS** requests SONI to turn Emergency Action **OFF** and waits until 1 minute after the **MW** output has reached 0MW |
| 4 | **ESPS** requests SONI to issue a **MW** set-point of 40% of **Registered Capacity** |
| 5 | **ESPS** requests SONI to turn Emergency Action ON and waits until 1 minute after the set-point has been achieved |
| 6 | **ESPS** requests SONI to issue a **MW** set-point of 30% of **Registered Capacity** and waits until 1 minute after the set-point has been achieved |
| 7 | **ESPS** requests SONI to issue a set-point of 0 **MW** and waits until 1 minute after the set-point has been achieved |
| 8 | **ESPS** informs SONI that the **Active Power** Control test is complete. If further testing is not being completed, go to 5: Return to Standard Settings |

*Demonstration of Capacity/Technical Characteristics*

Please refer to the **Frequency** Response ON, Mode 2 test in the **Frequency** Response Test Procedure. This test includes a step where a **Frequency** injection is held for up to TOR2 timeframe. If this is not sufficient to demonstrate battery capacity as per registered characteristics, then the following test can be completed.

*Note for Ramping services such as RRD there may also be a requirement to demonstrate EDIL response time. This should be discussed and agreed with Generator Testing if planning to apply for this service.*

| **Demonstration of Capacity/Technical Characteristics Test Sequence –Test No.4** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the **Active Power** Control test and confirms the following with SONI:<br>1. Emergency Action is OFF<br>2. **MW** output of **ESPS**<br>3. **Frequency** Response is OFF<br>4. AAP export of the **ESPS**<br>5. AAP import of the **ESPS**<br>6. Useable Energy MWhr remaining<br>7. Duration of battery at full output<br>8. **Capacity Limited Ramp Rate** setting applied |
| 2 | **ESPS** requests SONI to turn Emergency Action ON and issue a **MW** set-point of 100% of **Registered Capacity** |
| 3 | **ESPS** to remain at full output until **Capacity Limited Ramp Rate** reduces output to 0MW |
| 4 | **ESPS** requests SONI to issue a set-point of 0 MW and turn Emergency Action OFF |
| 5 | **ESPS** informs SONI that the **Active Power** Control test is complete. If further testing is not being completed, go to 5: Return to Standard Settings |

*Return to Standard Settings*

The **ESPS** settings are returned to standard following completion of the **Active Power** Control Test.

| **Return to Standard Settings Test Sequence –Test No.5** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** confirms the following with SONI:<br>1. **ESPS** Useable Energy Remaining (MWhr)<br>2. Emergency Action Set-point = 0MW<br>3. Emergency Action is OFF<br>4. **MW** output of the ESPS<br>5. **Frequency** Response is ON<br>6. **Frequency** Response is in Mode 1 (or as agreed with CHCC)<br>7. **ESPS** frequency reference is system frequency |
| 5 | **ESPS** informs SONI that **Active Power** Control testing is complete |

## 7.3 FREQUENCY CONTROL TESTS

Compliance Testing/monitoring

Title of Test: **Frequency Control**

*Purpose of Tests*:

To establish that the **Frequency Control** capability of the **ESPS** is in compliance with the requirements in CC.S2.1.7.2 of the Grid Code.

The purpose of this test is to confirm the ability of the **ESPS** to respond to changes in **System Frequency**. The **ESPS** shall be capable of operating with a "MW/Hz" slope – e.g. able to continuously adjust its **Active Power** output in response to changes in **Frequency**. As the **System Frequency** cannot be changed at will, the test will require **Frequency** to be simulated by means of injection of a **Frequency** signal into the **ESPS** control system.

*Results Required*:

The following data must be captured by the ESPS at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:

- **ESPS** Available **Active Power** Export (MW)
- **ESPS** Available **Active Power** Import (MW)
- **ESPS** Useable Energy Remaining (MWhr)
- **ESPS** Total Useable Storage Capacity (MWhr)
- Actual active power from the **ESPS** in MW
- Emergency Action ON/OFF
- Emergency Action set-point from SONI
- **Frequency** Response ON/OFF
- **Frequency** Response Reserve Mode 1-5
- Active under **Frequency** trigger setting
- Active under **Frequency** trajectory setting
- Active Maximum underfrequency response setting
- Active over **Frequency** trigger setting
- Active over **Frequency** trajectory setting
- Active Maximum overfrequency response setting

- Simulated Test **Frequency**
- **System Frequency**
- Number of modules online
- 

*Test Assessment*:
This test is required to show **Compliance** with CC.S2.1.7.2.

*Criteria of Assessment*:

- **Frequency** response mode settings have been implemented as per the table in 7.3.1 below.
- 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. If **Frequency Response** is OFF, the mode should not change.
- **ESPS** is capable of operating with parameters set anywhere in the following ranges:
  - Under **Frequency** Trigger $F_1$: 49Hz – 50Hz
  - Under **Frequency** Trajectory $F_1$-$F_2$: 1Hz – 10Hz
  - Maximum Under frequency Response: 0MW – **Operating Range**
  - Over **Frequency** Trigger $F_3$: 50Hz – 51Hz
  - Over **Frequency** Trajectory $F_3$-$F_4$: 1Hz – 10Hz
  - Maximum Over frequency Response: 0MW – **Operating Range**

*Note: A number of settings will be demonstrated as per existing mode settings during this Frequency Response test. A statement confirming the max and min ranges that can be applied for each parameter is to be provided by the customer in the test report to further support this criteria.*

- When **Frequency Response** is OFF, no response shall be provided.
- For **Frequency** ≥ $F_1$ and ≤ $F_3$, no response shall be provided
- For **Frequency** between $F_1$ and $F_2$, and $F_3$ and $F_4$ MW output is based on a MW/Hz slope, which is defined only by the Maximum Response setting and the trajectory, as defined for each Mode.
- Over **Frequency Response** (ΔP) will be limited by the lesser of availability, Maximum Over **Frequency Response** setting, maximum capacity (accounting for MIC), and application of the Capacity Limited Ramp Rate.
- Under **Frequency Response** (ΔP) 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**.
- **ESPS** provides ≥60% of its expected response within 5 seconds and 100% of its expected response within 15 seconds.
- **Frequency Response** is achieved by altering the output of all modules as opposed to switching modules on or off, insofar as possible.
- **ESPS** regulates its active power output to within the greater of:(±0.5 MW or ±3% of **Registered Capacity**) of the **Active Power Control Set-point** adjusted for Frequency Response.
- The **PPM** controller continuously recalculates its expected response during the **Frequency** excursion.

*Ramp Rates*

- Demonstration that the **Capacity Limited Ramp Rate** and **Active Power Control Set-point Ramp Rate** can each be set over a range between 1% and 100% of **Registered Capacity** per minute. Note: APC ramp rate setting is varied in the APC Test Procedure
- Ramp rate priority is applied as per CC.S2.1.5.

*Signals*

- FFR-TOR Availability signals behave correctly under Emergency Action set-point or EDIL dispatch
- Available **Active Power** export and import signals behave correctly when the unit is issued an **APC set-point** or is providing a **Frequency Response**
- 

### 7.3.1 FREQUENCY CONTROL TEST PROCEDURE

***Frequency*** *and Ramp Rate Settings to be implemented in* ***ESPS*** *Control System*

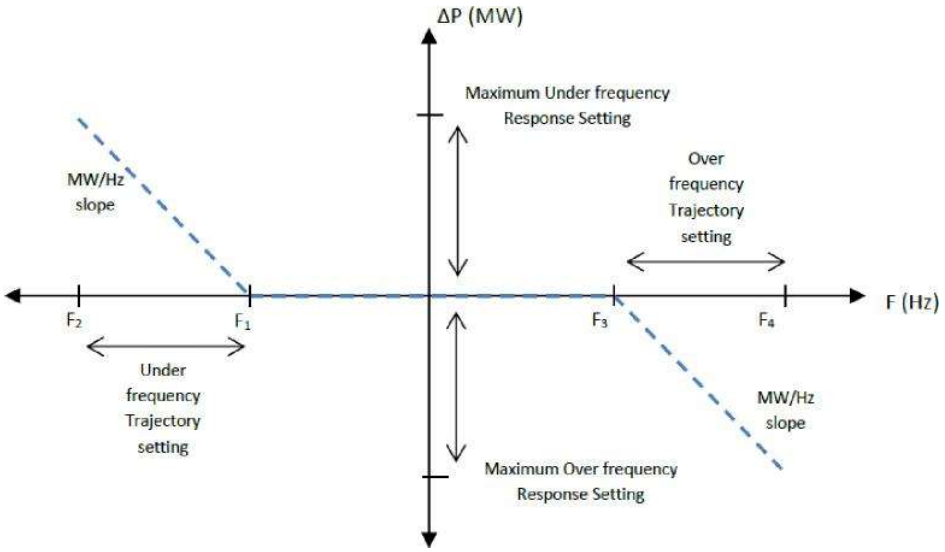



**Figure 1 Battery ESPS Frequency Response**

**Frequency Mode Settings**

| | *Active under frequency trigger setting (Hz)* | *Active under frequency trajectory setting (Hz)* | *Active Maximum underfrequency response setting (MW)* | *Active over frequency trigger setting (Hz)* | *Active over frequency trajectory setting (Hz)* | *Active Maximum overfrequency response setting (MW)* |
|---|---|---|---|---|---|---|
| ***Mode 1*** | 49.8 | 0.3 | **Operating Range** | 50.2 | 0.3 | **Operating Range** |
| ***Mode 2*** | TBC | TBC | **Operating Range** | TBC | TBC | **Operating Range** |
| ***Mode 3*** | 49.8 | 0.5 | **Operating Range** | 50.2 | 0.5 | **Operating Range** |
| ***Mode 4*** | 49.9 | 0.3 | **Operating Range** | 50.1 | 0.3 | **Operating Range** |
| ***Mode 5*** | 49.8 | 0.5 | 50% **Operating Range** | 50.2 | 0.5 | 50% **Operating Range** |

**Ramp Rates**

| Mode | Rate | Priority |
|---|---|---|
| **Capacity Limited** | 1-100% of **Registered Capacity** per Minute<br>(Standard Setting 20%) | 1 |
| **Frequency Response** | As fast as technically possible.<br>60% of its expected **Active Power** response within 5 seconds<br>100% of its expected **Active Power** response within 15 | 2 |
| **Active Power** Dispatch | 1- 100% of **Registered Capacity** per Minute<br>(Note: Setting as selected by SONI via SCADA) | 3 |

Note: The **ESPS** should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the **ESPS** should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected **MW** output is 0MW. It is understood that there may be small **MW** imports at the connection point to account for house load, unless otherwise instructed by SONI.

The **ESPS** is to specify:

- Whether **Frequency** is injected using software or external hardware
- Whether **Frequency** can be injected as a ramp or as a step
- Whether **Frequency** is injected as an offset to the **System Frequency** or the governor/control system is isolated from the **System Frequency**

**Functional Test Sequence –Test No.1**

| Step No. | Action |
|---|---|
| 1 | **ESPS** requests permission from SONI to proceed with the **Frequency Response** functional check and confirms the following with SONI:<br>1. **MW** output of the **ESPS**<br>2. EMERGENCY ACTION is OFF<br>3. **Frequency Response** is ON<br>4. **Frequency Response** Mode 1 is ON<br>5. Active Under **Frequency** Trajectory setting<br>6. Active Under **Frequency** Trigger setting<br>7. Active Maximum underfrequency response setting<br>8. Active Over **Frequency** Trajectory setting<br>9. Active Over frequency Trigger setting<br>10. Active Maximum overfrequency response setting |
| 2 | **ESPS** requests SONI to select Reserve Response Mode 2 and manually records the time between the command being issued from SONI and being implemented in the **ESPS** Control System<br><br>SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 2 settings |
| 3 | **ESPS** requests SONI to select Reserve Response Mode 3 and manually records the time between the command being issued from SONI and being implemented in the **ESPS** Control System<br><br>SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 3 settings |
| 4 | **ESPS** requests SONI to select Reserve Response Mode 4 and manually records the time between the command being issued from SONI and being implemented in the **ESPS** Control System<br><br>SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 4 settings |
| 5 | **ESPS** requests SONI to select **Frequency Response** OFF and manually records the time between the command being issued from SONI and being implemented in the **ESPS** controller |
| 6 | **ESPS** requests SONI to select Reserve Response Mode 5 and records any change to **Frequency Response** Mode status |
| 7 | **ESPS** requests SONI to select **Frequency Response** ON and manually records the time between the command being issued from SONI and being implemented in the **ESPS** controller |
| 8 | **ESPS** requests SONI to select Reserve Response Mode 5 and manually records the time between the command being issued from SONI and being implemented in the **ESPS** control system<br><br>SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 5 settings. |
| 9 | **ESPS** requests SONI to select **Frequency Response** Mode 1 |

| Mode 1 Frequency Response ON Test Sequence – Test No.2 | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the **Frequency Response** ON, Mode 1 test and confirms the following with SONI:<br>1. AAP of the **ESPS**<br>2. **MW** set-point is 0MW<br>3. APC is OFF<br>4. **MW** output of the **ESPS** is 0MW<br>5. **Frequency Response** is ON<br>6. **Frequency Response** is in Mode 1<br>7. Active Under **Frequency** Trajectory setting<br>8. Active Under **Frequency** Trigger setting<br>9. Active Maximum underfrequency response setting<br>10. Active Over **Frequency** Trajectory setting<br>11. Active Over **Frequency** Trigger setting<br>12. Active Maximum overfrequency response setting |
| 2 | **ESPS** replaces the system frequency with a simulated **Frequency** of 50 Hz and waits 1 minute. |
| 3 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz inside active underfrequency trigger and waits 1 minute |
| 4 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz outside active underfrequency trigger and waits 1 minute |
| 5 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 50Hz and waits 1 minute |
| 6 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 49Hz over 10 seconds and waits 1 minute |
| 7 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits 1 minute |
| 8 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz inside active overfrequency trigger and waits 1 minute |
| 9 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz outside active overfrequency trigger and waits 1 minute |
| 10 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 50Hz and waits 1 minute |
| 11 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 51Hz over 10 seconds and waits 1 minute |
| 12 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits 1 minute |
| 13 | **ESPS** requests SONI to turn Emergency Action ON and issue an MW set-point of 50% **MEC** and waits 1 minute after set-point has been achieved |
| 14 | **ESPS** confirms simulated **Frequency** of 50Hz is in place |
| 15 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 49Hz over 1 minute and waits 1 minute |
| 16 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 minute and waits 1 minute |
| 17 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 51Hz over 1 minute and waits 1 minute |
| 18 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 minute and waits 1 minute |
| 19 | **ESPS** requests SONI to issue an Emergency Action **MW** set-point of 50% **MIC** and waits 1 minute after set-point has been achieved |

| | |
|---|---|
| 20 | **ESPS** confirms simulated **Frequency** of 50Hz is in place |
| 21 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 49Hz over 1 second and waits 1 minute |
| 22 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 second and waits 1 minute |
| 23 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 51Hz over 1 second and waits 1 minute |
| 24 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 second and waits 1 minute |
| 25 | **ESPS** requests SONI to issue an Emergency Action **MW** set-point of **MEC** and waits 1 minute after set-point has been achieved |
| 26 | **ESPS** confirms simulated **Frequency** of 50Hz is in place |
| 27 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 49Hz over 10 seconds and waits 1 minute |
| 28 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits 1 minute |
| 29 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 51Hz over 10 seconds and waits 1 minute |
| 30 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits 1 minute |
| 31 | **ESPS** requests SONI to issue an Emergency Action MW set-point of MIC and waits 1 minute after set-point has been achieved |
| 32 | **ESPS** confirms simulated **Frequency** of 50Hz is in place |
| 33 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 49Hz over 1 minute and waits 1 minute |
| 34 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 minute and waits 1 minute |
| 35 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 51Hz over 1 minute and waits 1 minute |
| 36 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 minute and waits 1 minute |
| 37 | **ESPS** requests SONI to issue an Emergency Action set-point of 0MW and turn Emergency Action OFF and waits 1 minute after set-point has been achieved |
| 38 | **ESPS** ends data recording |
| 39 | **ESPS** informs SONI that the **Frequency Response** ON, Mode 1 test is complete. If further testing is not being completed, go to 7 Return to Standard Settings |

**Mode 2 Frequency Response ON Test Sequence – Test No.3**

| Step No. | Action |
|---|---|
| 1 | **ESPS** requests permission from SONI to proceed with the **Frequency Response** ON, Mode 2 test and confirms the following with SONI:<br>1. AAP of the **ESPS**<br>2. **MW** set-point is 0MW<br>3. EMERGENCY ACTION is OFF<br>4. **MW** output of the **ESPS** is 0MW<br>5. **Frequency Response** is ON<br>6. **Frequency Response** is in Mode 2<br>7. Active Under Frequency Trajectory setting<br>8. Active Under Frequency Trigger setting<br>9. Active Maximum underfrequency response setting<br>10. Active Over Frequency Trajectory setting<br>11. Active Over Frequency Trigger setting<br>12. Active Maximum overfrequency response setting<br>Note: The standard trigger test is an injection of 0.05Hz above and below the Mode 2 trigger setting. In the case that this would result in large **MW** step changes, for example for units with small trajectory settings, changes to these test steps should be discussed with Generator Testing. |
| 2 | **ESPS** replaces the **System Frequency** with a simulated **Frequency** of 50 Hz and waits 1 minute. |
| 3 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz inside active underfrequency trigger and waits 1 minute |
| 4 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz outside active underfrequency trigger and waits 1 minute |
| 5 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 50Hz and waits 1 minute |
| 6 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz inside active overfrequency trigger and waits 1 minute |
| 7 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 0.05Hz outside active overfrequency trigger and waits 1 minute |
| 8 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 50Hz and waits 1 minute |
| 9 | **ESPS** requests SONI to turn EMERGENCY ACTION ON and issue an EMERGENCY ACTION MW set-point of MIC and waits 1 minute after set-point has been achieved |
| 10 | **ESPS** confirms simulated Frequency of 50Hz is in place |
| 11 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of underfrequency trigger-trajectory and waits 20 minutes<br>Note 1: Unless capacity limited, the **ESPS** should remain at this output until the **Frequency** is returned towards 50Hz in step 12.<br>Note 2: This step is intended to be used to demonstrate **System** Services **Operating Reserve** response time and volumes, and will also demonstrate the capacity of the **ESPS**. If the **ESPS** has a greater duration than 20 minutes, this timing for this step should be extended. |
| 12 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 minute and waits 1 minute |
| 13 | **ESPS** requests SONI to issue an EMERGENCY ACTION **MW** set-point of MEC and waits 1 minute after set-point has been achieved |
| 14 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of overfrequency trigger + trajectory and waits 1 minute*<br>*Note if Battery **ESPS** unit has contracted for over-frequency services as part of the Volume Capped arrangements, the timing of this step should be extended |
| 15 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 1 second and waits 1 minute |

| | |
|---|---|
| 16 | **ESPS** requests SONI to issue an EMERGENCY ACTION set-point of 0MW and turn EMERGENCY ACTION OFF and waits 1 minute after set-point has been achieved |
| 17 | **ESPS** ends data recording |
| 18 | **ESPS** informs SONI that the **Frequency Response** ON, Mode 2 test is complete. If further testing is not being completed, go to 7 Return to Standard Settings |

**Mode 5 Frequency Response ON Test Sequence – Test No.4**

| Step No. | Action |
|---|---|
| 1 | **ESPS** requests permission from SONI to proceed with the **Frequency Response** ON, Mode 5 test and confirms the following with SONI:<br>1. AAP of the ESPS<br>2. MW set-point is 0MW<br>3. EMERGENCY ACTION is ON<br>4. MW output of the ESPS is 0MW<br>5. **Frequency Response** is ON<br>6. **Frequency Response** is in Mode 5<br>7. Active Under **Frequency** Trajectory setting<br>8. Active Under **Frequency** Trigger setting<br>9. Active Maximum underfrequency response setting<br>10. Active Over **Frequency** Trajectory setting<br>11. Active Over **Frequency** Trigger setting<br>12. Active Maximum overfrequency response setting |
| 2 | **ESPS** replaces the **System Frequency** with a simulated **Frequency** of 50 Hz and waits 1 minute. |
| 3 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 49Hz over 10 seconds and waits 1 minute |
| 4 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits 1 minute |
| 5 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 51Hz over 10 seconds and waits 1 minute |
| 6 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits 1 minute |
| 7 | **ESPS** requests SONI to turn EMERGENCY ACTION OFF and waits 1 minute |
| 8 | **ESPS** ends data recording |
| 9 | **ESPS** informs SONI that the **Frequency Response** ON, Mode 5 test is complete. If further testing is not being completed, go to 7 Return to Standard Settings |

| Frequency Response OFF Test Sequence – Test No.5 | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the **Frequency Response** OFF test and confirms the following with SONI:<br>1. EMERGENCY ACTION OFF<br>2. **MW** output of the ESPS is 0MW<br>3. **Frequency Response** is OFF<br>4. **Frequency Response** Mode 4 is selected |
| 2 | **ESPS** replaces the **System Frequency** with a simulated **Frequency** of 50 Hz and waits 1 minute |
| 3 | **ESPS** injects a simulated **Frequency** of 49 Hz and waits 1 minute |
| 4 | **ESPS** injects a simulated **Frequency** of 51 Hz and waits 1 minute |
| 5 | **ESPS** requests SONI to issue an EMERGENCY ACTION MW set-point of 40% Registered Capacity and turn EMERGENCY ACTION ON and waits until EMERGENCY ACTION set-point has been achieved |
| 6 | **ESPS** injects a simulated **Frequency** of 49 Hz and waits 1 minute |
| 7 | **ESPS** injects a simulated **Frequency** of 51 Hz and waits 1 minute |
| 8 | **ESPS** requests SONI to issue an EMERGENCY ACTION set-point of 0MW and turn EMERGENCY ACTION OFF, and waits until output reaches 0MW |
| 9 | **ESPS** ends data recording |
| 10 | ESPS informs SONI that the **Frequency Response** OFF test is complete. If further testing is not being completed, go to 7 Return to Standard Settings |

## *Ramp Rate Priority*

This test demonstrates that the three ramp rates are prioritised in correct manner.

| Ramp Rate Priority Test Sequence – Test No.6 | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the test and confirms the following with SONI:<br>1. EMERGENCY ACTION is OFF<br>2. **MW** output of the **ESPS**<br>3. **Frequency Response** is ON<br>4. Mode 1 is ON<br>5. **ESPS** Useable Energy Remaining (MWhr)<br>6. **ESPS** Total Useable Storage Capacity (MWhr) |
| | Under Frequency injection during EMERGENCY ACTION ramp EMERGENCY ACTION turned OFF during under frequency event |
| 2 | **ESPS** requests SONI to issue a **MW** set-point of 50% of **Registered Capacity** and turn EMERGENCY ACTION ON. |
| 3 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits until output settles |

| | |
|---|---|
| 4 | **ESPS** requests permission from SONI to inject a simulated underfrequency step injection and waits until **ESPS** output settles.<br>*(Note: size of under-frequency injection to be such that the required delta MW is approx. 10-20% **Operating Range**)* |
| 5 | **ESPS** requests SONI to turn EMERGENCY ACTION OFF and waits until unit output settles |
| 6 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits until output reaches 0MW |
| Over **Frequency** injection during EMERGENCY ACTION ramp<br>EMERGENCY ACTION turned OFF during over **Frequency** event | |
| 7 | **ESPS** requests SONI to issue a MW set-point of 15% of **Registered Capacity** and turn EMERGENCY ACTION ON.<br>While ramping to the EMERGENCY ACTION set-point, ESPS requests permission from SONI to inject a simulated overfrequency step injection and waits until ESPS finishes ramping.<br>*(Note: size of over-frequency injection to be such that the required delta MW is approx. 20-30% **Operating Range**)* |
| 8 | **ESPS** requests SONI to turn EMERGENCY ACTION OFF and waits until unit output settles |
| 9 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits until output settles |
| Over **Frequency** injection during EMERGENCY ACTION ramp<br>Returning to EMERGENCY ACTION set-point on **Frequency** recovery | |
| 10 | **ESPS** requests SONI to issue a **MW** set-point of 20% of **Registered Capacity** and turn EMERGENCY ACTION ON.<br>While ramping to the Emergency Action set-point, ESPS requests permission from SONI to inject a simulated overfrequency step injection and waits until ESPS finishes ramping.<br>*(Note: size of over-frequency injection to be such that the required delta MW is approx. 20-30% **Operating Range**)* |
| 11 | **ESPS** requests permission from SONI to inject a simulated **Frequency** ramp injection of 50Hz over 10 seconds and waits until output settles |
| **Frequency** injections during Capacity Limited Ramp Down | |
| 12 | **ESPS** sets the **Capacity Limited Ramp Rate** to an appropriate value to enable completion of this step.<br>*(Note: The capacity limited ramp rate to be set to different value than the current APC ramp rate setting. This setting should be such that Steps 15 & 16 can be carried out while the unit is ramping down from a 60% registered capacity set-point (Step 13). E.g. 10% Registered Capacity/minute would give 6 minutes of a ramp down to allow Step15 & 16 to be completed.)* |
| 13 | **ESPS** requests SONI to turn Emergency Action ON and issue a **MW** set-point of 60% of **Registered Capacity** |
| 14 | **ESPS** output to be held until the unit starts ramping at **Capacity Limited Ramp Rate** *(Note: State of charge should be low enough so that this wait time is reasonable)* |
| 15 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 49.5 Hz |
| 16 | **ESPS** requests permission from SONI to inject a simulated overfrequency step injection.<br><br>*(Note: size of over-frequency injection to be such that the required delta MW is approx. 10-20% **Operating Range**)*<br><br>If the unit is still exporting as a result of this injection, this simulated frequency injection is held until the unit output settles and/or Capacity Limited ramp is completed.<br>If the unit has started importing as a result of this injection, this simulated **Frequency** injection should be held for 1 minute. |
| 17 | **ESPS** requests permission from SONI to inject a simulated **Frequency** step injection of 50Hz and waits 1 minute. |

| | |
|---|---|
| 18 | **ESPS** sets the **Capacity Limited Ramp Rate** to 20% of **Registered Capacity** per minute, as and confirms to SONI. |
| 19 | **ESPS** requests SONI to issue a set-point of 0MW then turn Emergency Action OFF and waits until 1 minute after the **MW** output has reached 0MW |
| 20 | **ESPS** ends data recording |
| 21 | **ESPS** informs SONI that the Ramp Rate Priority test is complete. If further testing is not being completed, go to 7 Return to Standard Settings |

| **Return to Standard Settings Test Sequence – Test No.7** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** removes the simulated **Frequency**, returning the **ESPS** controller reference to **system Frequency** |
| 2 | **ESPS** confirms the following with SONI:<br>1. EMERGENCY ACTION Set-point = 0MW<br>2. EMERGENCY ACTION is OFF<br>3. **MW** output of the **ESPS**<br>4. **Frequency Response** is ON<br>5. **Frequency Response** is in Mode 1<br>6. **ESPS** control **System Frequency** reference is **System Frequency** |
| 3 | **ESPS** informs SONI that **Frequency Response** testing is complete |

## 7.4 REACTIVE POWER CAPABILITY TESTS

Compliance Testing/monitoring

Title of Test: **Reactive Capability**

*Purpose of Tests*:

To establish that the **Reactive Power** capability of the **ESPS** is in compliance with the requirements in CC.S2.1.3.2 of the Grid Code.

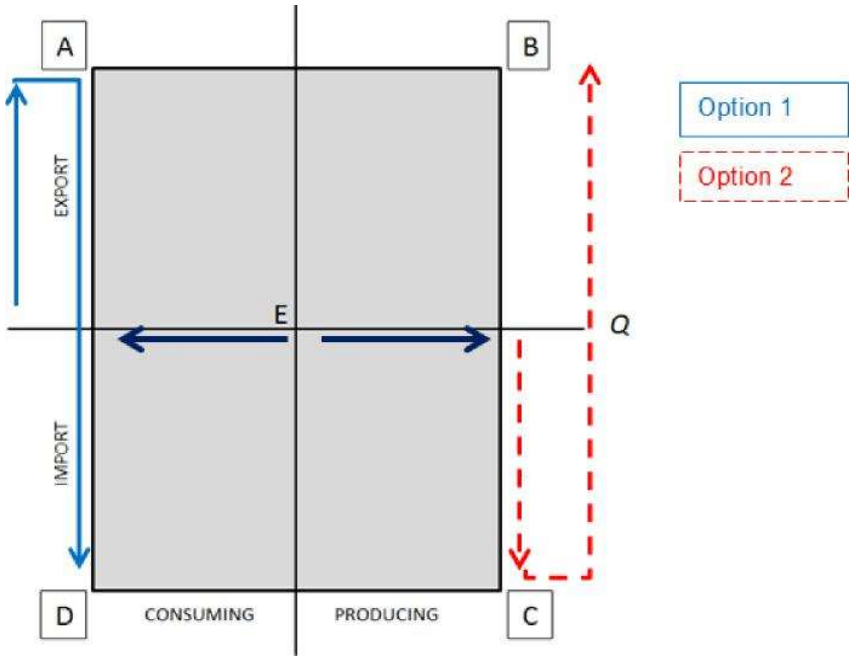
The tests should demonstrate the limits of the **ESPS Reactive Power** capability curve at the connection point. The test is undertaken at various load levels for both the export of Reactive Power from the **ESPS** and for the import of Reactive Power to the **ESPS**.

*Results Required*:

The following data must be captured by the **ESPS** at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:

- **ESPS** Available **Active Power** Export (MW)
- **ESPS** Available **Active Power** Import (MW)
- **ESPS** Useable Energy Remaining (MWhr)
- **ESPS** Total Useable Storage Capacity (MWhr)
- Actual **Active Power** from the ESPS (MW)
- **System** Voltage at Connection Point (kV)
- **Reactive Power** Flow at **Connection Point** (MVAr)
- Emergency Action ON/OFF
- Emergency Action set-point from SONI
- **Frequency Response** ON/OFF
- Number of modules online

The **ESPS** may capture any other signals as necessary to demonstrate compliance.




*Test Methodology*:

Depending on state of charge, the **ESPS** can follow the red or blue path to complete this test. Each option is shown on one side of the capability curve only for illustration purposes.

**ESPS** to start from a 0MW **Active Power** position at **MVAr** output close to 0 **MVAr** and

increase **MVAr** set-points until max lagging/leading capability as noted in Section 4 is reached. Note that this set-point shall be large enough to cover the max capability over all of the **MW** range, such that as the **MW** output is varied in subsequent test steps, the **MVAr** output is not limited by the **MVAr** set-point.

Option 1 (Blue solid line): Once at max leading/lagging capability, the **MVAr** set-point should be set to ensure the maximum capability as per the PQ chart in Section 4 is achievable. **Active power** set-points are then issued to increase from 0MW to 100% **Registered Capacity**, and then down to full import. Note depending on the capability curve, the **MVAr** output may vary as **MW** output is varied.

Option 2 (Red dashed line): Once at max leading/lagging capability, the **MVAr** set-point should be set to ensure the maximum capability as per the PQ chart in Section 4 is achievable. **Active power** set-points are then issued to decrease from 0MW to full import, and then increase to 100% **Registered Capacity**. Note depending on the capability curve, the **MVAr** output may vary as **MW** output is varied.

After each option the **MW** output is returned to 0MW and the **MVAr** output is returned to 0MVAr in steps. The size of these steps shall be confirmed with SONI.

*Criteria of Assessment*:

- Demonstration that the measured P-Q capability is in line with the submitted P-Q capability diagram
- Demonstration that the measured P-Q capability meets or exceeds the minimum expected **Reactive Power** capabilities of the controllable **ESPS**, as defined in the Grid Code, as measured at the **Connection Point**
- Completion of cable charging measurement
- **Reactive Power** import availability and reactive power export availability signals provide the real-time availability of **MVAr** that can be imported/consumed at point of connection, taking into account any relevant factors such as **Active Power** output (or import), module availability, faults etc.

Note: The **ESPS** should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the **ESPS** should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected **MW** output is 0MW. It is understood that there may be small **MW** imports at the **Connection Point** to account for house load, unless otherwise instructed by SONI.

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### 7.4.1 REACTIVE POWER CAPABILITY TEST PROCEDURE

| **Reactive Power Capability: Importing Test Sequence –Test No.1** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the **Reactive Power** Capability (Importing **Mvar**) test and confirms the following with SONI:<br>1. **MW** output of the **ESPS**<br>2. Emergency Action is OFF<br>3. **Frequency Response** is OFF<br>4. **Mvar** (Q) control mode is ON<br>5. The transformer tap position<br>6. On Load Tap Changer Mode<br>7. **System** Voltage<br>8. Maximum leading **Mvar** capability of the **ESPS**<br>9. **Mvar** Export at the connection point<br>10. **ESPS Reactive Power** Export Availability (**MVAr**)<br>11. **ESPS Reactive Power** Import Availability (**MVAr**)<br>12. **ESPS** to confirm which path it wishes to follow for testing, based on state of charge |
| 2 | **ESPS** requests SONI to decrease the MVAr set-point in steps as agreed with SONI until the **ESPS** has reached its maximum leading **MVAr** limit at the **Connection Point** |
| 3 | **ESPS** requests SONI to reduce the **MVAr** set-point by a further step (s).<br>*Note: Ensure that the **MVAr** set-point is sufficient to cover the max capability over all of the **MW** range, such that as the MW output is varied in subsequent test steps, the **MVAr** output is not limited by the **MVAr** set-point. |
| 4 | **ESPS** requests SONI to turn EMERGENCY ACTION ON and issue a **MW** set-point of **Registered Capacity** or **MIC**<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the **MVAr** output may vary as **MW** output is varied for |
| 5 | **ESPS** requests SONI to issue a set-point of 0 MW<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the **MVAr** output may vary as **MW** output is varied for |
| 6 | **ESPS** requests SONI to issue a **MW** set-point of **Registered Capacity** or **MIC**<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the **MVAr** output may vary as **MW** output is varied for |
| 7 | **ESPS** requests SONI to issue a set-point of 0MW and turn EMERGENCY ACTION OFF and waits until output reaches 0 MW.<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the **MVAr** output may vary as **MW** output is varied for subsequent steps. |
| 8 | **ESPS** requests SONI to increase the **MVAr** set-point in steps as agreed with SONI until the **ESPS** is exporting 0 MVAr at the **Connection Point**, or as agreed with SONI |
| 9 | **ESPS** ends data recording |

| | |
|---|---|
| 10 | **ESPS** informs SONI that the **Reactive Power** Capability (Importing **MVAr**) test is complete If further testing is not being completed, go to Section 4 Return to Standard Settings |

**Reactive Power Capability: Exporting Test Sequence –Test No.2**

| Step No. | Action |
|---|---|
| 1 | **ESPS** requests permission from SONI to proceed with the **Reactive Power** Capability (Exporting **Mvar**) test and confirms the following with SONI:<br>1. **MW** output of the **ESPS**<br>2. Emergency Action is OFF<br>3. **Frequency Response** is OFF<br>4. **Mvar** (Q) control mode is ON<br>5. The transformer tap position<br>6. On Load Tap Changer Mode<br>7. **System** Voltage<br>8. Maximum leading **Mvar** capability of the **ESPS**<br>9. **Mvar** Export at the connection point<br>10. **ESPS Reactive Power** Export Availability (**MVAr**)<br>11. **ESPS Reactive Power** Import Availability (**MVAr**)<br>12. **ESPS** to confirm which path it wishes to follow for testing, based on state of charge |
| 2 | **ESPS** requests SONI to increase the **MVAr** set-point in steps as agreed with SONI until the **ESPS** has reached its maximum lagging **MVAr** limit at the **connection point** |
| 3 | **ESPS** requests SONI to increase the **MVAr** set-point by a further step (s).<br>*Note: Ensure that the **MVAr** set-point is sufficient to cover the max capability over all of the **MW** range, such that as the **MW** output is varied in subsequent test steps, the **MVAr** output is not limited by the **MVAr** set-point. |
| 4 | **ESPS** requests SONI to turn EMERGENCY ACTION ON and issue a **MW** set-point of **Registered Capacity** or **MIC**<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the **MVAr** output may vary as **MW** output is varied for subsequent steps |
| 5 | **ESPS** requests SONI to issue a set-point of 0 MW<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the **MVAr** output may vary as **MW** output is varied for |
| 6 | **ESPS** requests SONI to issue a **MW** set-point of **Registered Capacity** or **MIC**<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the **MVAr** output may vary as **MW** output is varied for subsequent steps. |
| 7 | **ESPS** requests SONI to issue a set-point of 0MW and turn EMERGENCY ACTION OFF and waits until output reaches 0 MW.<br>*Note if **Registered Capacity/MIC** is larger than 10MW – this step may be split into multiple steps<br>*Note depending on the **ESPS** PQ curve, the MVAr output may vary as MW output is varied for subsequent steps |
| 8 | **ESPS** requests SONI to decrease the **MVAr** set-point in steps as agreed with SONI until the **ESPS** is exporting 0 **MVAr** at the connection point, or as agreed with SONI |

| | |
|---|---|
| 9 | **ESPS** ends data recording |
| 10 | **ESPS** informs SONI that the **Reactive Power** Capability (Exporting **MVAr**) test is complete If further testing is not being completed, go to Section 4 Return to Standard Settings |

| **Cable Network Charging Capacitance Test Sequence –Test No.3** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI and shuts down all Battery Modules |
| 2 | **ESPS** records the **MVAr** at the connection point |
| 3 | **ESPS** requests permission from SONI and restarts all Battery Modules |

| **Return To Standard Settings Test Sequence –Test No.4** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** confirms the following with SONI:<br>1. Emergency Action setpoint is 0MW<br>2. **MW** output of the **ESPS**<br>3. Emergency Action is OFF<br>4. **Frequency Response** is ON<br>5. **Frequency Response** is in Mode1<br>6. AVR (kV) control mode is ON<br>7. The transformer tap position<br>8. On Load Tap Changer is in Automatic mode<br>9. **System** Voltage<br>10. kV Set-point = system voltage at connection point<br>11. Voltage slope setting = 3%<br>12. **MVAr** Export at the connection point |

## 7.5 REACTIVE POWER CONTROL TESTS

| Compliance Testing/monitoring |
|---|
| Title of Test: **Reactive Control** |
| *Purpose of Tests*:<br><br>To establish that the **Reactive Power** control capability of the **ESPS** is in compliance with the requirements detailed CC.S2.1.3.2 of the Grid Code.<br><br>The purpose of this test is to confirm correct operation of AVR system in kV, Q and PF control modes, and changing between modes.<br><br>It should be noted that in normal operation, and unless otherwise instructed by SONI, the reactive slope characteristic should be set to 3%. This means that a system voltage 3% lower that the active voltage setpoint will result in **MVAr** production by the **ESPS** equivalent to its minimum required capability. Conversely, a system voltage 3% higher than the active voltage setpoint will result in **MVAr** absorption by the **ESPS** equivalent to its minimum required capability. |
| *Results Required*:<br><br>The following data must be captured by the **ESPS** at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:<br>• **ESPS** Available **Active Power** Export (**MW**)<br>• **ESPS** Available **Active Power** Import (**MW**)<br>• **ESPS** Useable Energy Remaining (MWhr)<br>• **ESPS** Total Useable Storage Capacity (MWhr)<br>• Actual **Active Power** from the ESPS (MW)<br>• **System** Voltage at **Connection Point** (kV)<br>• **Reactive Power** Flow at **Connection Point** (MVAr)<br>• Emergency Action ON/OFF<br>• Emergency Action set-point from SONI<br>• **Frequency Response** ON/OFF<br>• Number of modules online<br>• |
| *Test Assessment*::<br><br>The test results will be assessed against CC.S2.1.3.2.]<br><br>*Criteria of Assessment*:<br><br>AVR Control<br>• **ESPS** receives all kV set-points, implements kV all set-points within 20 seconds of receipt of the set-point and provides the correct set-point feedback<br>• **ESPS** regulates its reactive power at the point of connection correctly based on the voltage slope setting, system voltage and kV set-point<br>• Demonstration that the voltage regulation **System** slope setting can be set between 2% and 7%<br>• Voltage Regulation **System** responds to a step change in voltage at the **Connection Point**, it achieves 90% of its steady-state response within 1 second<br><br>**MVAr** Control<br>• **ESPS** receives all **MVAr** set-points, implements **MVAr** all set-points within 20 seconds of receipt of the set-point and provides the correct set-point feedback |

- **ESPS** maintains the **MVAr** set-point at the **Connection Point**
- The Battery **ESPS** controller will be required to maintain the effective **MVAr** setpoint during changes to **Active Power** export or import, including through zero **MW**.

Power Factor Control

- **ESPS** receives all PF set-points, implements PF all set-points within 20 seconds of receipt of the set-point and provides the correct set-point feedback
- **ESPS** maintains the PF per phase angle set-point at the **connection point**

Bumpless Transfer

- Voltage Regulation **System** implements bumpless transfer between **Reactive Power** control modes

Note: The **ESPS** should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the **ESPS** should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected **MW** output is 0MW. It is understood that there may be small **MW** imports at the connection point to account for house load, unless otherwise instructed by SONI.

- 

### 7.5.1 REACTIVE POWER CONTROL TEST PROCEDURE

*Functional Checks and Bumpless Transfer*

Bumpless Transfer between **Reactive Power** control modes is tested here by changing between each of the modes and sending a positive and a negative set-point in each mode. This also demonstrates that the controls are functioning.

| **Functional Checks and Bumpless Transfer Test Sequence –Test No.1** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the AVR response rate test and confirms the following with SONI:<br>1. **Frequency Response** is OFF<br>2. Emergency Action is ON<br>3. Emergency Action **MW** set-point is 50% of **Registered Capacity**<br>4. **MW** output of the **ESPS**<br>5. AVR (kV) control mode is ON<br>6. The transformer tap position<br>7. On Load Tap Changer is in Automatic Mode<br>8. **System** Voltage<br>9. kV set-point = system voltage at **Connection Point**<br>10. Voltage slope setting = 3%<br>11. **MVAr** Export is close to 0 **MVAr** at the **Connection Point** |
| 2 | **ESPS** requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute |
| 3 | **ESPS** requests SONI to issue a **MVAr** set-point of -1 **MVAr** |
| 4 | **ESPS** requests SONI to select **MVAr** (Q) control mode and waits 1 minute |

| | |
|---|---|
| 5 | **ESPS** requests SONI to issue a **MVAr** set-point of 10% of lagging **MVAr** capability and waits 1 minute |
| 6 | **ESPS** requests SONI to issue a PF set-point of 0 degrees |
| 7 | **ESPS** requests SONI to select Power Factor control mode and waits 1 minute |
| 8 | **ESPS** requests SONI to issue a PF set-point of +12 degrees noting calculated response and waits 1 minute |
| 9 | **ESPS** requests SONI to select AVR control mode and waits 1 minute |
| 10 | **ESPS** requests SONI to issue a kV set-point 1 kV lower than **system** voltage at the **connection point** |
| 11 | **ESPS** requests SONI to select Power Factor control mode and waits 1 minute |
| 12 | **ESPS** requests SONI to issue a PF set-point of -12 degrees noting calculated response and waits 1 minute |
| 13 | **ESPS** requests SONI to select **MVAr** (Q) control mode and waits 1 minute |
| 14 | **ESPS** requests SONI to issue a **MVAr** set-point of 15% of leading **MVAr** capability and waits 1 minute |
| 15 | **ESPS** requests SONI to select AVR control mode and waits 1 minute |
| 16 | **ESPS** requests SONI to issue a kV set-point equal to system voltage at the **Connection Point** |
| 17 | Ensure that the **ESPS** is producing approximately 0 **MVAr** at the **Connection Point** |
| 18 | **ESPS** requests SONI to issue an Emergency Action set-point of 0 **MW**, turn Emergency Action OFF and wait until set-point has been achieved |
| 19 | **ESPS** ends data recording |
| 20 | **ESPS** informs SONI that the bumpless transfer test is complete<br>If further testing is not being completed, go to 6: Return to Standard Settings |

## *Automatic Voltage Regulation Mode*

SONI issues a series of kV set-points both above and below **System** voltage to demonstrate the ability of the **ESPS** to correctly calculate and maintain these set-points.

| **Automatic Voltage Regulation Mode Test Sequence –Test No.2** | |
|---|---|
| Step No. | Action |

| | |
|---|---|
| 1 | **ESPS** requests permission from SONI to proceed with the AVR Mode test and confirms the following with SONI:<br>1. Emergency Action is OFF<br>2. **Frequency Response** is OFF<br>3. **MW** output of the **ESPS**<br>4. AVR (kV) control mode is ON<br>5. Transformer tap position<br>6. On Load Tap Changer is in Automatic Mode<br>7. **System** Voltage<br>8. kV set-point = system voltage at **Connection Point**<br>9. Voltage slope setting = 3%<br>10. **MVAr** export is close to 0 **MVAr** at the **Connection Point** |
| 2 | **ESPS** sets the Voltage Regulation **System** slope to 2% confirms the following to SONI:<br>1. Voltage Slope is now 2%<br>2. Calculated change in **MVAr** output caused by a 0.5 kV change in voltage set-point<br>3. Current **MVAr** output of **ESPS** |
| 3 | **ESPS** requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute |
| 4 | **ESPS** requests SONI to decrease the voltage set-point by 0.5 kV and waits 1 minute |
| 5 | **ESPS** confirms with SONI that **ESPS MVAr** output is approximately 0 **MVAr** at the **Connection Point**. If not, **ESPS** requests SONI to issue a voltage set-point to achieve approximately 0 **MVAr** |
| 6 | **ESPS** sets the Voltage Regulation System slope to 7% and confirms the following to SONI:<br>1. Voltage Slope is now 7%<br>2. Calculated change in **MVAr** output caused by a 2kV change in voltage set-point<br>3. Current **MVAr** output of **ESPS** |
| 7 | **ESPS** requests SONI to decrease the voltage set-point by 2 kV and waits 1 minute |
| 8 | **ESPS** requests SONI to increase the voltage set-point by 2 kV and waits 1 minute |
| 9 | **ESPS** confirms with SONI that **ESPS MVAr** output is approximately 0 **MVAr** at the **Connection Point**. If not, **ESPS** requests SONI to issue a voltage set-point to achieve approximately 0 **MVAr** |
| 10 | **ESPS** sets the Voltage Regulation System slope to 3% and confirms the following to SONI:<br>1. Voltage Slope is now 3%<br>**2.** Calculated change in MVAr output caused by a 1kV change in voltage set-point<br>**3.** Current **MVAr** output of **ESPS** |
| 11 | **ESPS** requests SONI to increase the voltage set-point by 1 kV and waits 1 minute |
| 12 | **ESPS** requests SONI to turn Emergency Action ON and issue an Emergency Action MW set-point of 20% of **Registered Capacity** and wait until 1 minute after Emergency Action set-point |
| 13 | **ESPS** requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute |
| 14 | **ESPS** requests SONI to issue an Emergency Action MW set-point of -10% of **Registered Capacity** and wait until 1 minute after Emergency Action set-point has been achieved |
| 15 | **ESPS** requests SONI to decrease the voltage set-point by 1 kV and waits 1 minute |
| 16 | **ESPS** requests SONI to issue an Emergency Action set-point of 0 **MW** and turn Emergency Action OFF and wait until 1 minute after set-point has been achieved |
| 17 | **ESPS** requests SONI to decrease the voltage set-point by 0.5 kV and waits 1 minute |

| | |
|---|---|
| 18 | **ESPS** requests SONI to decrease the voltage set-point by 1 kV and waits 1 minute |
| 19 | **ESPS** requests SONI to decrease the voltage set-point by 0.5 kV and waits 1 minute |
| 20 | **ESPS** requests SONI to increase the voltage set-point by 1 kV and waits 1 minute |
| 21 | **ESPS** requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute |
| 22 | ESPS confirms with SONI that **ESPS MVAr** output is approximately 0 **MVAr** at the **Connection Point**. If not, **ESPS** requests SONI to issue a voltage set-point to achieve approximately 0 **MVAr** at the **Connection Point** |
| 23 | **ESPS** ends data recording |
| 24 | **ESPS** informs SONI that the AVR Mode test is complete<br>If further testing is not being completed, go to 6: Return to Standard Settings |

*Automatic Voltage Regulation Response Rate*

A step change in **System** voltage is created here to allow analysis of the AVR rate of response. The step change is ideally created by SONI carrying out switching on the system. If this is not possible, the **ESPS** shall carry out a manual tap change to induce a small step change in **System** voltage.

| **Automatic Voltage Regulation Response Rate Test Sequence – Test No.3** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the AVR response rate test and confirms with SONI the following with SONI:<br>1. **Frequency Response** is OFF<br>2. Emergency Action is OFF<br>3. **MW** output of the **ESPS**<br>4. AVR (kV) control mode is ON<br>5. The transformer tap position<br>6. On Load Tap Changer is in Automatic Mode<br>7. **System** Voltage<br>8. Voltage slope setting = 3%<br>9. **MVAr** Export at the **Connection Point** |
| 2 | **ESPS** requests SONI to induce a step change in **System** voltage by carrying out transformer tapping or carrying out switching on the **System**, if possible. |
| 3 | **ESPS** ends data recording |
| 4 | **ESPS** informs SONI that the AVR response rate test is complete |
| *If SONI cannot facilitate switching on the **System** to induce a step change in **System** voltage, carry out the following steps:* | |

| | |
|---|---|
| 5 | **ESPS** requests permission from SONI and puts the on-load tap changer into manual mode |
| 6 | **ESPS** requests permission from SONI and taps the transformer up 1 tap and waits 1 minute |
| 7 | **ESPS** requests permission from SONI, **ESPS** taps the transformer up 1 tap and waits 1 minute |
| 8 | **ESPS** requests permission from SONI, **ESPS** taps the transformer down 1 tap and waits 1 minute |
| 9 | **ESPS** requests permission from SONI, **ESPS** taps the transformer down 1 tap and waits 1 minute |
| 10 | **ESPS** requests permission from SONI, puts the on-load tap changer into automatic mode and confirms to SONI |
| 11 | **ESPS** confirms with SONI that the **ESPS** is at approximately 0 **MVAr** at the **Connection Point** |
| 12 | **ESPS** ends data recording |
| 13 | **ESPS** informs SONI that the AVR response rate test is complete<br>If further testing is not being completed, go to 6: Return to Standard Settings |

## *MVAr Control Mode*

SONI issues a series of positive and negative **MVAr** set-points to demonstrate the ability of the **ESPS** to maintain these set-points.

| **MVAr Control Mode Test Sequence –Test No.4** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the **MVAr** Control Mode test and confirms with SONI the following with SONI:<br>1. **Frequency Response** is OFF<br>2. Emergency Action is OFF<br>3. **MW** output of the ESPS<br>4. **MVAr** (Q) control mode is ON<br>5. The transformer tap position<br>6. On Load Tap Changer is in Automatic Mode<br>7. **Mvar** Set-point = 0 **MVAr**<br>8. System Voltage<br>9. Voltage slope setting = 3%<br>10. **MVAr** Export is 0 **MVAr** at the **Connection Point** |
| 2 | **ESPS** requests SONI to issue a **MVAr** set-point of 25% of lagging **MVAr** capability and waits 1 minute |
| 3 | **ESPS** requests SONI to turn Emergency Action ON and issue an Emergency Action **MW** set-point of 20% of **Registered Capacity** and wait until 1 minute after Emergency Action set-point has been achieved |
| 4 | **ESPS** requests SONI to issue a **MVAr** set-point of 60% of lagging **MVAr** capability and waits 1 minute |

| | |
|---|---|
| 5 | **ESPS** requests SONI to issue an Emergency Action MW set-point of -10% of **Registered Capacity** and wait until 1 minute after Emergency Action set-point has been achieved |
| 6 | **ESPS** requests SONI to issue a **MVAr** set-point of 10% of lagging **MVAr** capability and waits 1 minute |
| 7 | **ESPS** requests SONI to issue an Emergency Action set-point of 0 MW and turn Emergency Action OFF and wait until 1 minute after set-point has been achieved |
| 8 | **ESPS** requests SONI to issue a set-point of 0 **MVAr** and waits 1 minute |
| 9 | **ESPS** requests SONI to issue a **MVAr** set-point of 25% of leading **MVAr** capability and waits 1 minute |
| 10 | **ESPS** requests SONI to issue a **MVAr** set-point of 60% of leading **MVAr** capability and waits 1 minute |
| 11 | **ESPS** requests SONI to issue a **MVAr** set-point of 10% of leading **MVAr** capability and waits 1 minute |
| 12 | **ESPS** requests SONI to issue a set-point of 0 **MVAr** and waits 1 minute |
| 13 | **ESPS** confirms with SONI that the **ESPS** is at approximately 0 **MVAr** at the **Connection Point** |
| 14 | **ESPS** ends data recording |
| 15 | **ESPS** informs SONI that the **MVAr** Control Mode test is complete<br>If further testing is not being completed, go to 6: Return to Standard Settings |

## *Power Factor Control Mode*

SONI issues a series of positive and negative PF set-points to demonstrate the ability of the **ESPS** to correctly calculate and maintain these set-points.

| **Power Factor Control Mode Test Sequence –Test No.5** | |
|---|---|
| Step No. | Action |
| 1 | **ESPS** requests permission from SONI to proceed with the Power Factor Control Mode test and confirms the following with SONI:<br>1. **Frequency Response** is OFF<br>2. Emergency Action is ON<br>3. Emergency Action setpoint is 100% of **Registered Capacity**<br>4. **MW** output of the **ESPS**<br>5. Power Factor (PF) control mode is ON<br>6. The transformer tap position<br>7. On Load Tap Changer Mode<br>8. Voltage Set-point Control (Local/Remote)<br>9. **System** Voltage<br>10. PF set-point = 0 degrees<br>11. Voltage slope setting = 3%<br>12. **MVAr** Export |
| 2 | **ESPS** requests SONI to issue a PF set-point of +8 degrees noting calculated **MVAr** response to set-point of +8 degrees at 100% of **Registered Capacity** and waits 1 minute |
| 3 | **ESPS** requests SONI to issue a PF set-point of +12 degrees noting calculated **MVAr** response to set-point of +12 degrees at 100% of **Registered Capacity** and waits 1 minute |

| | |
|---|---|
| 4 | **ESPS** requests SONI to issue an Emergency Action MW set-point of 30% of **Registered Capacity** noting calculated **MVAr** response to set-point of +12 degrees at 30% of **Registered Capacity** and wait until 1 minute after Emergency Action set-point has been achieved |
| 5 | **ESPS** requests SONI to issue a PF set-point of +8 degrees noting calculated **MVAr** response to set-point of +8 degrees at 30% of **Registered Capacity** and waits 1 minute |
| 6 | **ESPS** requests SONI to issue a PF set-point of 0 degrees and waits 1 minute |
| 7 | **ESPS** requests SONI to issue a PF set-point of -8 degrees noting calculated **MVAr** response to set-point of -8 degrees at 30% of **Registered Capacity** and waits 1 minute |
| 8 | **ESPS** requests SONI to issue a PF set-point of -12 degrees noting calculated **MVAr** response to set-point of -12 degrees at 30% of **Registered Capacity** and waits 1 minute |
| 9 | **ESPS** requests SONI to issue an Emergency Action MW set-point of -10% of **Registered Capacity** noting calculated **MVAr** response to set-point of -12 degrees at -10% of **Registered Capacity** and waits until 1 minute after **Active Power** output has reached the |
| 10 | **ESPS** requests SONI to issue a PF set-point of -8 degrees noting calculated **MVAr** response to set-point of -8 degrees at -10% of **Registered Capacity** and waits 1 minute |
| 11 | **ESPS** requests SONI to issue a PF set-point of 0 degrees and waits 1 minute |
| 12 | **ESPS** requests SONI to issue an Emergency Action set-point of 0 **MW** and turn Emergency Action OFF and wait until 1 minute after set-point has been achieved |
| 13 | **ESPS** requests SONI to select AVR control mode |
| 14 | **ESPS** confirms with SONI that the **ESPS** is at approximately 0 **MVAr** at the **Connection** Point |
| 15 | **ESPS** ends data recording |
| 16 | **ESPS** informs SONI that the Power Factor Control Mode test is complete<br>If further testing is not being completed, go to 6: Return to Standard Settings |

*Return to Standard Settings*

The steps below return the **ESPS** to standard settings at the completion of testing.

| **Return To Standard Settings Test Sequence –Test No.6** | |
|---|---|
| Step No. | Action |

| | |
|---|---|
| 1 | **ESPS** informs SONI that **Reactive Power** Control Testing is complete and confirms the following the following:<br>1. **MW** output of the **ESPS**<br>2. Emergency Action Setpoint is 0MW<br>3. Emergency Action is OFF<br>4. **Frequency Response** is ON<br>5. Response is in Mode Frequency 1<br>6. AVR (kV) control mode is ON<br>7. The transformer tap position<br>8. On Load Tap Changer is in Automatic Mode<br>9. **System** Voltage<br>10. kV set-point = **system** voltage at **Connection Point**<br>11. Voltage slope setting = 3%<br>12. **MVAr** Export at the **Connection Point** |

3.6 PPM Setting Schedule Signals List

*Such signals as are required for battery energy storage have been added to new tables in the Setting Schedule.*

## Appendix E SCADA SIGNALS AND CONTROLS BETWEEN ESPS AND SONI/NIE NETWORKS

The signals list shown below may be subject to change should SONI/NIE Networks feel that additional controls/indications are required from an **ESPS**.

| *Analogue Input Signals (to SONI/NIE Networks) from **ESPS*** | | | | | |
|---|---|---|---|---|---|
| *Signal Description* | *Description* | *Range* | *Units* | *Scale* | *Display Units* |
| ESPS (Useable) Energy Remaining | Real-time quantity of energy that can be completely extracted from the ESPS | 4 - 20 | mA | TBA | **MWh** |
| ESPS Total (Usable) Storage Capacity | Represents the total energy that can be contained in the ESPS based on the | 4 - 20 | mA | TBA | **MWh** |
| ESPS Active Power Export Availability | Real-time signal indicating capability to export active power onto the grid | 4 - 20 | mA | TBA | **MW** |
| ESPS Active Power Import Availability | Real-time signal indicating capability to import active power from the grid. | 4 - 20 | mA | TBA | **MW** |
| ESPS Reactive Powe Availability | Real-time signal indicating capability to export Reactive power onto the grid | 4 - 20 | mA | TBA | **MVAr** |
| ESPS Reactive Power Import | Real-time signal indicating capability to Import Reactive power from the grid | 4 - 20 | mA | TBA | **MVAr** |
| ESPS Active Power Export/Import | Real-time signal indicating active power flow to/from the Grid at Point of Connection. | 4 - 20 | mA | TBA | **MW** |
| ESPS Reactive Power Export/Import | Real-time signal indicating Reactive power flow to/from the Grid at Point of Connection. | 4 - 20 | mA | TBA | **MVAr** |

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| ESPS HV Voltage magnitude | Real-time signal indicating Customer Voltage at Point of Connection to the Grid | 4 – 20 | mA | TBA | **kV** |
| ESPS 110 kV Power factor (decimal) | Real-time signal indicating Customer measured Power Factor at Point of Connection to the Grid. | 4 - 20 | mA | TBA | Decimal |
| Active Power Set Point feedback | Feedback to confirm received value of Active Power Dispatch Set Point Command | 4 - 20 | mA | TBA | **MW** |
| Reactive Power Set Point feedback | Feedback to confirm received value of Reactive Power Dispatch Set Point Command | 4 - 20 | mA | TBA | **MVAr** |
| Voltage Set Point Feedback | Feedback to confirm received value of Voltage Dispatch Set Point Command (kV) | 4 - 20 | mA | TBA | **kV** |
| Power Factor Set Point Feedback | Feedback to confirm received value of Power Factor Dispatch Set Point Command (decimal) | 4 - 20 | mA | TBA | Decimal |
| Ramp Rate to reach set point feedback | Feedback to confirm received value of Ramp Rate to reach Set Point Command | 4 - 20 | mA | 0-100 | % Registered |
| System Frequency | Real-time signal indicating System frequency as measured by ESPS | 4 - 20 | mA | TBA | Hz |
| Active Low Frequency Trigger Setting | Low frequency trigger which is currently active in the ESPS controller as defined by the active frequency response mode | 4- 20 | mA | 49-50 | Hz |
| Active High Frequency Trigger Setting | High frequency trigger which is currently active in the ESPS controller as defined by the active frequency response mode | 4 - 20 | mA | 50-51 | Hz |
| Active Low Frequenc Setting | Low frequency trajectory which is currently active in the ESPS controller as defined by the active frequency response mode | 4 - 20 | mA | 0-10 | Hz |
| Active High Frequency Trajectory Setting | High frequency trajectory which is currently active in the ESPS controller as defined by the active frequency response mode | 4 - 20 | mA | 0-10 | Hz |
| Active Maximum underfrequency response setting | Maximum underfrequency response which is currently active in the ESPS controller as defined by the active frequency response mode | 4 - 20 | mA | TBA | MW |
| Active Maximum overfrequency response setting | Maximum overfrequency response which is currently active in the ESPS controller as defined by the active frequency response mode | 4 - 20 | mA | TBA | MW |
| FFR Availability | Real-time signal indicating the remaining quantity of FFR which is available | 4 - 20 | mA | TBA | MW |
| POR Availability | Real-time signal indicating the remaining quantity of POR which is available | 4 - 20 | mA | TBA | MW |
| SOR Availability | Real-time signal indicating the remaining quantity of SOR which is available | 4 - 20 | mA | TBA | MW |
| TOR1 Availability | Real-time signal indicating the remaining quantity of TOR1 which is available | 4 - 20 | mA | TBA | MW |

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| TOR2 Availability | Real-time signal indicating the remaining quantity of TOR2 which is available | 4 - 20 | mA | TBA | MW |
| FFR-o Availability | Real-time signal indicating the remaining quantity of overfrequency response which is available in the FFR timeframe | 4 - 20 | mA | TBA | MW |
| POR-o Availability | Real-time signal indicating the remaining quantity of overfrequency response which is available in the POR timeframe | 4 - 20 | mA | TBA | MW |
| SOR-o Availability | Real-time signal indicating the remaining quantity of overfrequency response which is available in the SOR timeframe | 4 - 20 | mA | TBA | MW |
| TOR1-o Availability | Real-time signal indicating the remaining quantity of overfrequency response which is available in the TOR1 timeframe | 4 - 20 | mA | TBA | MW |
| TOR2-o Availability | Real-time signal indicating the remaining quantity of overfrequency response which is available in the TOR2 timeframe | 4 - 20 | mA | TBA | MW |
| Ambient Temperature on Site | Ambient temperature on site | 4 - 20 | mA | -20 to +50 | °C |
| Average Battery Temperature | Average temperature of battery racks | 4 - 20 | mA | -40 to +120 | °C |

## 4. Next steps

4.1 The consultation period will run for 4 weeks. Users are invited to send their comments to SONI via email to gridcode@soni.ltd.uk by close of business on Friday 23rd December 2022. In the meantime, should any Users have any queries they should contact SONI via gridcode@soni.ltd.uk.

4.2 Following receipt of comments in relation to this Consultation Paper and the expiration of the period for making comments, SONI will, in accordance with Condition 16 of its Licence, send to the Utility Regulator a report on the outcome of this review.

4.3 If you require your response to remain confidential you should clearly state this on the coversheet of the response. We intend to publish all non-confidential responses. Please note that, in any event, all responses will be shared with the Utility Regulator.

4.4 Following the end of the consultation period and report to the Utility Regulator upon which the final decision will be based, the Modification will be formally incorporated into the Grid Code.