GRID CODE MODIFICATION GC0148

LEGAL TEXT – STORAGE

RELEVANT GRID CODE EXTRACTS

15 FEBRUARY 2022

Extracts from the Planning Code

……..

PC.A.5.5.4 Each **Generator** in respect of an **Electricity Storage Module** with a **Completion Date** on or after XXXX shall provide **Frequency** response curves that demonstrate the ability of their **Electricity Storage Modules** to a transition that occurs over 20 seconds or less from a mode analogous to **Demand** to a mode analogous to generation in accordance with the requirements of ECC.6.3.3.2. **Generators** who own and operate **Electricity Storage Modules** with a **Completion Date** before XXXX, and who choose to satisfy the requirements of ECC.6.3.3.2, shall also provide **Frequency** response curves as required by this PC.A.5.5.4.

Extracts from the European Connection Conditions

……

ECC.6.3.3 OUTPUT POWER WITH FALLING FREQUENCY

ECC.6.3.3.1 Output power with falling frequency for **Power Generating Modules** and **HVDC Equipment**

ECC.6.3.3.1.1 Each **Power Generating Module** and **HVDC Equipment** must be capable of:

(a) continuously maintaining constant **Active Power** output for **System Frequency** changes within the range 50.5 to 49.5 Hz; and

(b) (subject to the provisions of ECC.6.1.2) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure ECC.6.3.3(a) for **System Frequency** changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25^{0}C, such that if the **System Frequency** drops to 47 Hz the **Active Power** output does not decrease by more than 5%. In the case of a **CCGT Module**, the above requirement shall be retained down to the **Low Frequency Relay** trip setting of 48.8 Hz, which reflects the first stage of the Automatic Low **Frequency Demand Disconnection** scheme notified to **Network Operators** under OC6.6.2. For **System Frequency** below that setting, the existing requirement shall be retained for a minimum period of 5 minutes while **System Frequency** remains below that setting, and special measure(s) that may be required to meet this requirement shall be kept in service during this period. After that 5 minutes period, if **System Frequency** remains below that setting, the special measure(s) must be discontinued if there is a materially increased risk of the **Gas Turbine** tripping. The need for special measure(s) is linked to the inherent **Gas Turbine Active Power** output reduction caused by reduced shaft speed due to falling **System Frequency**. Where the need for special measures is identified in order to maintain output in line with the level identified in Figure ECC.6.3.3(a) these measures should be still continued at ambient temperatures above 25^{0}C maintaining as much of the **Active Power** achievable within the capability of the plant. For the avoidance of doubt, **Generators** in respect of **Pumped Storage Plant** ~~and **Electricity Storage Modules**~~ shall also be required to satisfy the requirements of OC6.6.6.

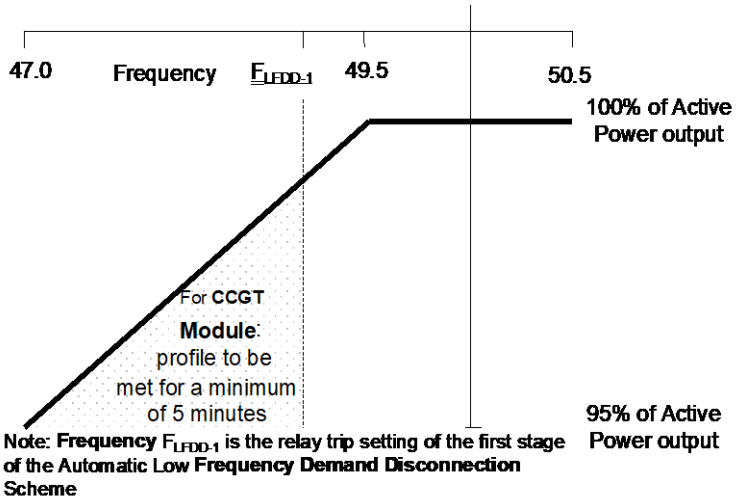


Figure ECC.6.3.3(a) **Active Power** Output with falling frequency for **Power Generating Modules** and **HVDC Systems** and **Electricity Storage Modules** when operating in an exporting mode of operation

(c) For the avoidance of doubt, in the case of a **Power Generating Module** including a **DC Connected Power Park Module** using an **Intermittent Power Source** where the mechanical power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of **System Frequency** under (a) above and should not drop with **System Frequency** by greater than the amount specified in (b) above.

(d) An **HVDC System** must be capable of maintaining its **Active Power** input (i.e. when operating in a mode analogous to **Demand**) from the **National Electricity Transmission System** (or **User System** in the case of an **Embedded HVDC System**) at a level not greater than the figure determined by the linear relationship shown in Figure ECC.6.3.3(b) for **System Frequency** changes within the range 49.5 to 47 Hz, such that if the **System Frequency** drops to 47.8 Hz the **Active Power** input decreases by more than 60%.

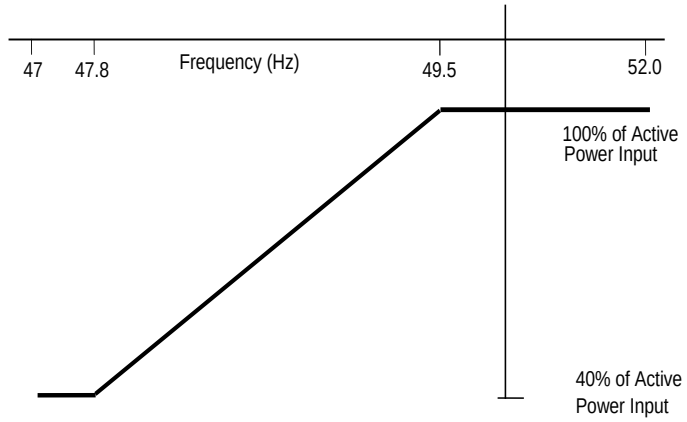


Figure ECC.6.3.3(b) **Active Power** input with falling frequency for **HVDC Systems**

(e) In the case of an **Offshore Generating Unit** or **Offshore Power Park Module** or **DC Connected Power Park Module** or **Remote End HVDC Converter** or **Transmission DC Converte**r, the **EU Generator** shall comply with the requirements of ECC.6.3.3. **EU Generators** should be aware that Section K of the **STC** places requirements on **Offshore Transmission Licensees** which utilise a **Transmission DC Converter** as part of their **Offshore Transmission System** to make appropriate provisions to enable **EU Generators** to fulfil their obligations.

(f) **Transmission DC Converters** and **Remote End HVDC Converters** shall provide a continuous signal indicating the real time frequency measured at the **Interface Point** to the **Offshore Grid Entry Point** or **HVDC Interface Point** for the purpose of **Offshore Generators** or **DC Connected Power Park Modules** to respond to changes in **System Frequency** on the Main Interconnected **Transmission System**. A **DC Connected Power Park Module** or **Offshore Power Generating Module** shall be capable of receiving and processing this signal within 100ms.

ECC.6.3.3.2 Output power with falling frequency for **Electricity Storage Modules** when operating in an importing mode of operation

ECC.6.3.3.2.1 In addition to the applicable requirements of ECC.6.3.3.1, each **Electricity Storage Module** with a **Completion Date** on or after XXXX, or any **Electricity Storage Module** with a **Completion Date** before XXX where the **Generator** in respect of that **Electricity Storage Module** has elected not to satisfy the requirements of OC6.6.6, is required to meet the following requirements:-

(a) Be capable of automatically maintaining its **Active Power** output within the shaded operating region shown in Figure ECC.6.3.3(c) until the stored energy has been depleted. This characteristic applies for **System Frequency** changes within the range 49.5 Hz to 47 Hz for all ambient temperatures up to and including 25^{0}C. For the avoidance or doubt the Interim Loading Points in Figure ECC.6.3.3(c) represents operating points of the **Electricity Storage Module** when in an importing mode of operation which could be at any MW value between zero and the **Maximum Import Power**. The **Droop** shall be any value within the shaded area and agreed with **The Company**. A typical value of the **Droop** would be 0.5% where this is agreed with **The Company** and does not result in control system instability or plant difficulties.

(b) Automatically respond in accordance with the characteristic of Figure ECC.6.3.3(c) when the **System Frequency** falls to 49.5Hz and below;

(c) The reduction in **Active Power** import (during an import mode of operation) ~~must~~shall be continuously and linearly proportional, as far as is practicable, to the ~~excess of~~reduction in **Frequency** below 49.5 Hz and must be provided increasingly with time as required by (d) below.

(d) As much as possible of the proportional reduction in **Active Power** import (when the **Electricity Storage Module** is in an import mode of operation) must result from the **Frequency** control device (or speed governor) action and must be achieved within 10 seconds of the time of the **Frequency** decreases below 49.5 Hz. The **Electricity Storage Module** shall be capable of initiating a power **Frequency** response with an initial delay that is as short as possible. ~~If the d~~Delays that exceed~~s~~ 2 seconds~~, the~~ shall be justified by the **Generator** ~~shall justify the variation,~~ providing technical evidence to **The Company**. This performance requirement is to be maintained when the **Electricity Storage Module** transitions to an **Active Power** export mode of operation unless the energy store is depleted, in which case it shall be required to operate a zero MW output.

(e) Where the **Electricity Storage Module** is not capable of transitioning from an import level of operation to an export level of operation within 20 seconds of the **System Frequency** falling to 49.2Hz, then it shall immediately reduce its **Active Power** import to zero; and

(f) If the **Electricity Storage Module** has not achieved at least a zero **Active Power** output when the **System Frequency** has reached 48.9Hz, it shall~~-~~ be instantaneously tripped. Where a **Electricity Storage Module** trips, it shall not be permitted to reconnect to the **System** until instructed by **The Company** in accordance with BC2.5.2 and as provided for in ECC.6.2.2.11.

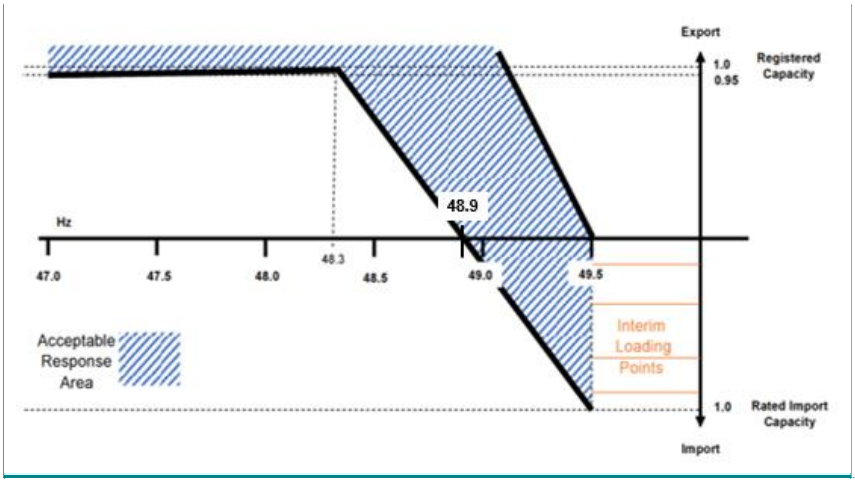


Figure ECC.6.3.3(c) **Active Power** performance with falling frequency ~~for~~ **~~Electricity Storage Modules~~** with a **~~Completion Date~~** ~~on or after XXXX~~

Commented [J(A1]: Diagram to be updated to improve legibility

ECC.6.3.3.2.2 Where an **Electricity Storage Module** has been importing and has responded in accordance with the requirements of ECC.6.3.3.2.1, its performance, once the **System Frequency** starts to rise above the minimum reached, the **Active Power** output and **Active Power** import shall be in accordance with Figure ECC.6.3.3(d). For example, Figure ECC.6.3.3(d), illustrates the three points X, Y and Z. If points X, Y and Z denotes the minimum frequency that an **Electricity Storage Module** reached during a particular low frequency event, as the **System Frequency** starts to rise, the **Active Power** output of the **Electricity Storage Module** should remain at a constant level until 49.5Hz is reached as denoted by the dashed black lines. Once the **System Frequency** has risen above 49.5Hz the **Electricity Storage Module** is permitted to reduce **Active Power** output so long as it is operates within the shaded area above 49.5Hz shown in Figure ECC.6.3.3(d).

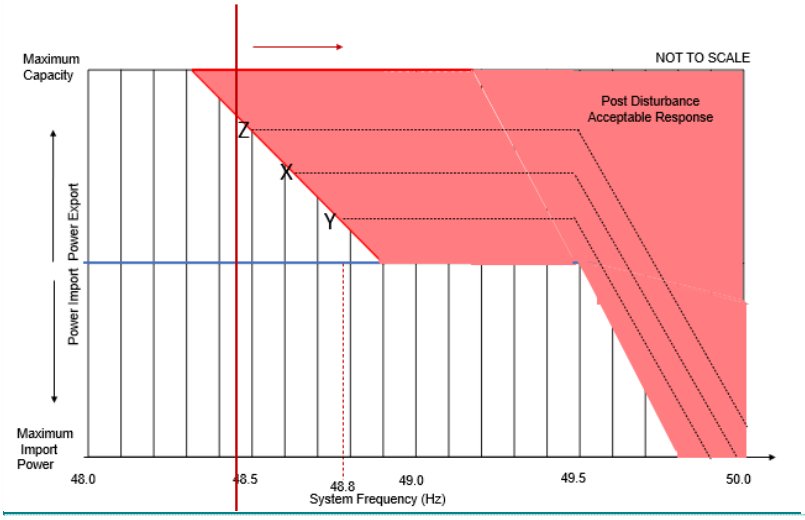


Figure ECC.6.3.3(d) **Active Power** performance with increasing frequency

Commented [J(A2]: Diagram to be updated

APPENDIX E3 - MINIMUM FREQUENCY RESPONSE CAPABILITY REQUIREMENT PROFILE AND OPERATING RANGE FOR POWER GENERATING MODULES AND HVDC EQUIPMENT

ECC.A.3.1 Scope

The frequency response capability is defined in terms of **Primary Response**, **Secondary Response** and **High Frequency Response**. In addition to the requirements defined in ECC.6.3.7 this appendix defines the minimum frequency response requirements for:-

(a) each **Type C** and **Type D Power Generating Module**

(b) each **DC Connected Power Park Module**

(c) each **HVDC System**

For the avoidance of doubt, this appendix does not apply to **Type A** and **Type B Power Generating Modules**.

OTSDUW Plant and Apparatus should facilitate the delivery of frequency response services provided by **Offshore Generating Units** and **Offshore Power Park Units**.

The functional definition provides appropriate performance criteria relating to the provision of **Frequency** control by means of **Frequency** sensitive generation in addition to the other requirements identified in ECC.6.3.7.

In this Appendix 3 to the E**CC**, for a **Power Generating Module** including a **CCGT Module** or a **Power Park Module** or **DC Connected Power Park Module**, the phrase **Minimum Regulating Level** applies to the entire **CCGT Module** or **Power Park Module** or **DC Connected Power Park Module** operating with all **Generating Units Synchronised** to the **System**.

The minimum **Frequency** response requirement profile is shown diagrammatically in Figure ECC.A.3.1. The capability profile specifies the minimum required level of **Frequency Response** Capability throughout the normal plant operating range.

ECC.A.3.2 Plant Operating Range

The upper limit of the operating range is the **Maximum Capacity** of the **Power Generating Module** or **Generating Unit** or **CCGT Module** or **HVDC Equipment**.

The **Minimum Stable Operating Level** may be less than, but must not be more than, 65% of the **Maximum Capacity**. Each **Power Generating Module** and/or **Generating Unit** and/or **CCGT Module** and/or **Power Park Module or HVDC Equipment** must be capable of operating satisfactorily down to the **Minimum Regulating Level** as dictated by **System** operating conditions, although it will not be instructed to below its **Minimum Stable Operating Level** . If a **Power Generating Module** or **Generating Unit** or **CCGT Module** or **Power Park Module**, or **HVDC Equipment** is operating below **Minimum Stable Operating Level** because of high **System Frequency**, it should recover adequately to its **Minimum Stable Operating Level** as the **System Frequency** returns to **Target Frequency** so that it can provide **Primary** and **Secondary Response** from its **Minimum Stable Operating Level** if the **System Frequency** continues to fall. For the avoidance of doubt, under normal operating conditions steady state operation below the **Minimum Stable Operating Level** is not expected. The **Minimum Regulating Level** must not be more than 55% of **Maximum Capacity**.

In the event of a **Power Generating Module** or **Generating Unit** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** load rejecting down to no less than its **Minimum Regulating Level** it should not trip as a result of automatic action as detailed in BC3.7. If the load rejection is to a level less than the **Minimum Regulating Level** then it is accepted that the condition might be so severe as to cause it to be disconnected from the **System**.

ECC.A.3.3 Minimum Frequency Response Requirement Profile

Figure ECC.A.3.1 shows the minimum **Frequency** response capability requirement profile diagrammatically for a 0.5 Hz change in **Frequency**. The percentage response capabilities and loading levels are defined on the basis of the **Maximum Capacity** of the **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment**. Each **Power Generating Module** or and/or **CCGT Module** or **Power Park Module** (including a **DC Connected Power Park Module**) and/or **HVDC Equipment** must be capable of operating in a manner to provide **Frequency** response at least to the solid boundaries shown in the figure. If the **Frequency** response capability falls within the solid boundaries, the **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** is providing response below the minimum requirement which is not acceptable. Nothing in this appendix is intended to prevent a **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** from being designed to deliver a **Frequency** response in excess of the identified minimum requirement.

The **Frequency** response delivered for **Frequency** deviations of less than 0.5 Hz should be no less than a figure which is directly proportional to the minimum **Frequency** response requirement for a **Frequency** deviation of 0.5 Hz. For example, if the **Frequency** deviation is 0.2 Hz, the corresponding minimum **Frequency** response requirement is 40% of the level shown in Figure ECC.A.3.1. The **Frequency** response delivered for **Frequency** deviations of more than 0.5 Hz should be no less than the response delivered for a **Frequency** deviation of 0.5 Hz.

Each **Power Generating Module** and/or **CCGT Module** and/or **Power Park Module** or **HVDC Equipment** must be capable of providing some response, in keeping with its specific operational characteristics, when operating between 95% to 100% of **Maximum Capacity** as illustrated by the dotted lines in Figure ECC.A.3.1.

At the **Minimum Stable Operating** level, each **Power Generating Module** and/or **CCGT Module** and/or **Power Park Module** and/or HV**DC Equipment** is required to provide high and low frequency response depending on the **System Frequency** conditions. Where the **Frequency** is high, the **Active Power** output is therefore expected to fall below the **Minimum Stable Operating** level.

The **Minimum Regulating Level** is the output at which a **Power Generating Module** and/or **CCGT Module** and/or **Power Park Module** and/or HV**DC Equipment** has no **High Frequency Response** capability. It may be less than, but must not be more than, 55% of the **Maximum Capacity**. This implies that a **Power Generating Module** or **CCGT Module** or **Power Park Module**) or **HVDC Equipment** is not obliged to reduce its output to below this level unless the **Frequency** is at or above 50.5 Hz (cf BC3.7).

ECC.A.3.4 Testing of Frequency Response Capability

The frequency response capabilities shown diagrammatically in Figure ECC.A.3.1 are measured by taking the responses as obtained from some of the dynamic step response tests specified by **The Company** and carried out by **Generators** and HV**DC System** owners for compliance purposes. The injected signal is a step of 0.5Hz from zero to 0.5 Hz **Frequency** change, and is sustained at 0.5 Hz **Frequency** change thereafter, the latter as illustrated diagrammatically in figures ECC.A.3.4 and ECC.A.3.5.

In addition to provide and/or to validate the content of **Ancillary Services Agreements** a progressive injection of a **Frequency** change to the plant control system (i.e. governor and load controller) is used. The injected signal is a ramp of 0.5Hz from zero to 0.5 Hz **Frequency** change over a ten second period, and is sustained at 0.5 Hz **Frequency** change thereafter, the latter as illustrated diagrammatically in figures ECC.A.3.2 and ECC.A.3.3. In the case of an **Embedded Medium Power Station** not subject to a **Bilateral Agreement** or **Embedded HVDC System** not subject to a **Bilateral Agreement**, **The Company** may require the **Network Operator** within whose System the **Embedded Medium Power Station** or **Embedded HVDC System** is situated, to ensure that the **Embedded Person** performs the dynamic response tests reasonably required by **The Company** in order to demonstrate compliance within the relevant requirements in the **ECC**.

The **Primary Response** capability (P) of a **Power Generating Module** or a **CCGT Module** or **Power Park Module** or **HVDC Equipment** is the minimum increase in **Active Power** output between 10 and 30 seconds after the start of the ramp injection as illustrated diagrammatically in Figure ECC.A.3.2. This increase in **Active Power** output should be released increasingly with time over the period 0 to 10 seconds from the time of the start of the **Frequency** fall as illustrated by the response from Figure ECC.A.3.2.

The **Secondary Response** capability (S) of a **Power Generating Module** or a **CCGT Module** or **Power Park Module** or **HVDC Equipment** is the minimum increase in **Active Power** output between 30 seconds and 30 minutes after the start of the ramp injection as illustrated diagrammatically in Figure ECC.A.3.2.

The **High Frequency Response** capability (H) of a **Power Generating Module** or a **CCGT Module** or **Power Park Module** or **HVDC Equipment** is the decrease in **Active Power** output provided 10 seconds after the start of the ramp injection and sustained thereafter as illustrated diagrammatically in Figure ECC.A.3.3. This reduction in **Active Power** output should be released increasingly with time over the period 0 to 10 seconds from the time of the start of the **Frequency** rise as illustrated by the response in Figure ECC.A.3.2.

ECC.A.3.5 Repeatability o~~f~~ Response

When a **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** has responded to a significant **Frequency** disturbance, its response capability must be fully restored as soon as technically possible. Full response capability should be restored no later than 20 minutes after the initial change of **System Frequency** arising from the **Frequency** disturbance.

In the case of an **Electricity Storage Module** with a **Completion Date** on or after XXXX each **Electricity Storage Module** which has responded to a significant **Frequency** disturbance (including but not limited to the requirements of ECC.6.3.3.2), its response capability must be fully restored as soon as technically possible. Full response capability should be restored no later than 20 minutes after the initial change of **System Frequency** arising from the **Frequency** disturbance. This requirement would also apply to a an **Electricity Storage Module** operated by a **Generator** that chooses to satisfy the requirements of ECC.6.3.3.2 rather than the requirements of OC6.6.6.

Figure ECC.A.3.1 - Minimum **Frequency** Response requirement profile for a 0.5 Hz frequency change from **Target Frequency**

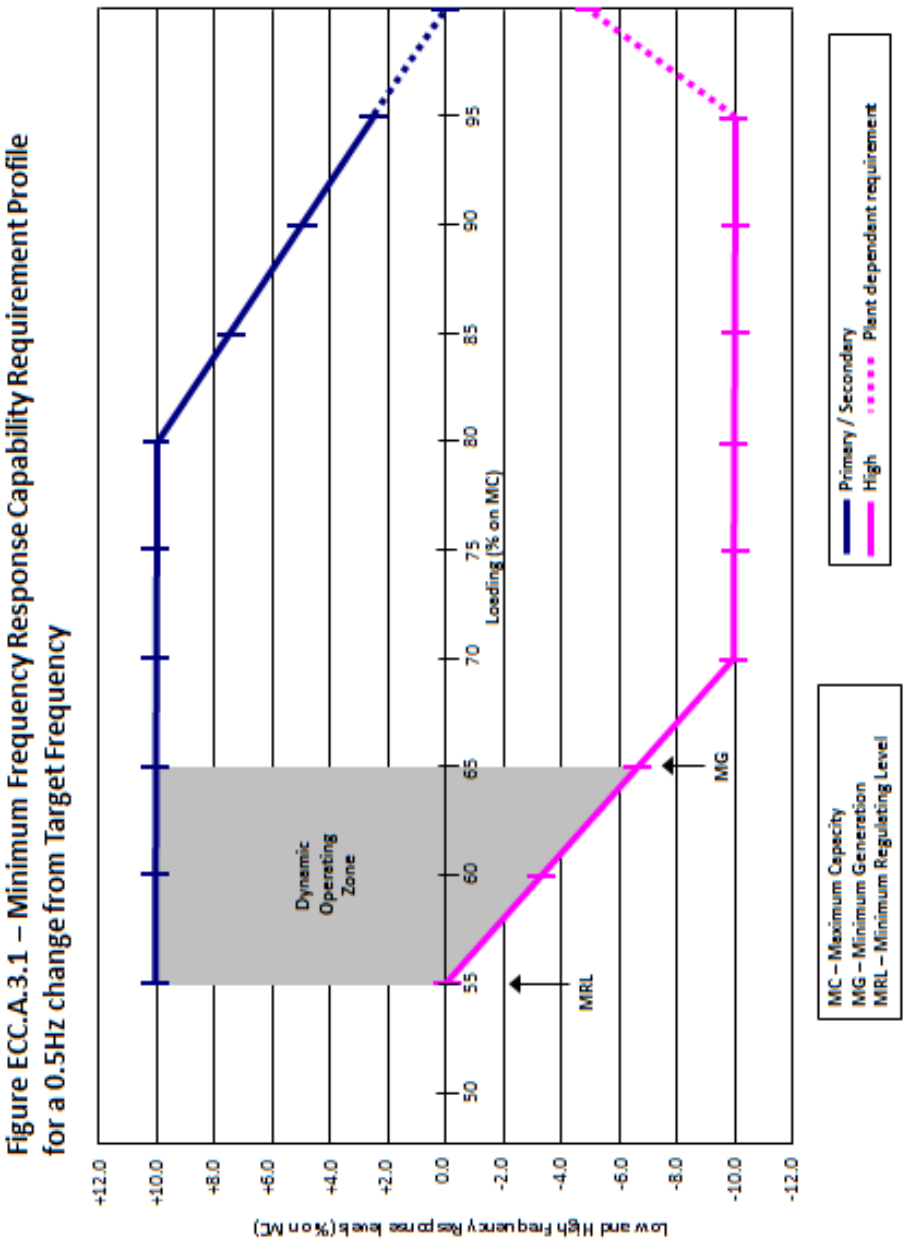


Figure ECC.A.3.2 – Interpretation of Primary and Secondary Response Service Values

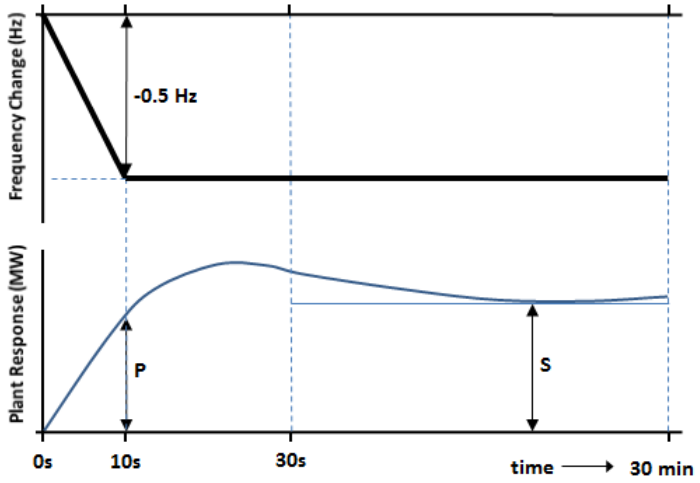


Figure ECC.A.3.3 – Interpretation of High Frequency Response Service Values

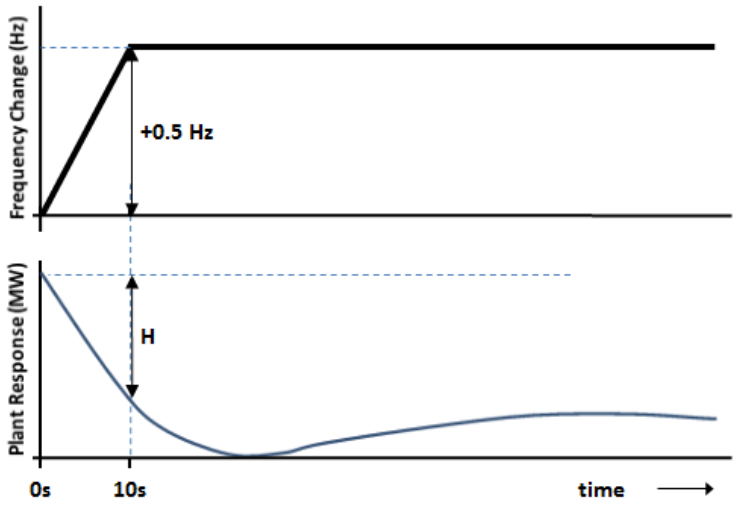


Figure ECC.A.3.4 – Interpretation of Low Frequency Response Capability Values

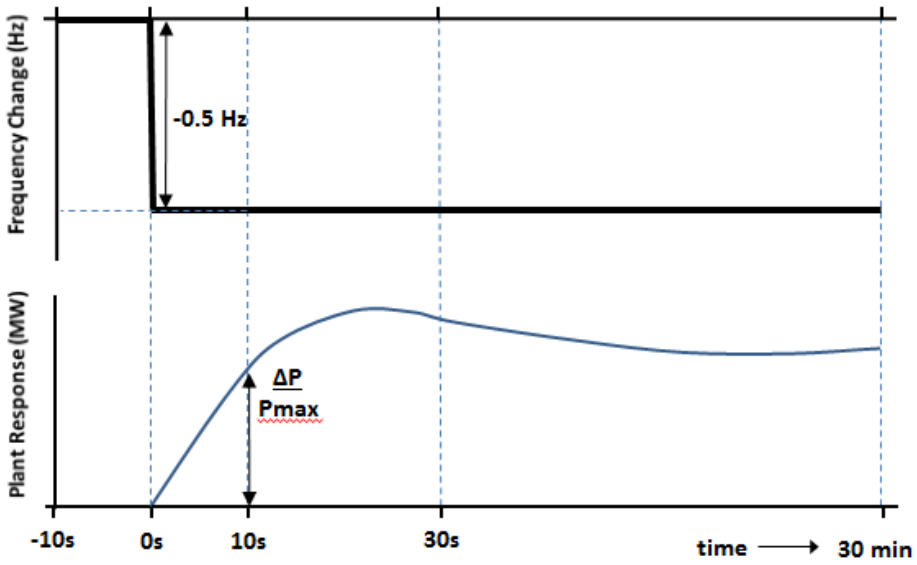
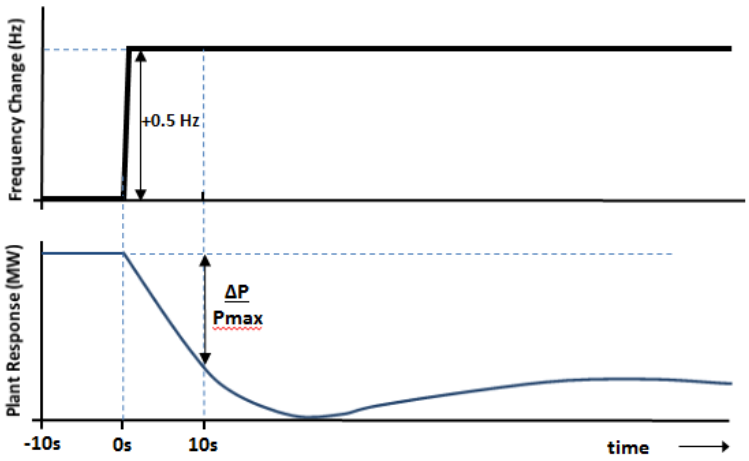


Figure ECC.A.3.5 – Interpretation of High Frequency Response Capability Values



Extracts from the European Compliance Processes

…….

ECP.A.3.6 **Limited Frequency Sensitive Mode** – Over Frequency (**LFSM-O**)

ECP.A.3.6.1 This section applies to **Type B**, **Type C and Type D Power Generating Modules**, **HVDC Equipment** to demonstrate the capability to modulate **Active Power** at high frequency as required by ECC6.3.7.3.5(ii).

ECP.A.3.6.2 The simulation study should comprise of a **Power Generating Module** or **HVDC Equipment** connected to the total **System** with a local load shown as "X" in figure ECP.A.3.6.1. The load "X" is in addition to any auxiliary load of the **Power Station** connected directly to the **Power Generating Module** or **HVDC Equipment** and represents a small portion of the **System** to which the **Power Generating Module** or **HVDC Equipment** is attached. The value of "X" should be the minimum for which the **Power Generating Module** or **HVDC Equipment** can control the power island **Frequency** to less than 52Hz consistent with ECC.6.3.7.3.5(ii). Where transient excursions above 52Hz occur the **Generator** or **HVDC Equipment Owner** should ensure that the duration above 52Hz is less than any high **Frequency** protection system applied to the **Power Generating Module** or **HVDC Equipment.**

ECP.A.3.6.3 For **HVDC Equipment** and **Power Park Modules** consisting of units connected wholly by power electronic devices the simulation methodology may be modified by the addition of a **Synchronous Power Generating Module** (G2) connected as indicated in Figure ECP.A.3.6.2. This additional **Synchronous Power Generating Module** should have an inertia constant of 3.5MWs/MVA, be initially operating at rated power output and unity **Power Factor**. The mechanical power of the **Synchronous Power Generating Module** (G2) should remain constant throughout the simulation.

ECP.A.3.6.4 At the start of the simulation study the **Power Generating Module** or **HVDC Equipment** will be operating maximum **Active Power** output. The **Power Generating Module** or **HVDC Equipment** will then be islanded from the **Total System** but still supplying load "X" by the opening of a breaker, which is not the **Power Generating Module** or **HVDC Equipment** connection circuit breaker (the governor should therefore, not receive any signals that the breaker has opened other than the reduction in load and subsequent increase in speed). A schematic arrangement of the simulation study is illustrated by Figure ECP.A.3.6.1.

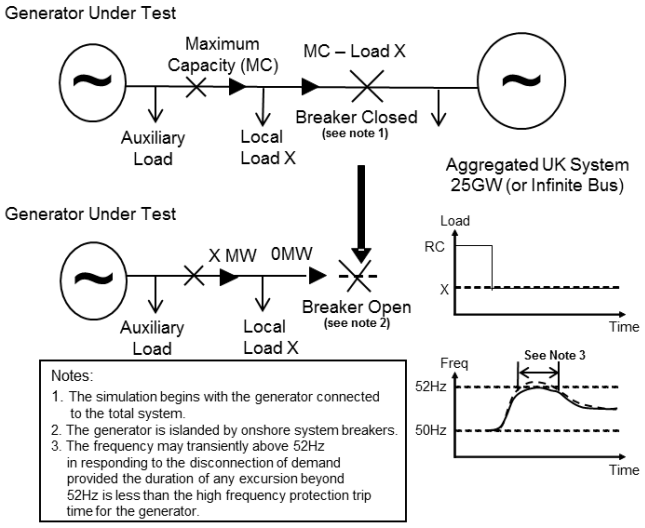


Figure ECP.A.3.6.1 – Diagram of Load Rejection Study

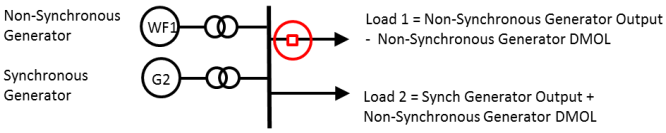


Figure ECP.A.3.6.2 – Addition of Generator G2 if applicable

ECP.A.3.6.5 A simulation study shall be performed for **Type B**, **C** & **D Power Generating Modules** in **Limited Frequency Sensitive Mode** (LFSM) and **Frequency Sensitive Mode** (FSM) for **Type C** & **D Power Generating Modules**. The simulation study results should indicate **Active Power** and **Frequency**.

ECP.A.3.6.6 To allow validation of the model used to simulate load rejection in accordance with ECC.6.3.7.3.5 as described, a further simulation study is required to represent the largest positive **Frequency** injection step or fast ramp (BC1 and BC3 of Figure 2) that will be applied as a test as described in ECP.A.5.8 and ECP.A.6.6.

ECP.A.3.6.7 The above suite of simulations equally apply for **Electricity Storage Modules** when in an export mode of operation and should demonstrate transition to an import mode of operation in line with the stated **Droop** characteristics of the **Electricity Storage Module**. The tests also need to be repeated when the **Electricity Storage Module** is in an import mode of operation. Three simulation studies need to be run

i) The **Electricity Storage Module** should initially be operating at zero MW output and have sufficient capability so that it is possible to operate the **Electricity Storage Module at Maximum Capacity** and **Maximum Import Power**. The above suite of tests should then be conducted to ensure the **Electricity Storage Modules Active Power** output achieves its **Maximum Import Power** in line with the **Droop** and response time settings as declared by the **Generator**.

ii) The **Electricity Storage Module** should be operating at 50% of its **Maximum Import Power** and have sufficient capability so that it is possible to operate the **Electricity Storage Module at Maximum Capacity** and **Maximum Import Power**. The above suite of tests should then be conducted to ensure the **Electricity Storage Modules Active Power** output achieves its **Maximum Import Power** in line with the **Droop** and response time settings as declared by the **Generator**.

iii) The **Electricity Storage Module** should be operating at its **Maximum Import Power**. The above suite of tests should then be conducted to ensure the **Electricity Storage Modules Active Power** remains at its **Maximum Import Power**, unless it is in **Frequency Sensitive Mode** and the tested **Frequency** falls below 50.5Hz.

Limited Frequency Sensitive Mode – Under Frequency (**LFSM-U**)

ECP.A.3.6.7 This section applies to:
Synchronous Power Generating Modules, **Type C & D;** or,
HVDC Equipment; or,
Power Park Modules, **Type C & D** to demonstrate the modules capability to modulate Active Power at low frequency.

ECP.A.3.6.8 To demonstrate the **LFSM-U** low **Frequency** control when operating in **Limited Frequency Sensitive Mode** the **Generator** or **HVDC System Owner** shall submit a simulation study representing the response of the **Power Generating Module** or **HVDC Equipment** operating at 80% of **Maximum Capacity**. These simulation studies need also to be supplied by **Generators** who own and operate **Electricity Storage Modules**. The simulation study event shall be equivalent to:

(i) a sufficiently large reduction in the measured **System Frequency** ramped over 10 seconds to cause an increase in **Active Power** output to the **Maximum Capacity** followed by

(ii) 60 seconds of steady state with the measured **System Frequency** depressed to the same level as in ECP.A.3.6.8.1 (i) as illustrated in Figure ECP.A.3.6.~~31~~ below.

(iii) then increase of the measured **System Frequency** ramped over 10 seconds to cause a reduction in **Active Power** output back to the original **Active Power** level followed by at least 60 seconds of steady output.

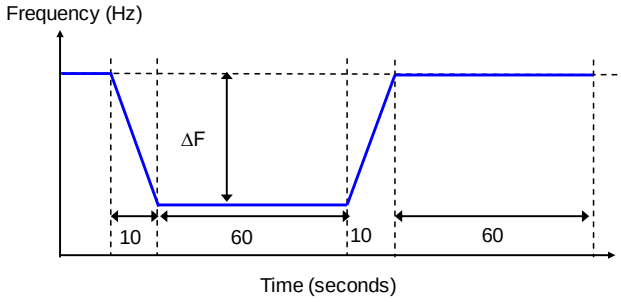


Figure ECP.A.3.6.~~31~~

Operation of **Electricity Storage Modules** in an import mode of operation during low **System Frequencies**

ECP.A.3.6.8 This section applies to **Type A**, **Type B**, **Type C** and **Type D Electricity Storage Modules** when in an import mode of operation during low **System Frequencies**.

(i) For **Generators** in respect of **Electricity Storage Modules** with a **Completion Date** before XXX who opt to meet the requirements of OC6.6.6 the simulation studies as detailed in ECP.A.3.6.9 shall apply.

(ii) For **Generators** in respect of **Electricity Storage Modules** with a **Completion Date** on or after XXX or **Generators** with a **Completion Date** before XXX and who choose to satisfy the requirements of ECC.6.3.3.2 the simulation studies as detailed in ECP.A.3.6.10 shall apply.

ECP.A.3.6.9 For **Generators** in respect of **Electricity Storage Modules** with a **Completion Date** before XXX who opt to satisfy the requirements of OC6.6, the **Generator** shall submit a simulation study representing the response of the **Electricity Storage Module** operating **at Maximum Import Power** followed by a simulated fall in **System Frequency**. The simulation shall comprise:-

(i) a sufficiently large reduction in the measured **System Frequency** ramped over 10 seconds over the **Frequency** range 49.5Hz to 48.85Hz to cause each demand block (as specified in the **Bilateral Agreement**) to trip

(ii) The simulation study shall demonstrate the tripping of each demand block at the specified frequency and time of disconnection following the frequency excursion at the specified setting. The test results shall be assessed against the settings in the **Bilateral Agreement**.

ECP.A.3.6.10 For **Generators** in respect of **Electricity Storage Modules** with a **Completion Date** on or after XXX or **Generators** in respect of **Electricity Storage Modules** with a **Completion Date** before XXX who opt to satisfy the requirements of ECC.6.3.3.2, the **Generator** shall submit simulation studies representing the response of the **Electricity Storage Module**.

ECP.A.3.6.11 The simulated tests shall comprise:-

(i) Initial conditions where the **Electricity Storage Module** shall be operating at its **Maximum Import Power** with the **Electricity Storage Module** in **Limited Frequency Sensitive Mode**.

(ii) A test signal shall be applied which ramps the **System Frequency** from 50Hz to 49.3 Hz over 10s. The **System Frequency** shall be held at 49.3Hz for 60s and the then ramped back to 50Hz in 10s as shown in Figure ECP.3.6.4.

(iii) The test result shall demonstrate a reduction in **Active Power** in accordance with the requirement of ECC.6.3.3.2. When the test injection signal is held at 49.3Hz, the **Active Power** output of the **Electricity Storage Module** should achieve a steady state operating point in no more than 10s and this should be maintained whilst the test frequency signal is held at 49.3Hz.

(iv) A test signal is then ramped from 49.3 Hz to 50Hz over a 10s period. The **Electricity Storage Module** should return back to its **Maximum Import Power** at 49.5Hz in line with the performance requirements of ECC.6.3.3.2.

(v) The above test shall be repeated with the **Electricity Storage Module** is operating at 50% of its **Maximum Import Power**.

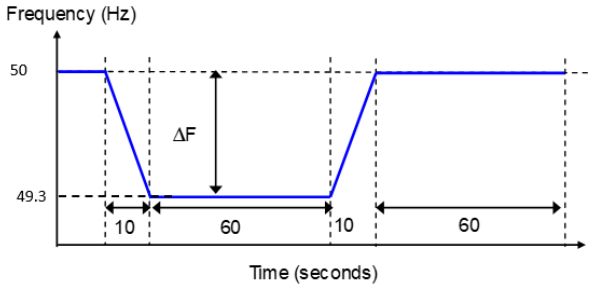


Figure ECP.A.3.6.4

ECP.A.3.6.12 In addition to the requirements of ECP.A.3.6.10 a set of simulation studies shall be submitted to demonstrate the performance of the **Electricity Storage Module** during extreme **Frequency** conditions. The simulated test shall comprise:-

(i) Initial conditions where the **Electricity Storage Module** shall be operating at its **Maximum Import Power** with the **Electricity Storage Module** in **Limited Frequency Sensitive Mode**.

(ii) A test signal shall be applied which ramps the **System Frequency** from 50Hz to 48.3 Hz over 20s. The **System Frequency** shall be held at 48.3Hz for 60s and the then ramped back to 50Hz in 20s as shown in Figure ECP.3.6.5.

(iii) The test result shall demonstrate the ability of the **Electricity Storage Module** to reach its **Maximum Capacity** (or otherwise) in accordance with the requirements of ECC.6.3.3.2. When the test injection signal is held at 48.3Hz, the **Active Power** output of the **Electricity Storage Module** should achieve a steady state operating point in no more than 10s and this should be maintained whilst the test frequency signal is held at 48.3Hz.

(iv) A test signal is then ramped from 48.3 Hz to 50Hz over a 20s period. The **Electricity Storage Module** should return back to its **Maximum Import Power** at 49.5Hz in line with the performance requirements of ECC.6.3.3.2.

(v) The above test shall be repeated with the **Electricity Storage Module** is operating at 50% of its **Maximum Import Power**.

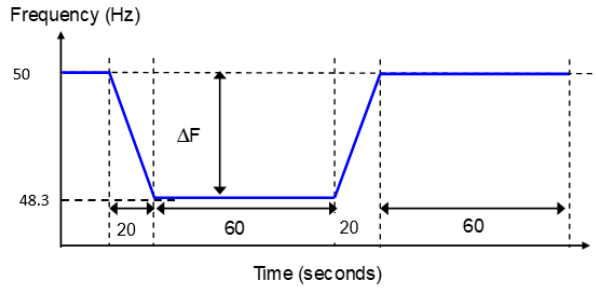


Figure ECP.A.3.6.5

.....

ECP.A.5.10 Compliance of **Synchronous Electricity Storage Modules** during low **System Frequencies**

(i) Prior to the test, the **Synchronous Electricity Storage Module** shall be operating at its **Maximum Import Power** with the **Synchronous Electricity Storage Module** in **Limited Frequency Sensitive Mode**.

(ii) A test signal shall be applied which ramps the **System Frequency** from 50Hz to 49.3 Hz over 10s. The **System Frequency** shall be held at 49.3Hz for 60s and the then ramped back to 50Hz in 10s as shown in Figure 4.

(iii) The test result shall demonstrate a reduction in **Active Power** in accordance with the requirement of ECC.6.3.3.2. When the test injection signal is held at 49.3Hz, the **Active Power** output of the **Synchronous Electricity Storage Module** should achieve a steady state operating point in no more than 10 seconds and this should be maintained whilst the test **Frequency** signal is held at 49.3Hz.

(iv) A test signal is then ramped from 49.3–Hz to 50Hz over a 10s period. The **Synchronous Electricity Storage Module** should return back to its **Maximum Import Power** at 49.5Hz in line with the performance requirements of ECC.6.3.3.2.

(v) The above test shall be repeated with the **Synchronous Electricity Storage Module** is operating at 50% of its **Maximum Import Power**.

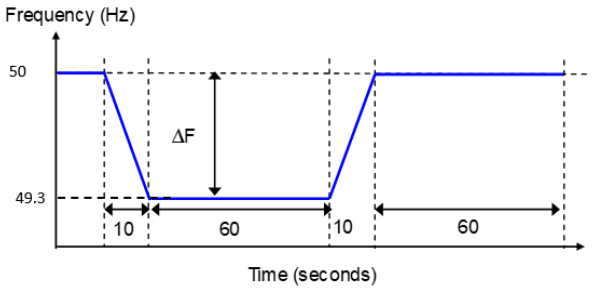


Figure 4

.....

ECP.A.6.6.10 Compliance of **Non-Synchronous Electricity Storage Modules** during low **System Frequencies**

(i) Prior to the test, the **Non-Synchronous Electricity Storage Module** shall be operating at its **Maximum Import Power** with the **Non-Synchronous Electricity Storage Module** in **Limited Frequency Sensitive Mode**.

(ii) A test signal shall be applied which ramps the **System Frequency** from 50Hz to 49.3 Hz over 10s. The **System Frequency** shall be held at 49.3Hz for 60s and the then ramped back to 50Hz in 10s as shown in Figure 4.

(iii) The test result shall demonstrate a reduction in **Active Power** in accordance with the requirement of ECC.6.3.3.2. When the test injection signal is held at 49.3Hz, the **Active Power** output of the **Non-Synchronous Electricity Storage Module** should achieve a steady state operating point in no more than 10 seconds and this should be maintained whilst the test **Frequency** signal is held at 49.3Hz.

(iv) A test signal is then ramped from 49.3 Hz to 50Hz over a 10 second period. The **Non-Synchronous Electricity Storage Module** should return back to its **Maximum Import Power** at 49.5Hz in line with the performance requirements of ECC.6.3.3.2.

(v) The above test shall be repeated with the **Non-Synchronous Electricity Storage Module** is operating at 50% of its **Maximum Import Power**.

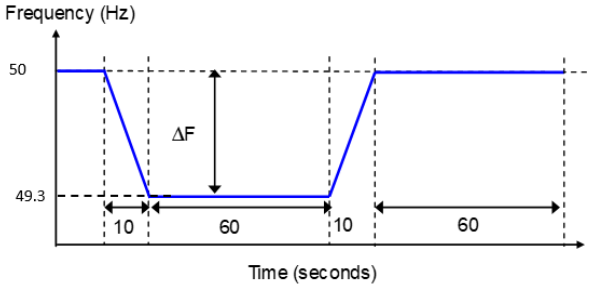


Figure 4

……..

Extracts from the Operating Code 6

……

OC6.6.6 (a) **Non-Embedded Customers** ~~**Pumped Storage Generators**~~ and **Pumped Storage Generators**, must provide automatic low **Frequency** disconnection, which will be split into discrete blocks.~~ For the avoidance of doubt, the data required from **Pumped Storage Generators** and **Electricity Storage Modules** would only apply when they operate in a mode analogous **to Demand**~~. **Generators** in respect of **Electricity Storage Modules** with a **Completion Date** before XXX must either provide automatic low **Frequency** disconnection, which will be split into discrete blocks or satisfy the requirements of ECC.6.3.3.2.

(b) The number and size of blocks and the associated low **Frequency** settings will be as specified by **The Company** by week 24 each calendar year following discussion with the **Non-Embedded Customers** and~~,~~ **Pumped Storage Generators** in accordance with the relevant **Bilateral Agreement**. ~~For the avoidance of doubt, the data required **Pumped Storage Generators** and **Electricity Storage Modules** would only apply when they operate in a mode analogous to **Demand**.~~ For **Generators** who own and operate **Electricity Storage Modules** with a **Completion Date** before XXX and who elect to satisfy the requirements of OC6.6.6, rather than ECC.6.3.3.2, the number and size of blocks and the associated low **Frequency** settings will be specified by **The Company** by week 24 each calendar year following discussion with the **Generator** in accordance with the relevant **Bilateral Agreement**.

……