Public

Mid-Term (Y-1) Stability Market

Proving Tests

Tender Year: 2025-2026

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NESO
National Energy System Operator

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Version Control

Version Number	Date	Notes
V1	28th January 2026	Instructions for tenderers during the Expression of Interest (EOI) and consultation stages of the tender. This document may be amended or updated at the Invitation to Tender (ITT) stage.

Contents

1. Aim

The aim of this document is to provide an overview of the compliance and proving simulations and tests that are required to be completed as part of the Mid Term (Y-1) Stability Market. These tests are an important part of the tender and will demonstrate the real physical capability of the solution and its compliance against the relevant sections of the GB Grid Code. Please note all solutions need to meet the requirements set out in ECC.6.3.19 for Grid Forming plant. This document also provides an overview of the Grid Code testing and simulations that must be completed prior to the start of the service.

2. Overview

This document sets out the compliance simulations and capability tests that successful parties in the Mid Term (Y-1) Market will have to complete and have approved by NESO before their scheduled service start date.

The basis of compliance for both GB Grid Forming-Inverter (GBGF-I) and GB Grid Forming-Synchronous (GBGF-S) will be based upon the Grid Code. For both GBGF-I and GBGF-S, the Grid Code compliance procedure will follow the requirements for the host technology to which the Grid Forming equipment is installed with the additional tests detailed in ECP.A.9 being completed for GBGF-I technology. For clarity a hybrid solution would need to meet both the requirements for GBGF-I[1] and GBGF-S[2]. Furthermore, for Hybrid Solutions NESO may provide an alternative test and simulation plan that the provider must complete.

Solutions must prove that the stacking of other services does not impact upon their delivery of the Stability Service. Stacking with other services or different operational strategy of assets may not be allowed if this is not proven at the compliance stage. The provider must agree with NESO a method to prove the ability to stack services, before the stacking can commence. The acceptance of this methodology will be at NESO's sole discretion. The provider must also ensure that stacking with any other service is done so in accordance with the service terms of that service.

In line with Clause 7 of the Standard Contract Terms for the Mid-Term Stability Market, should a Provider make any physical changes to their equipment (such as reducing the number of in-service inverters) during the contract, NESO reserve the right to enact Clause 7.1 to request a Reproving Test to evidence the impact this has upon their delivery of the stability service.

As a part of being awarded a contract and in addition to completing Grid Code compliance obligations, successful parties will have to complete additional compliance activities, a summary of these are shown in Table 1. Providers that are successful will be required to submit a full technical report with explanation for the behaviours shown in the tests and simulations.

[1] [2] Any definitions used in this document will take their definition from the GB Grid Code.

Where the provider carries out tests in a FAT environment the results of these tests must be approved by NESO before any simulation studies can be conducted and submitted. This is to ensure that the correct parameters from the final accepted FAT test are reflected in any simulations completed.

In this document the Point of Stability takes the meaning from the contract. The solution terminal is the first AC point where the Grid Forming Capability can be demonstrated. For a GBGF-S solution this would be the terminals of the machine, for a GBGF-I solution this would be the AC side of the inverter. For plant which may be made up of multiple machines, all solution terminals should be provided. For GBGF-I plant which utilise a lumped model of multiple inverters, the solution terminal can be provided at the terminal of the lumped model.

Table 1: Summary of Compliance Requirements

Compliance Requirement	GBGF-I	GBGF-S
Section 3. Grid Code Compliance	✓	✓
Section 4. Additional Technical Compliance Simulations (Phase Angle Withstand, RoCoF Simulations, Combined Frequency and Voltage Events)	✓	✓
Section 5. Commercial Service Proving Tests (Phase Angle Withstand, RoCoF Events, Combined Frequency and Voltage Events)	✓	×
Grid Forming Plant verification and validation (ECP.A.3.9.1)	✓	×

3. Non-Contractual Testing

As a part of the facilitation of this Market, NESO may provide support for users who wish to undertake testing who do not currently hold a Mid-Term Stability Contract. The purpose of this is to provide support to users who are otherwise completing the physical Grid-Code testing for Grid Forming requirements in the Grid Code who also wish to complete the Y-1 Proving Tests simultaneously.

Any support offered will be at NESO's discretion and based upon the availability of NESO staff to support the testing. The test results may then be submitted for approval as part of the tender process if the party were latter successful. Noting that NESO reserves the right to change the Proving Tests Requirements for the Mid-Term Stability Market.

Providers who wish to have support from NESO for the completion of the Proving Tests should contact box.stability@neso.energy

4. Grid Code Compliance

Please note all solutions must meet the fault ride through requirements in the ECC code (Section ECC.6.3.15).

For additional guidance for Synchronous Condensers please refer to the Synchronous Condenser Guidance Note.

For GBGF-I solutions, the relevant sections of the Grid Code must be followed for the host technology as well as additional testing detailed in ECP.A.9. For more detail, please refer to the GB Grid Forming Guidance Notes [3]and [4]the GB Grid Forming Best Practice Guide.

For both GBGF-I and GBGF-S solutions, the provision of an Electro-Magnetic Transient (EMT) model in addition to an RMS model is required, for this please refer to the EMT Guidance Notes. Please note that the service cannot be started until a validated model in line with PC.A.4.2 has been accepted by NESO.

In addition to these requirements, it is required that as a part of these tender full accurate models of all the user's plant is modelled. For instance, for Grid Forming batteries a full battery model must be used and for GBFG-S a multi-mass model of the plant must be used.

For absolute clarity, to start the Stability Service the Provider must have completed full compliance with the relevant Grid Code clauses for the following sections set out below. The provider must complete all other activities in the contract and this document required for the service-go live. The compliance guidance notes and processes for different users can be found on the NESO website:

https://www.neso.energy/industry-information/connections/compliance-process#Compliance-documents

Any plant that has previously completed Grid Code compliance, that is making changes to their H constant to deliver a greater inertia will be required to re complete full compliance against all Grid Code clauses. This includes re completing any tests and simulations and the submission of any updated EMT and RMS models.

4.1 Reactive Power Capability

The provider is required to demonstrate compliance with the technical requirements set out in the technical specifications and any relevant Grid Code clauses that would apply to the technology type.

[3] https://www.neso.energy/document/289921/download
[4] https://www.neso.energy/document/278491/download

Synchronous Machine (GBGF-S) Reactive Capability Tests:

For synchronous generators, the provider should follow the test mentioned in the compliance guidance notes for synchronous generators (Appendix for Reactive Capability)

For synchronous compensators, the provider should follow the tests mentioned in the compliance guidance notes for synchronous compensators (Appendix for Reactive Capability)

Grid Forming Inverter Technology (GBGF-I) Reactive Capability Tests:

For GBGF-I Plant treated as a Storage User in the BCA, the provider should follow the tests mentioned in the compliance guidance notes for Electricity Storage Modules (EU Code User) (Appendix for Reactive Capability)

For GBGF-I Plant treated as an HVDC System Owner or DC Converter Station Owner in the BCA the provider should follow the tests mentioned in the compliance guidance notes for DC converter stations (EU Code User) (Appendix for Reactive Capability)

For GBGF-I Plant treated as Power Park Module in the BCA, the provider should follow the tests mentioned in the compliance guidance notes for Power Park Modules (EU Code User) (Appendix for Reactive Capability)

All plant, constant MVAR mode Tests:

For Plant which is providing a Constant MVAr mode of operation additional compliance requirements will be provided by NESO separately.

4.2 Voltage Control and Testing

The provider is required to demonstrate compliance with the technical requirements set out in the technical specifications and any relevant Grid Code clauses that would apply to the technology type.

Synchronous Machine (GBGF-S) Reactive Capability Tests:

For synchronous generators, providers show follow the tests mentioned in the compliance guidance notes for synchronous generators (Appendix for Voltage Control and Testing)

For synchronous compensators, providers should follow the tests mentioned in the compliance guidance notes for synchronous compensators (Appendix for Voltage Control and Testing)

Grid Forming Inverter Technology (GBGF-I) Reactive Capability Tests:

For GBGF-I Plant treated as a Storage User in the BCA, the provider should follow the tests mentioned in the compliance guidance notes for Electricity Storage Modules (EU Code User) (Appendix for Reactive Capability)

For GBGF-I Plant treated as an HVDC System Owner or DC Converter Station Owner in the BCA the provider should follow the tests mentioned in the compliance guidance notes for DC converter stations (EU Code User) (Appendix for Reactive Capability)

For GBGF-I Plant treated as Power Park Module in the BCA, the provider should follow the tests mentioned in the compliance guidance notes for Power Park Modules (EU Code User) (Appendix for Reactive Capability)

All plant, constant MVAR mode Tests:

For Plant which is providing a Constant MVAr mode of operation additional compliance requirements will be provided by NESO separately.

4.3 Frequency Control

If a plant participating in the Stability Mid-Term market is also providing any frequency response services, it must demonstrate the relevant frequency control tests based on its Grid Code connection. For absolute clarity these tests must be completed before the service can start.

The specific requirements for Frequency Control tests are specified in the relevant plant guidance notes.

4.4 Fault Ride Through and Fast Fault Current Injection

All Plants under the Mid-Term Stability Market must ride through voltage depressions at the Point of Stability of down to 0 p.u. for 140ms. All plant must be able to ride through the relevant voltage depressions for a connection at or above 110kV.

In addition, GBGF-I plant must be complaint with section ECC.6.3.19.5 of the Grid Code.

4.5 Grid Forming Capability

All plants under the Mid-Term Stability Market must meet the requirements of ECC.6.3.19, including the completion and acceptance of the simulations in ECP.A.3.9 and the testing requirements in ECP.A.9.

5. Additional Commercial Service Technical Compliance Simulations

Within this section simulations that must be completed by all successful solutions are provided. These simulations are covered in sections 5.1 – 5.5

For all the following simulations, covered in sections 5.1-5.5 the Initial Conditions in Table 2 will apply.

For EMT simulations, EMT and RMS quantities must be provided. The method adopted to compute RMS values must be clearly stated, explained and agreed with NESO. All RMS results must include positive, negative and zero sequence quantities.

All results must be recorded with step sizes not greater than 1ms

The test model must be set up as following:

- The solution must be modelled in EMT for GBGF-I and Hybrid solutions. For GBGF-S solutions RMS models may be used. However, all models must ensure that the modelling method is suitable to capture the performance of the plant and any limitations.
- Any equipment (including protection settings) that impacts the performance at the Point of Stability must be modelled.
- The equivalent system impedance (Z_{sys}) for the connection location parameters are to be the same as those used in the Feasibility Study.
- Nominal settings and ratings of assets should be used in the model and simulations
- All simulation settings, model parameters, model settings and controller parameters must remain unchanged for all simulation tests. Any change in these settings and parameters, other than those requested by NESO must be declared, justified and agreed with NESO.
- For GBGF-I, all converter limitations and associated protection settings must be modelled.
- Hybrid Plants must follow all tests described for GBGF-I Plants.

Any provider completing these simulations should agree the exact methodology with NESO before completing the simulations.

Table 2: Simulation Initial Conditions

	Initial Conditions for Simulation Tests
Definitions	**Maximum Active Power Export** in this document**,** depending on the submission in the commercial tender is defined as either 1) the maximum export / maximum discharged state of a GBGF-I asset or 2) the maximum Active Power export based on participation in other services/BM. It must be clearly stated and explained. **Maximum Active Power Import** in this document, depending on the submission in the commercial tender, is defined as either 1) maximum import/maximum charging state of a GBGF-I asset or 2) maximum Active Power Import based on participation in other services/BM. It must be clearly stated and explained.
Initial Condition 1	Plant Running at Maximum Active Power Export and Maximum Reactive Power Import This condition is not applicable to 0MW Plant.
Initial Condition 2	Plant Running at Maximum Active Export and Maximum Reactive Power Export

	This condition is not applicable to 0MW Plant.
Initial Condition 3	Plant running at Maximum Active Power Import and Maximum Reactive Power Import This condition is not applicable to 0MW Plant.
Initial Condition 4	Plant Running at Maximum Active Power Import and Maximum Reactive Power Export This condition is not applicable to 0MW Plant
Initial Condition 5	Plant Running at 0MW and Maximum Reactive Power Import
Initial Condition 6	Plant Running at 0MW and Maximum Reactive Power Export.
Initial Condition 7	Plant Running at 0MW and 0 Reactive Power Export.

5.1 Phase Angle Withstand Simulations

This simulation is to validate the performance of the plant when exposed to the Phase Angle Withstand limit of the plant.

The following measurements are required for this simulation:

- voltage magnitude and phase angle at the Grid Entry Point (GEP) or User System Entry Point (USEP) and the solution terminal.
- active power and reactive power at the Grid Entry Point or User System Entry Point and the solution terminal.
- active, reactive, and total current at the Grid Entry Point or User System Entry Point and the solution terminal.
- frequency and RoCoF at the Grid Entry Point or User System Entry Point and the solution terminal
- The Phase Angle event must be modelled as an event within the Ideal Voltage Source, this quantity must be measured.
- The equivalent system impedance (Z_{sys}) for the connection location parameters are to be the same as those used in the Feasibility Study.
- The time step must not be greater than 1ms.

- The simulation must be setup in accordance with Figure 1.
- For each step, all required initial conditions must be completed.
- For plant with a Constant MVAr mode, these simulations must also be carried out in Constant MVAr mode.

Table 3: Phase Angle Withstand Simulations

Step	Initial Conditions	Phase Angle Event
1	Setup	With the System Frequency set to 50Hz, the Plant must have both Limited Frequency Sensitive Mode and Frequency Sensitive Mode disabled. Pre-event voltage at the Grid Entry Point equal to 1.p.u. Voltage control should be enabled
2	1,2,3,4,5,6	Apply a phase jump equivalent to the positive Phase Jump Angle Withstand at the GEP or USEP. Allow conditions to stabilise for at least 10 seconds.
3	1,2,3,4,5,6	Apply a phase jump equivalent to the negative Phase Jump Angle Withstand at the GEP or USEP. Allow conditions to stabilise for at least 10 seconds.

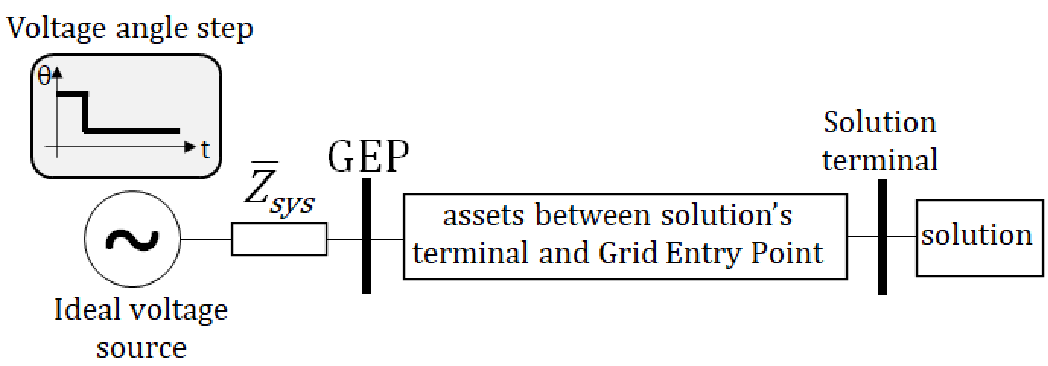

Figure 1: Network configuration for simulations in Table 3

5.2 RoCoF Event Simulations

This simulation is to validate the Inertia performance of the plant against the tendered Inertia value and to assess the overall performance of the plant.

The following measurements are required for this simulation:

- voltage magnitude and phase angle at the Grid Entry Point or User System Entry Point and the solution terminal.
- active power and reactive power at the Grid Entry Point or User System Entry Point and the solution terminal.

- active, reactive, and total current at the Grid Entry Point or User System Entry Point and the solution terminal.
- frequency and RoCoF at the Grid Entry Point or User System Entry Point and the solution terminal
- The Frequency event must be modelled as an event within the Ideal Voltage Source.
- The equivalent system impedance (Z_{sys}) for the connection location parameters are to be the same as those used in the Feasibility Study.
- The time step must not be greater than 1ms.
- The simulation must be setup in accordance with Figure 2, all parameter changes must be implemented as a change in the Ideal Voltage Source.
- For each test step, all required initial conditions must be completed
- A summary of Inertia values must be provided and must match or be greater than the Inertia values stated in the feasibility study.
- the methodology for the calculation of Inertia must follow that used in the feasibility study.
- For plant with a Constant MVAr mode, these simulations must also be carried out in Constant MVAr mode.

Table 4: RoCoF Simulations

Step	Initial Conditions	Frequency Event
1	Setup	With the System Frequency set to 50Hz, the Plant must have both Limited Frequency Sensitive Mode and Frequency Sensitive Mode disabled. Pre-event voltage at the Grid Entry Point equal to 1p.u. Voltage control should be enabled
2	1,2,3,4,5,6	Inject a 1Hz frequency drop taking the frequency from 50Hz to 49Hz over a period of 1 second.
3	1,2,3,4,5,6	Inject a 1Hz frequency rise taking the frequency from 50Hz to 51Hz over a period of 1 second.
4	7	Inject a frequency **step** event from 50Hz to 49Hz lasting for 0.5s.

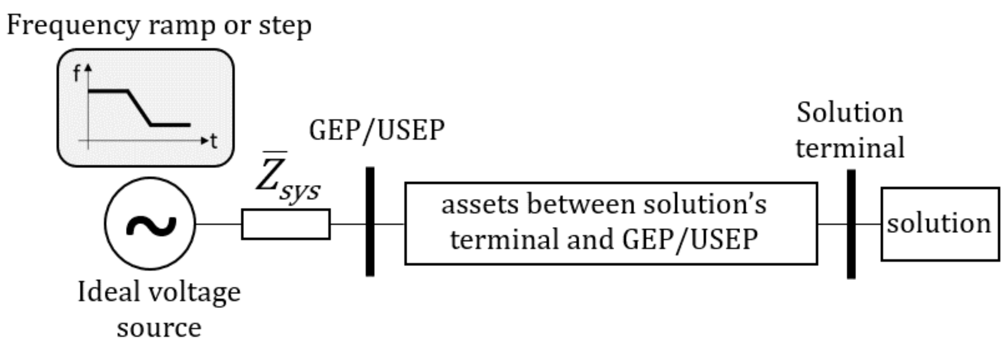

Figure 2: Network configuration for simulations in Table 4

5.3 Combined Voltage and Frequency Simulations

This simulation is to validate the inertia performance and overall performance of the plant when subjected to both a voltage and a frequency event simultaneously.

The following measurements are required for this simulation:

- voltage magnitude and phase angle at the Grid Entry Point or User System Entry Point and the solution terminal.
- active power and reactive power at the Grid Entry Point or User System Entry Point and the solution terminal.
- active, reactive, and total current at the Grid Entry Point or User System Entry Point and the solution terminal.
- frequency and RoCoF at the Grid Entry Point or User System Entry Point and the solution terminal
- The Frequency event must be modelled as an event within the Ideal Voltage Source.
- The equivalent system impedance (Z_{sys}) for the connection location parameters are to be the same as those used in the Feasibility Study The time step must not be greater than 1ms.
- The time step must not be greater than 1ms.
- The simulation must be setup in accordance with Figure 3, all parameter changes must be implemented as a change in the Ideal Voltage Source. The Phase Angle of the voltage source must be measured.
- For each test step, all required initial conditions must be completed
- A summary of Inertia values must be provided and must match or be greater than the Inertia values stated in the feasibility study.
- These simulations must be completed once with LFSM and Voltage Control Enabled, then repeated with just Voltage Control Enabled.

- For plant with a Constant MVAr mode, these simulations must be carried out in Constant MVAr mode as well.

Table 5: Combined Voltage and Frequency Simulations

With the System Frequency set to 50Hz, the Plant must have Limited Frequency Sensitive Mode and Voltage Control Enabled. The simulations must be completed again with LFSM disabled. All simulations are to be completed with initial conditions 1,2,3,4,5,6						
Voltage Events	Frequency Events					
	Frequency Rise from 50Hz to 51Hz at 0.5 Hz/s	Frequency Fall from 50Hz to 49Hz at 0.5 Hz/s	Frequency Rise from 50Hz to 52Hz at 1 Hz/s	Frequency Fall from 50Hz to 47Hz at 1Hz/s	Frequency Rise from 50Hz to 51Hz at 1Hz/s	Frequency Fall from 50Hz to 49Hz at 1Hz/s
3 Phase-Earth fault followed by a step drop to 0.9 p.u. and a phase angle drop of 5 degrees						
3 Phase-Earth fault followed by a step drop to 0.9 p.u. and a phase angle jump of 5 degrees						

3 Phase-Earth fault followed by a rise to 1.1 p.u. and a phase angle drop of 5 degrees						
3 Phase-Earth fault followed by a step rise to 1.1 p.u. and a phase angle rise of 5 degrees						

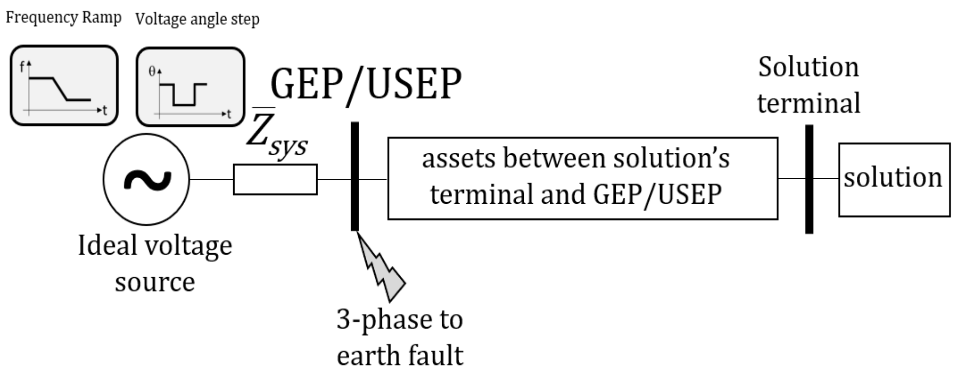

Figure 3: Network Configuration for Simulations in Table 5

5.4 Multiple Fault Ride Through Simulations

This simulation is to validate the ability of the plant to ride through multiple consecutive faults.

The following measurements are required for this simulation:

- voltage magnitude and phase angle at the Grid Entry Point or User System Entry Point and the solution terminal.
- active power and reactive power at the Grid Entry Point or User System Entry Point and the solution terminal.
- active, reactive, and total current at the Grid Entry Point or User System Entry Point and the solution terminal.
- frequency and RoCoF at the Grid Entry Point or User System Entry Point and the solution terminal
- The Frequency event must be modelled as an event within the Ideal Voltage Source.
- The equivalent system impedance (Z_{sys}) for the connection location parameters are to be the same as those used in the Feasibility Study The time step must not be greater than 1ms.
- The time step must not be greater than 1ms.
- For each test step, all required initial conditions must be completed
- The simulation must be setup in accordance with Figure 4, all parameter changes must be implemented as a change in the Ideal Voltage Source.
- For plant with a Constant MVAr mode, these simulations must be carried out in Constant MVAr mode as well.

Table 6: Multiple Fault Ride Through Simulations

Step	Initial Conditions	Fault Event
1	Setup	With the System Frequency set to 50Hz, the Plant must have Limited Frequency Sensitive Mode and Voltage Control Enabled.
2	1,2,3,4,5,6	Apply a 3 phase-earth fault at the point of stability for 140ms before clearing the fault. Repeat the fault 5 times with 15 seconds between each two consecutive faults. Explain the Plant's behaviour and any observations.
3	1,2,3,4,5,6	Apply a 2 phase-earth fault at the point of stability for 140ms before clearing the fault. Repeat the fault 5 times with 15 seconds between each two consecutive faults. Explain the Plant's behaviour and any observations.

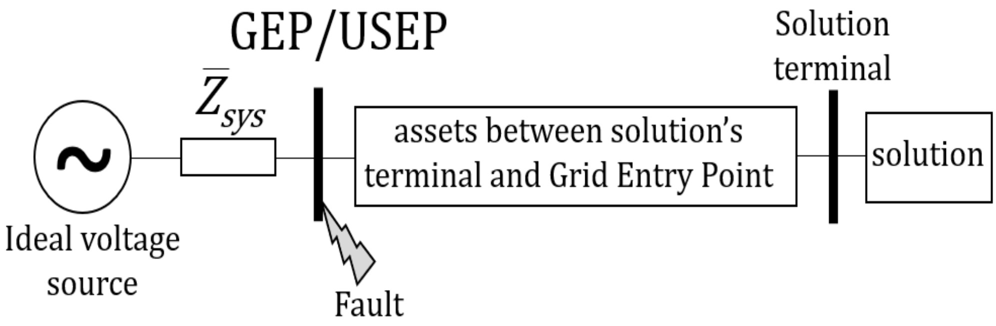

Figure 4: Network Configuration for Simulations in Table 6

5.5 Power Oscillation Damping Simulations

This simulation will establish if the Grid Forming Plant is meeting the reactive and/or active power oscillation damping capability as specified in the technical specification.

GBGF-S Plant must be able to

1. Detect system voltage oscillations in the sub-synchronous frequency range 0.3-2Hz
2. Upon detecting oscillations, inject reactive current adequately in antiphase to achieve a reduction in voltage oscillation at the Grid Entry Point
3. Change the amount of reactive current injection proportional to the amplitude of the oscillations.
4. Limit the influence of these subsidiary control actions at 10% of the primary function.
5. Achieve 1-4 whilst keeping the solution stable and not compromise other aspects of the technical specification.

GBGF-I and Hybrid Plants must be able to

1. Detect system voltage and active power oscillations in the sub-synchronous frequency range 0.3Hz to 2Hz.
2. Upon detecting voltage oscillations, inject/absorb reactive current adequately in antiphase to achieve a reduction in voltage oscillation at the Grid Entry Point
3. Upon detecting active power oscillations, inject/absorb active current adequately in antiphase to achieve a reduction in active power oscillations at the Grid Entry Point
4. Change the amount of reactive current injection proportional to the amplitude of the voltage oscillations
5. Change the amount of active current injection proportional to the amplitude of the active power oscillations

6. Limit the influence of these subsidiary control functions at 10% of the primary function
7. Achieve 1-6 whilst keeping the solution stable and not compromise other aspects of the technical specification.

Hybrid solutions must follow same tests as GBGF-I

For all Grid Forming Plants (GBGF-S or GBGF-I), NESO expects the Provider to contribute to damping over the frequency range 0.3Hz to 2Hz.

The report must include any limitations on damping over the frequency range 0.3Hz to 2Hz based on the tuning.

The following procedure is provided to assist Providers in drawing up their own site-specific procedures.

All solutions must provide a table showing the angle between reactive power and voltage and if applicable active power and frequency.

Table 7: Power Oscillation Damping - Voltage Oscillations

Steps	Simulation Events
	Plant running at 0 MVAr and 0 MW Equivalent system representation is shown in Figure 7.
1	Inject 0.3Hz oscillations in system voltage. The 0.3Hz oscillations should be superimposed to the fundamental frequency (50 Hz) voltage. The amplitude of the oscillation must be 5% of the rate voltage at the Grid Entry Point. If 5% is not sufficiently large to demonstrate damping capability, increase further until able to demonstrate the solutions contribution to damping. Observe differences with and without the plant connected on the contribution to towards damping the reactive power oscillations. Explain the Plant’s behaviour and any observations
2	Repeat step 1 by increasing oscillation frequencies with steps of 0.1Hz up to 2Hz.

Additional test defined in Table 8 must be undertaken by GBGF-I and Hybrid Plants.

Table 8: Power Oscillation Damping - Active Power Oscillations

Steps	Simulation Events
	Plant running at 0 MVAr and 0 MW Equivalent system representation is shown in Figure 7
1	Inject 0.3Hz oscillations in system frequency. The 0.3 Hz oscillations should be superimposed to the fundamental frequency (50Hz) value. The amplitude of the oscillation must be 0.5% of the rate frequency at the Grid Entry Point. If 0.5% is not sufficiently large to demonstrate the damping capability, increase further until the amplitude is able to demonstrate the solutions contribution towards damping. Observe differences with and without the plant connected on the contribution to towards damping the active power oscillations. Explain the Plant's behaviour and any observations
2	Repeat step 1 by increasing oscillation frequencies with steps of 0.1Hz up to 2Hz.

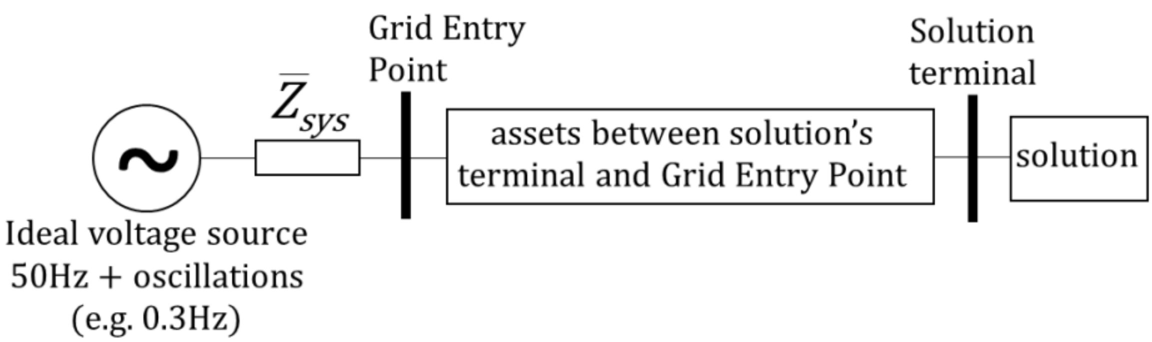

Figure 5: Network Configuration for Simulations in Table 7 and Table 8

6. Commercial Service Physical Tests

A requirement of the Mid-Term (Y-1) Stability Market Framework Agreement and Standard Contract Terms is the proving of the contracted inertia and Grid Forming service from providers. Due to the inherent ability of GBGF-S plant to provide inertia and Grid Forming capability, these tests are not required from this type of solution. However, it is a requirement that GBGF-S solutions submit evidence of their inertia value through their manufacturer data sheets. The objective of these tests is to demonstrate that the tendered inertia value is deliverable across the asset's operating range and the Grid Forming performance of the plant. These tests must be completed through physical testing. The exact testing methodology must be agreed with NESO.

The Provider must discuss the route through which they wish to complete this Physical Testing (For instance, Factory Acceptance Testing (FAT), On-Site testing or other) with NESO. It is at NESO's sole discretion to agree and accept the route through which Physical Testing will be conducted.

Any report that is outputted from the FAT process must be of sufficient quality to enable it to be reviewed, this includes but is not limited to ensuring that any time-series plots have legible markers, data points and are clearly presented within the report. These time-series plots should be of sufficient resolution to enable the performance they illustrate to be comprehensively reviewed.

The Provider must submit a test protocol including equipment setup and measurement calibration ahead of the tests for NESO approval. NESO reserves the right to witness any Physical Testing In-Person.

The tests that must be completed by the service providers are covered in sections 6.1 – 6.4. For each step, all required initial conditions must be completed

For these tests, covered In Sections 6.1-6.4 the Initial conditions In Table 9 will apply. The measurement quantities below must be provided for all tests; each measurement must be sampled at a minimum of 1 kHz.

- Voltage magnitude and phase angle at the Grid Entry Point or User System Entry Point and the solution terminal.
- Active power and reactive power at the Grid Entry Point or User System Entry Point and the solution terminal.
- Active, reactive, and total current at the Grid Entry Point or User System Entry Point and the solution terminal.
- Frequency and RoCoF at the Grid Entry Point or User System Entry Point and the solution terminal

Table 9: Proving Test Initial Conditions

	Initial Conditions for Proving Tests
Definitions	<u>**Maximum Active Power Export**</u> in this document**,** depending on the submission in the commercial tender is defined as either 1) the maximum export / maximum discharged state of a GBGF-I asset or 2) the maximum Active Power export based on participation in other services/BM. It must be clearly stated and explained. **Maximum Active Power Import** in this document, depending on the submission in the commercial tender, is defined as either 1) maximum import/maximum charging state of a GBGF-I asset or 2) maximum Active Power Import based on participation in other services/BM. It must be clearly stated and explained.

Initial Condition 1	Plant Running at Maximum Active Power Export and Maximum Reactive Power Import This condition is not applicable to 0MW Plant.
Initial Condition 2	Plant Running at Maximum Active Export and Maximum Reactive Power Export This condition is not applicable to 0MW Plant.
Initial Condition 3	Plant running at Maximum Active Power Import and Maximum Reactive Power Import This condition is not applicable to 0MW Plant.
Initial Condition 4	Plant Running at Maximum Active Power Import and Maximum Reactive Power Export This condition is not applicable to 0MW Plant
Initial Condition 5	Plant Running at 0MW and Maximum Reactive Power Import
Initial Condition 6	Plant Running at 0MW and Maximum Reactive Power Export
Initial Condition 7	Plant Running at 0MW and 0 Reactive Power Export.

6.1 Phase Angle Withstand Tests

The tests covered in this section are to verify the performance of the plant when subjected to both positive and negative Phase Angle jumps up to the limit.

Table 10: Phase Angle Withstand Tests

Step	Initial Conditions	Event
1	Setup	With the System Frequency set to 50Hz, the Plant must have both Limited Frequency Sensitive Mode and Frequency Sensitive Mode disabled. Pre-event voltage at the Grid Entry Point equal to 1p.u.
2	1,2,3,4	Apply a phase jump equivalent to the positive Phase Jump Angle Withstand at the GEP or USEP. Allow conditions to stabilise for at least 10 seconds.

3	1,2,3,4	Apply a phase jump equivalent to the negative Phase Jump Angle Withstand at the GEP or USEP. Allow conditions to stabilise for at least 10 seconds.

6.2 RoCoF Event Tests

The tests covered in this section are to verify the Inertia performance of the plant against the tendered Inertia value and to assess the overall performance of the plant.

Table 11: RoCoF Event Tests

Step	Initial Conditions	Frequency Event
1	Setup	With the System Frequency set to 50Hz, the Plant must have both Limited Frequency Sensitive Mode and Frequency Sensitive Mode disabled. Pre-event voltage at the Grid Entry Point equal to 1p.u.
2	1,2,3,4,5,6	Inject a 1Hz frequency drop taking the frequency from 50Hz to 49Hz over a period of 1 second.
3	1,2,3,4,5,6	Inject a 1Hz frequency drop taking the frequency from 50Hz to 49Hz over a period of 1 second.
4	7	Inject a frequency **step** event from 50Hz to 49Hz lasting for 0.5s.

6.3 Combined Voltage and Frequency Event Tests

This test is to validate the Inertia Performance and overall performance of the plant when subjected to both a voltage and a frequency event simultaneously.

Table 12: Combined Voltage and Frequency Event Tests

Step	Initial Conditions	Frequency Event
	Setup	With the System Frequency set to 50Hz, the Plant must have Limited Frequency Sensitive Mode and Voltage Control Enabled. The test must be completed again with Constant MVAr mode enabled if applicable.
1	1,2,3,4,5,6	Apply a 3-Phase Fault lasting 140ms, upon fault clearance there should be a 5-degree angle drop in the voltage and the magnitude

		be 1.1 p.u. From the start of the fault event concurrent with the fault event a 1Hz RoCoF drop from 50Hz to 49Hz should be simulated.
2	1,2,3,4,5,6	Apply a 3-Phase Fault lasting 140ms, upon fault clearance there should be a 5-degree angle drop in the voltage and the magnitude be 0.9 p.u. From the start of the fault event concurrent with the fault event a 1Hz RoCoF drop from 50Hz to 49Hz should be simulated.
3	1,2,3,4,5,6	Apply a 3-Phase Fault lasting 140ms, upon fault clearance there should be a 5-degree angle rise in the voltage and the magnitude be 1.1 p.u. From the start of the fault event concurrent with the fault event a 1Hz RoCoF rise from 50Hz to 51Hz should be simulated.
4	1,2,3,4,5,6	Apply a 3-Phase Fault lasting 140ms, upon fault clearance there should be a 5-degree rise change in the voltage and the magnitude be 0.9 p.u. From the start of the fault event concurrent with the fault event a 1Hz RoCoF rise from 50Hz to 51Hz should be simulated.

6.4 Power Oscillation Damping Tests

This test is required to demonstrate that the GBGF-I plant can contribute to Active Damping Power.

The suitability of the tuning of any POD will be checked in both the time and frequency domains. In the time domain, testing is by small voltage step changes injected into the voltage control reference block. Comparisons are made between performance with and without the POD in service.

For analysis in the frequency domain, a bandwidth-limited (0.3Hz to 2Hz) random noise injection should be made to the voltage control reference. The generator should provide a suitable band limited (300mH-2Hz) noise source to facilitate noise injection testing. Any POD gain should be continuously controllable (i.e. not discrete components) during testing.

The stability of the POD gain setting will also be assessed by increasing the gain in stages to 3x the propose setting. This increase is carried out gradually while monitoring the unit for any signs of instability. The tests will be regarded as supporting compliance of the POD if:

- POD gives improved damping following a step change in the voltage.

- Any oscillations resulting from a 2% step to the voltage reference are damped out within 2 cycles of oscillation.

- The POD gives improved damping of frequencies in the band 300mHz – 2Hz.
- The gain margin test demonstrates no appreciable instability at 3x the proposed gain.
- The interaction of POD to any changes in Active Power shows less than 2% difference in the reactive power output.

The above guidance is based on PSS testing of synchronous generators provided in ECP.A.5.4.3 although NESO will be happy to consider an alternative test procedure suggested by the GBGF-I plant.