Technical Feasibility Study v1

NOA Pathfinder Stability Phase 3

September 2021

nationalgridESO

Contents

Deadline and how to provide consultation feedback

NGESO are requesting any feedback on this document to be provided by 22nd October 2021. The deadline for consultation feedback on all other Stability Phase 3 pre-tender documents remains 8th October 2021.

Please provide feedback through the Technical & Connections Consultation Form, or alternatively by emailing box.ESO.StabilityP3@nationalgrideso.com

Overview

1. Aim

The aim of this document is to provide an overview of the desktop-based simulation studies that are required as part of the NOA Pathfinder Stability Phase 3 tender. Through the technical feasibility study, NGESO will:

- determine key technical capabilities of all proposed solutions
- decide if the proposed solutions meet the key technical specification

The information provided must be based on factual statements relevant to the Stability Phase 3 technical specification with relevant references and desktop-based simulation including:

- description of the proposed solution and its key technical considerations relevant to the technical specification
- any specific data needs that would be critical to the proposed solution
- feasibility demonstration for each proposed option

2. Scope

Table 1 sets out the key performance criteria of the technical specification that will need to be demonstrated as part of this technical study. Simulation tests are set out in Appendix A to demonstrate key aspects of these clauses.

Please note that any simulation tests carried out and capabilities demonstrated during the Stability Phase 3 tender do not remove proving or compliance testing requirements before and after commissioning of the solutions.

Technical specification clause	Description	Feasibility Test (Appendix A references) and notes
2.1	Short circuit current value	Test 1 – value determined in the technical study will be used in the commercial assessment & contract
2.2	Inertia value and percentage availability	Test 2 – value determined in the technical study will be used in the commercial assessment & contract
1.5.3	Phase angle jump response	Test 3
1.9	Fast Fault current injection timing and magnitude	Test 1
Definitions section	Response within 5 ms	Tests 1, 2, 3

2.2	Inertia behaviour	Test 2
1.5.2	Voltage source behind a real reactance	Tests 1, 2, 3
2.5	Fault current nature (reactive current prioritisation)	Test 1

Table 1: List of tests with reference to technical performance specification clauses

3. Outputs

The required output of the technical feasibility study is a technical report for each solution submitted by a bidder during the tender. A report template will be provided at the time of tender launch, which bidders would be requested to complete.

- Each bidder must provide a complete technical study report. The technical study report (completed using the template provided) must include the simulation results of all the relevant tests in Appendix A for each solution that has been submitted.
    - If a solution has different inertia availabilities based on its participation in other services and/or active power status (e.g. during charging/discharging), the proposed inertia value must be demonstrated and its associated percentage availability for the tender submission must be explained.
- The report should demonstrate compliance with the technical specification as described in this document.
- The report must be in clear English. Where the report relies on data to demonstrate compliance, the data should be shown in the report in the form of a graph or figure that shall be clearly legible including any axes or legends.
- Where the report relies on equipment specification, copies of manufacturer documentation should be attached to the report as appendices.
- Where the demonstration of compliance is ambiguous in the report provided, the NGESO may seek additional clarification and request additional information including but not limited to raw data, models, and additional study results. For avoidance of doubt this will not be an opportunity for a different or new submission but will purely be a clarification request for additional information.

4. Assessment criteria

Solutions must pass the technical feasibility simulation study part of the tender assessment. The NGESO will consider a solution to pass the technical feasibility study if these key criteria are met:

- The bidder has completed all the relevant tests as described in Appendix A and followed the requirements set out in Section 3 of this report
- Test results are presented to the NGESO in a clear and concise report with clearly readable graphs and figures
- The report is submitted within the tender submission timescales
- The report is submitted using the template provided
- The report shows performance that meets the relevant clauses of the specification stated in Table 1

Further details of the Stability Phase 3 tender assessment process will be published with the Invitation to Tender.

5. Technical queries

Any technical queries should be directed to box.ESO.StabilityP3@nationalgrideso.com

6. Confidentiality

All details of the Stability Phase 3 tender and associated documents must be treated by bidders as private and confidential and shall not be disclosed to any other party, except where this is necessary for bidders to prepare and submit tenders. Bidders must ensure that they have an adequate confidentiality agreement in place with any subcontractors, consultants, or agents before issuing them with any information concerning the requirements of this tender. Bidders must release only that part of the information concerning the requirements as is essential to obtain quotations from potential subcontractors, consultants, or agents.

National Grid ESO reserves the right to audit bidders to confirm if such confidentiality agreements are in place. In the event that the bidder is not in compliance with these provisions, National Grid ESO reserves the right to disqualify the bidder from further participation in the event.

The information submitted as part of this technical study will also be treated as confidential. The NGESO will only share relevant information where required, for example with relevant TOs in relation to the Stability Phase 3 connections approach, or with all participants in an anonymised and generalised way.

7. Changes later in process

Information provided in the technical feasibility study that will be used in the tender assessment cannot be changed. This includes value of short circuit current contribution at the Grid Entry Point, inertia and availability values and reactive power range. Any changes post contract award will be subject to the contract terms.

Appendix A: List of desktop simulations

This appendix provides a list of desktop simulations that are required as part of the technical study. For each test category, the bidder must give an overview of the test method and provide output results, observations, limitations in clear English and in a legible format.

All tests are required for each solution submitted; for each technology type, rating and substation location within the solutions.

Grid Entry Point (GEP)

Unless otherwise stated in individual tests, all feasibility test results should be shown at the Grid Entry Point. The Grid Entry Point is defined as the point where the solution will directly or radially connect to the transmission system (this shall be at 275kV or 400kV in England & Wales network). Any equipment between the solution and the Grid Entry Point that impact the solution's performance (e.g. connection transformers/cables/circuits etc.) must be explicitly modelled.

The test simulation must be run for long enough to allow the system to settle to a steady state before any event is applied and long enough after the test to allow the system to return to steady state.

For every test, the following must be recorded:

- voltage magnitude and phase angle at the Grid Entry Point and solution terminal
- active power and reactive power at the Grid Entry Point and solution terminal
- active, reactive and total current at the Grid Entry Point and solution terminal. Both AC and DC components must be included
- frequency and RoCoF at the Grid Entry Point

Unless otherwise stated:

- all positive sequence RMS results should be recorded
- for EMT simulation, EMT and RMS quantities must be provided. The method adopted to compute RMS values must be clearly stated and explained
- all results must be recorded with step sizes not higher than 1ms

The test model must be set up as follows:

a. The solution must be modelled as in EMT for GBGF-I and Hybrid solutions. For GBGF-S solutions RMS models are required. The model in all cases must accurately reflect actual solution's performance and limitations

b. Any equipment that impacts the performance at the Grid Entry Point must be modelled

c. The transmission network should be modelled as an ideal voltage source behind an impedance, for which network short circuit level and X/R ratio values will be provided by NGESO

d. Nominal settings and ratings of assets should be used in the model and simulations

e. All simulation settings, model parameters, model settings and controllers' parameters must remain unchanged for all tests. Any change in these settings and parameters, other than those requested by NGESO (e.g. reactive power set point, frequency of the system, etc.) must be declared and justified

Test 1. Short-circuit events

The purpose of this test is to understand:

- fault current injection at the Grid Entry Point during a fault at the Grid Entry Point
- fault current injection at the Grid Entry Point in response to a retained voltage experienced at the Grid Entry Point as a result of a remote fault at a specified Reference point

For GBGF-S solutions (i.e. synchronous machines), please refer to Table 2 for a description of the tests required. For GBGF-I solutions (i.e. Grid Forming Inverters) or hybrid solutions (i.e. for solutions involving a combination of synchronous machines and Grid Forming inverters) please refer to Table 3 for a description of the tests required.

Steps S1-S3 and I1-I9 are required to establish the lowest fault current for a range of credible operating conditions and are required to be simulated only once, irrespective of the number of locations being targeted. Steps S4 and I10 are required to understand the fault current contribution of the solutions with respect to specific Reference point(s), which are equivalent to the points on the network where the stability services are required. As the fault current contribution to the Reference points will depend on the impedance between the Grid Entry Point and the Reference point, Steps S4 and I10 will need to be repeated for each location being targeted.

Throughout these steps, the short circuit current contribution from the solution should be recorded as the positive sequence RMS fault current at 100ms after the fault initiation, measured in kA at the Grid Entry Point, following a three phase to earth fault at the stated location. It is the lowest short circuit current value from Steps S1-S3 or I1-I9 which will be entered in the service contract against which contract payments will be considered. Effectiveness factors, which will be provided by the NGESO at the time of tender launch, will be considered to evaluate the fault current contribution from the Grid Entry Point (derived from Steps S4 and I10) to the relevant Reference points. The results from Steps S4 and I10 will be considered in the commercial assessment.

All solutions must demonstrate all short circuit values from Test 1 Steps S1-S4 and I1-I9 in the compliance and proving tests along with requested aspects of the technical specification. Service commencement will be dependent on this demonstration.

Table 2 and Table 3 below are for GBGF-S and GBGF-I or hybrid solutions respectively and present the different steps for the short circuit test along with the network configuration, initial conditions and fault event applicable for each step.

Step	Network Configuration	Initial Conditions	Simulated Event
S1	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at maximum reactive power **export** (i.e. lagging mode or reactive power injection).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
S2	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at maximum reactive power **import** (i.e. leading mode or reactive power absorption).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.

S3	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output and **zero** reactive power output.	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
S4	Figure 2	Pre-event voltage at the Grid Entry Point and Reference point equal to 1p.u. From Steps S1, S2 and S3, the reactive power output resulting in the **lowest** short circuit current injected at the GEP should be used as the reactive power setpoint for Step S4. Repeat Step S4 for all specified Reference point(s) for the targeted locations.	Simulate a 3 phase to earth fault at a Reference point on the network, where the fault impedance between the Reference point and the GEP is Z_f. The fault should be cleared after 140ms.

Table 2: Test 1: Simulations required for all GBGF-S solutions

Number of simulations for each solution: minimum of 4 per location targeted assuming that the Grid Entry Point is not the same as the Reference point(s). Please note that some locations may have to simulate faults with respect to multiple Reference points within a region.

Step	Network Configuration	Initial Conditions	Simulated Event
I1	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I2	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I3	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **zero** reactive power output	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I4	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. If applicable, solution operating at **maximum active power import** (demand).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.

		Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	
I5	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. If applicable, solution operating at **maximum active power import** (demand). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I6	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. If applicable, solution operating at **maximum active power import** (demand) Solution operating at **zero** reactive power output	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I7	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I8	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I9	Figure 1	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output Solution operating at **zero** reactive power output.	Simulate a 3 phase to earth fault at the Grid Entry Point that is cleared after 140ms.
I10	Figure 2	From step I1 to I9, the combined reactive power and active power outputs resulting in the **lowest** short circuit current injected at the GEP should be used as the active and reactive power setpoints for Step I10. Repeat Step I10 for all specified Reference point(s) for the targeted locations.	Simulate a 3 phase to earth fault at a Reference point on the network, where the fault impedance between the Reference point and the GEP is Z_f. The fault should be cleared after 140ms.

Table 3: Test 1: Simulations required for all GBGF-I and Hybrid solutions

<u>Number of simulations for each solution</u>: minimum of 10 per locations targeted, assuming that the Grid Entry Point is not the same as the Reference point(s). Please note that some locations may have to simulate faults with respect to multiple Reference points within a region.

Network Configurations for Short Circuit Test

Figure 1 illustrates the single-line diagram of the system to be simulated in Test 1, Steps S1-S3 and Steps I1-I9. The equivalent system impedance (Z_{sys}) for each location will be provided by the NGESO at the time of tender launch.

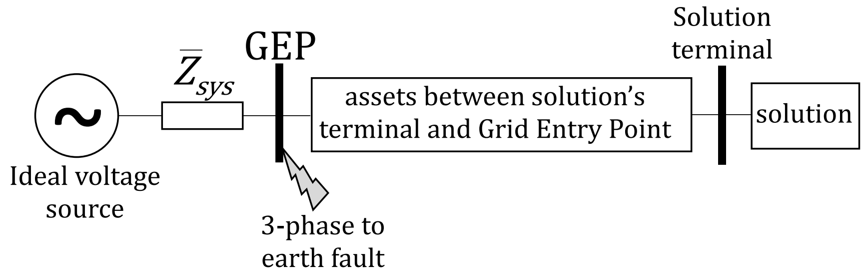

Figure 1. Network configuration for Test 1, Steps S1-S3 and Steps I1 -I9

Figure 2 illustrates the single-line diagram of the system to be simulated in Test 1, Steps S4 and I10. The equivalent system impedance (Z_{sys}) and the fault impedance (Z_f) for each location will be provided by the NGESO at the time of tender launch.

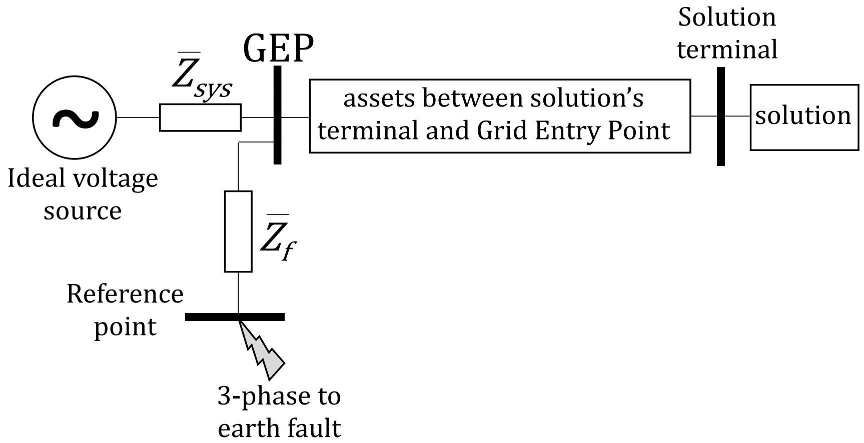

Figure 2. Network configuration for Test 1, Steps S4 and I10

Test 2. Frequency events

The purpose of this test is to understand inertial response of the solution.

The bidder must demonstrate that their solution can:

- respond to a change in frequency with a change in active power output within 5ms
- provide an inertial response equal to the amount to be declared in the tender and establish its associated percentage availability

The frequency events must be modelled as a change in the grid source frequency. Using other methods such as sudden decrease/increase of demand or generation will not be accepted.

2.1 Test conditions

In the following frequency events:

- provide further explanation on damping time constant of the inertial response
- calculation should show how the performance in the tests relates to the declared values for inertia (MW.s)

For each **GBGF-S solution**, the tests described in Table 4 are required:

Step	Network Configuration	Initial Conditions	Simulated Event
S1	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate frequency event to drop from 50Hz to 49Hz with RoCoF of 1Hz/s.
S2	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate frequency event to drop from 50Hz to 49Hz with RoCoF of 1Hz/s.
S3	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate frequency event to increase from 50Hz to 51Hz RoCoF of 1Hz/s.
S4	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at maximum reactive power **import** (i.e. leading mode or reactive power absorption).	Simulate frequency event to increase from 50Hz to 51Hz RoCoF of 1Hz/s.

S5	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **zero** reactive power output.	Simulate a frequency **step** event from 50Hz to 49Hz lasting for 0.5s.

Table 4: Test 2: Simulations required for each GBGF-S solution

Number of simulations for each GBGF-S solution: 5

For each **GBGF-I or Hybrid solution**, the tests described in Table 5 are required:

Step	Network Configuration	Initial Conditions	Simulated Event
I1	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate frequency event to drop from 50Hz to 49Hz with RoCoF of 1Hz/s.
I2	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate frequency event to drop from 50Hz to 49Hz with RoCoF of 1Hz/s.
I3	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. If applicable, solution operating at **maximum active power import** (demand). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate frequency event to increase from 50Hz to 51Hz with RoCoF of 1Hz/s.
I4	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. If applicable, solution operating at **maximum active power import** (demand). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate frequency event to increase from 50Hz to 51Hz with RoCoF of 1Hz/s.
I5	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output.	Simulate frequency event to drop from 50Hz to 49Hz with RoCoF of 1Hz/s.

		Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	
I6	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate frequency event to increase from 50Hz to 51Hz with RoCoF of 1Hz/s.
I7	Figure 3	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output Solution operating at **zero** reactive power output.	Simulate a frequency **step** event from 50Hz to 49Hz lasts for 0.5s.

Table 5: Test 2: Simulations required for each GBGF-I or Hybrid solution

Number of simulations for each GBGF-I and Hybrid solution: 7

Active Inertia Power must be provided without activating current limiting functions for a Rate of Change of System Frequency (RoCoF) whose magnitude is of less than or equal to 1Hz/s.

If a solution has different inertia availabilities based on its participation in other services and/or active power status (e.g. during charging/discharging), the proposed inertia value must be demonstrated and its associated percentage availability for the tender submission must be explained.

Network Configurations for Frequency and RoCoF tests

Figure 3 illustrates the single-line diagram of the system to be simulated in Test 2. The equivalent system impedance (Z_{sys}) for each location will be provided by the NGESO at the time of tender launch.

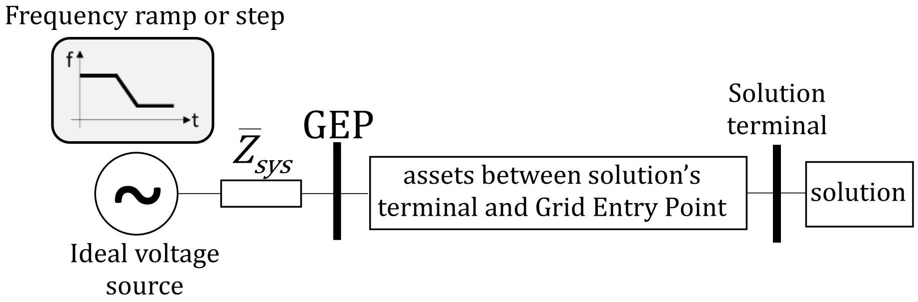

Figure 3. Network configuration for Test 2

For GBGF-S, the inertia value to be used in the tender assessment and contract should match the one provided in the manufacturer datasheet. The inertia values should also be demonstrated from simulations based on the Active Inertia Power computed for each frequency event.

For GBGF-I and hybrid solutions, the inertia value to be used in the tender assessment and contract should be either:

- the lowest value demonstrated from Steps I1 to I6 which is considered to have a 100% availability and is not affected by active power output; or
- the minimum value demonstrated from Step I5 and I6 (0 MW cases), which must be presented with a declared availability (<100%) that will be part of the commercial assessment and contract.

Only one inertia value and availability can be submitted in the tender for each solution and hence one of the two options above should be chosen.

For both GBGF-S, GBGF-I and hybrid solutions, the inertia values in MW.s should be computed through Equations (1) and (2). For each event, the Active Inertia Power in Equation (2) should be based on an average over the duration of the ramp event.

$$\mathbf{Inertia} = \boldsymbol{H} \times \boldsymbol{S_{rating}} \qquad \text{Equation 1}$$

$$\boldsymbol{H} = \frac{\Delta P\, f_0}{2\, S_{rating}\, RoCoF} \qquad \text{Equation 2}$$

Where:

H is the inertia constant

S_{rating} is the installed rating of the **Grid Forming Plant** (MVA)

ΔP is the **Active Inertia Power** of the **Grid Forming Plant** for a frequency event of 1Hz/s (MW)

RoCoF is the rate of change of **Frequency** in Hz/s

f_0 is the pre-fault **System Frequency** (Hz)

Test 3. Voltage angle change events

The purpose of this test is to understand how a solution will behave under extreme voltage angle changes at the Grid Entry Point.

The voltage phase jump event must be modelled as a step change in the grid source voltage phase angle. Using other methods such as fault impedance will not be accepted.

3.1 Test conditions

The bidder must note any limitations and observations related to the performance of their solutions.

For each **GBGF-S solution**, the tests described in Table 6 are required:

Step	Network Configuration	Initial Conditions	Simulated Event
S1	Figure 4	Pre-fault voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate 60 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
S2	Figure 4	Pre-fault voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate 60 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
S3	Figure 4	Pre-fault voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate 90 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
S4	Figure 4	Pre-fault voltage at the Grid Entry Point equal to 1p.u. Solution operating at **zero** active power output. Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate 90 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.

Table 6: Test 3: Simulations required for each GBGF-S solution

Number of simulations for each GBGF-S solution: 4

For each **GBGF-I or Hybrid solution**, the tests described in Table 7 are required:

Step	Network Configuration	Initial Conditions	Simulated Event
I1	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate 60 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
I2	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate 60 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
I3	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power import** (demand). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate 60 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
I4	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power import** (demand). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate 60 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
I5	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate 90 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
I6	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate 90 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.

I7	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power import** (demand). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate 90 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.
I8	Figure 4	Pre-event voltage at the Grid Entry Point equal to 1p.u. Solution operating at **maximum active power import** (demand). Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Simulate 90 degrees drop at the Grid Entry Point, sustained for 0.5s after the event.

Table 7: Test 3: Simulations required for each GBGF-I or Hybrid solution

Number of simulations for each GBGF-I or Hybrid solution: 8

The bidder must demonstrate the performance of their solution(s) under various voltage angle changes. Solutions that do not demonstrate the capability to withstand a voltage phase jump of 60 degrees will not pass the assessment. If a solution can withstand a voltage phase jump of 60 degrees but fails to withstand voltage angle change of 90 degrees, it will still pass the assessment; however, a detailed explanation on the solutions' limitations must be provided. Solutions must be modelled in detail to capture limitations such as inverter blocking and controller saturation.

Network configurations for voltage angle change tests

Figure 4 shows the single-line diagram of the system to be simulated in Test 3. The equivalent system impedance (Z_{sys}) for each location will be provided by the NGESO at the time of tender launch.

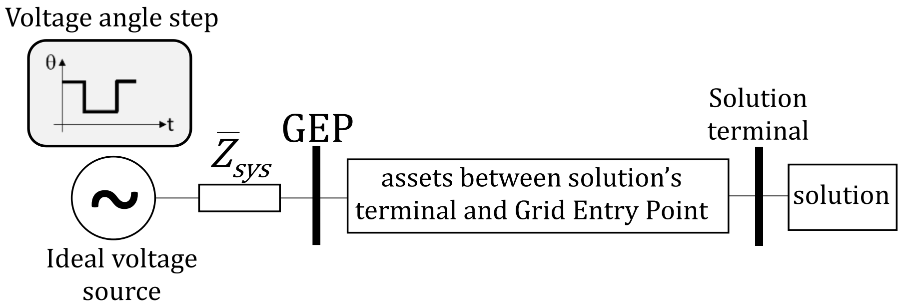

Figure 4. Network configuration for Test 3