Mid-Term (Y-1) Stability Market

Round 1(2025/2026)

Technical Feasibility Study

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Version Control

Date	Version number	Notes
20 December 2023	1.0	Initial version published at Invitation To Tender launch.

Contents

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 Mid Term (Y-1) Stability 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 specifications.

The information provided must be based on factual statements relevant to the Mid Term (Y-1) Stability Market 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 solution.

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 Mid-Term (Y-1) Stability tender do not remove proving or compliance testing requirements before and after commissioning of the solutions.

Table 1: List of tests with reference to ECC 6.3.19

Description	Feasibility Test (Appendix A references) and notes
Inertia value	Test 1 – value determined in the technical study will be used in the commercial assessment & contract
Response within 5 ms	Tests 1, 2
Inertia behaviour	Test 1
Voltage source behind a real physical reactance	Tests 1, 2
Phase angle jump response	Test 2

3. Outputs

The required output of the technical feasibility study is a technical report covering all solutions submitted by a Tenderer during the tender. A report template will be provided at the ITT stage of the tender, which Tenderers would be requested to complete in conjunction with Section B of the Technical Submission Document.

- Each Tenderer 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.
- The report should demonstrate compliance with the technical specification as described in this document.

- The report must be in Plain 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, 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 as part of the tender assessment. NGESO will consider a solution to pass the technical feasibility study if these key criteria are met:

- The Tenderer has completed all the relevant tests as described in Appendix A and followed the requirements set out in Section 3 of this report.

The Tenderer has completed Section B of the Technical Submission Document and meets all the pass/fail requirements in accordance with the Contract Award Criteria. Note:

- Test results should be presented to NGESO in a clear and concise report with clearly readable graphs and figures.
- The report must be submitted within the tender submission timescales.
- The report must be submitted using the template provided.
- The report must show the capability of the solution to respond to both frequency events (Up to 1 Hz/s RoCoF events only for this report) and voltage angle change events.

Technical queries

Any technical queries should be submitted to NGESO in accordance with the query process outlined in the Instructions to Tenderers document.

5. Confidentiality

All details of the ITT and associated documents must be treated as private and confidential and shall not be disclosed to any other party, except where this is necessary for Tenderers to prepare and return a Tender Submission. Tenderers must ensure that they have an adequate confidentiality agreement in place with any subcontractors, funders, consultants, or agents before issuing them with any information concerning the requirements of this ITT. Tenderers must release only that part of the information concerning the requirements as is essential to obtain quotations from potential subcontractors, consultants, or agents.

NGESO reserves the right to audit Tenderers to confirm if such confidentiality agreements are in place. If the Tenderer is not in compliance with these provisions, NGESO reserves the right to disqualify the Tenderer from further participation in the event.

By returning a Tender Submission, the Tenderer irrevocably consents to NGESO carrying out all necessary actions to verify the information that they have provided, including but not limited to third party verification.

The information submitted as part of this technical study will also be treated as confidential.

6. Changes later in process

Information provided in the technical feasibility study that will be used in the tender assessment cannot be changed.

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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 Tenderer must give an overview of the test method and provide output results, observations, limitations in clear English and in a legible format.

Tests 1 and 2 are required for each solution submitted, for each technology type, rating, and substation location within the solutions. Where relevant either Test 3 or Test 4 should be completed.

Grid Entry Point (GEP) and User System Entry Point (USEP)

Unless otherwise stated in individual tests, all feasibility test results should be shown at the Grid Entry Point or User System Entry Point whichever is relevant. The Grid Entry Point shall take the Grid Code definition, whereby the Grid Entry Point shall be defined as the point where the user's solution connects to the National Electricity Transmission System if directly connected. The User System Entry Point is defined as the point where the solution will connect to the relevant distribution system for Embedded users (for this tender only a User System Entry Point of 132kV is allowed).

Any equipment between the solution and the Grid Entry Point or User System 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 or User System Entry Point and solution terminal.
- active power and reactive power at the Grid Entry Point or User System Entry Point and solution terminal.
- active, reactive, and total current at the Grid Entry Point or User System Entry Point and solution terminal.
- frequency and RoCoF at the Grid Entry Point or User System Entry Point.
- Tap Changer Positions for any transformers for the duration of the test.

An Excel workbook or a csv file, containing the above recorded measurements, must be submitted as a supplementary dataset along the feasibility study report. For Hybrid solutions, datasets of measurements at the GBGF-I terminals must be provided in addition to the datasets of the measurements at the Grid Entry Point or User System Entry Point for the overall hybrid solution.

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.
- For all simulations a suitable timestep should be used, for GBGF-I solutions please refer to the GBGF best practise guide.
- The time constant for EMT to RMS conversion (for GBGF-I and Hybrid solutions), must be 20ms.
- all results must be recorded with step sizes not higher than 1ms.
- Both AC and DC components must be included for EMT measured current.

The test model must be set up as follows:

a. The solution must be modelled 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 or User System Entry Point must be modelled.

c. The total system equivalent should be modelled as an ideal voltage source behind an impedance.

d. Nominal settings and ratings of assets should be used in the model and simulations. When a range of parameters is indicated in the manufacturer datasheet, the simulations can be performed considering the nominal values.

e. All simulation settings, model parameters, transformer tap changer position, 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, justified and approved by NGESO.

Test 1. Frequency events

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

The Tenderer 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.

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.

1.1 Test conditions

In the following frequency events:

- calculation should show how the performance in the tests relates to the declared values for inertia (MW.s).[1]

For all solutions, please refer to Table 2 for a description of the tests required. For solutions which do not have the ability to import or export active power only steps 5-11 are required. However, for numbering consistency, please keep numbering the steps as Steps 5-11 even if other steps are not performed.

For each **solution**, the tests described in Table 2 are required:

Table 2: Test 1: Simulations required for each solution.

Step	Network Configuration	Initial Conditions	Simulated Event
1	Figure 3	Pre-event voltage at the Grid Entry Point or User System Entry Point equal to 1p.u. Pre-event voltage at the Grid Entry Point or User System Entry Point equal to 1p.u. If applicable, solution operating at **maximum active power export** (generation).	Simulate frequency event to drop from 50Hz to 49Hz with RoCoF of 1Hz/s.

[1] Note: We consider 1 GW.s = 1 GVA.s for the provision of inertia.

		Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	
2	Figure 3	Pre-event voltage at the Grid Entry Point or User System Entry Point equal to 1p.u. If applicable, 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.
3	Figure 3	Pre-event voltage at the Grid Entry Point or User System 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.
4	Figure 3	Pre-event voltage at the Grid Entry Point or User System 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.
5	Figure 3	Pre-event voltage at the Grid Entry Point or User System 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.
6	Figure 3	Pre-event voltage at the Grid Entry Point or User System 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.
7	Figure 3	Pre-event voltage at the Grid Entry Point or User System 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 with RoCoF of 1Hz/s.
8	Figure 3	Pre-event voltage at the Grid Entry Point or User System Entry Point equal to 1p.u.	Simulate frequency event to increase from 50Hz to 51Hz

		Solution operating at **zero** active power output. Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	with RoCoF of 1Hz/s.
9	Figure 3	Pre-event voltage at the Grid Entry Point or User System 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.
10	Figure 3	Pre-event voltage at the Grid Entry Point or User System Entry Point equal to 1p.u. If applicable, solution operating at **maximum active power export** (generation). Solution operating at **maximum reactive power export** (i.e. lagging mode or reactive power injection).	Simulate 5 successive Frequency drops from 50Hz to 49Hz with a RoCoF of 1Hz/s. At the end of the RoCoF event the frequency event should be removed as a step change, the time between the end of one event and the start of the next should be 5 seconds.(An example image of the first two frequency injections is shown in Figure 1)
11	Figure 3	Pre-event voltage at the Grid Entry Point or User System 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 5 successive Frequency rises from 50Hz to 51Hz with a RoCoF of 1Hz/s. At the end of the RoCoF event the frequency event should be removed as a step change, the time between the end of one event and the start of the next should be 5 seconds. (An example image of the first two frequency injections is shown in Figure 2)

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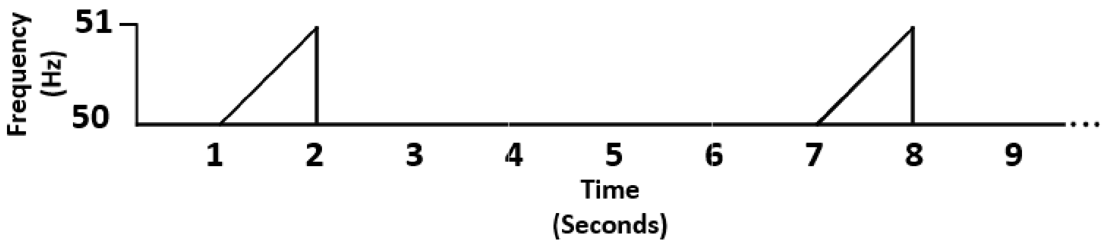

Figure 1: Representation of Step 10

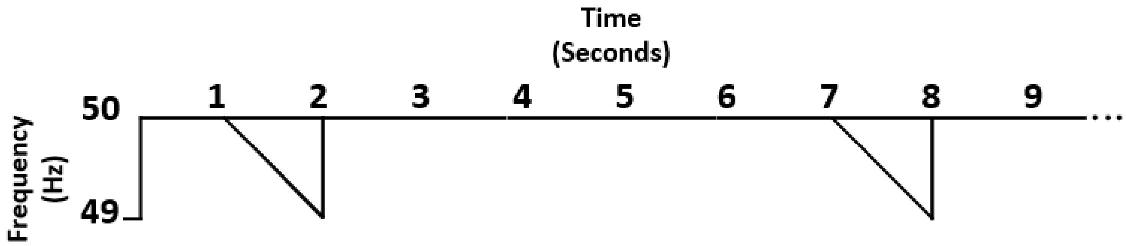

Figure 2: Representation of Step 11

<u>**Number of simulations for each solution:** 11 for solutions with non-zero MW capability and 5 (Steps 5-11) for zero MW solutions.</u>

During these simulations the provision of Active Inertia Power should not activate any current limiting functions.

Network Configurations for Frequency and RoCoF tests

Figure 1 11 illustrates the single-line diagram of the system to be simulated in Test 1. The equivalent system impedance (Z_{sys}) for the connection location parameters are to be obtained from NGESO (If Transmission Connected) or the relevant DNO (If Distribution Connected).

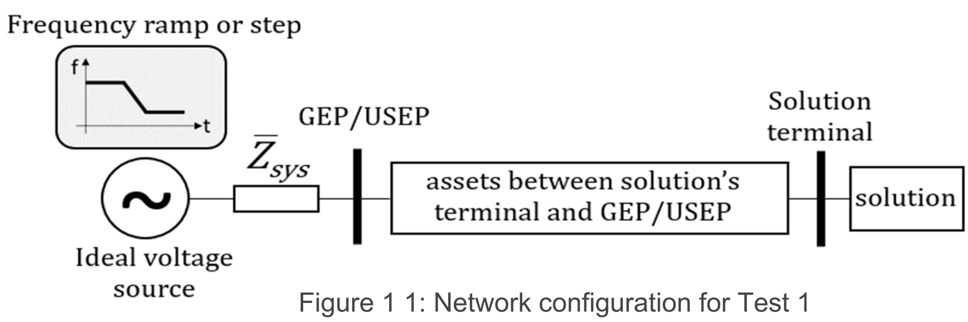

Figure 1 1: Network configuration for Test 1

The inertia values should also be demonstrated from simulations based on the Active Inertia Power computed for each frequency event.

For all solutions, the inertia value to be used in the tender assessment and contract should be the lowest value demonstrated from Steps 1 to 8.

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For all solutions, the inertia values in MW.s should be computed through Equation 1. For each event, the **Active Inertia Power** (ΔP in Equation 1) should be based on an average across all the recorded samples over the duration of the frequency ramp event.

$$\text{Inertia} = \frac{\Delta P\, f_0}{2 \times RoCoF} \qquad \text{Equation 1}$$

Where:

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)

For the avoidance of doubt ΔP should be calculated as follows:

ΔP = [Average MW provided by the solution at GEP across all recorded samples over the frequency ramp period (1 second)] – [Initial MW provided by the solution prior to the event].

Test 2. 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 or User System 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.

2.1 Test conditions

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

For all solutions, please refer to Table 3 for a description of the tests required. For solutions which do not have the ability to import or export active power only steps 5 and 6 are required. However, for numbering consistency, please keep numbering the steps as Steps 1-6 even if other steps are not performed.

For each **solution**, the tests described in Table 3 are required:

Table 3: Test 2: Simulations required for each solution.

Step	Network Configuration	Initial Conditions	Simulated Event
1	Figure 4	Pre-event voltage at the Grid Entry Point or User System 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 or User System Entry Point, sustained for 0.5s after the event.
2	Figure 4	Pre-event voltage at the Grid Entry Point or User System Entry Point equal to 1p.u. Solution operating at **maximum active power export** (generation).	Simulate 60 degrees drop at the Grid Entry Point or User System Entry

		Solution operating at **maximum reactive power import** (i.e. leading mode or reactive power absorption).	Point, sustained for 0.5s after the event.
3	Figure 4	Pre-event voltage at the Grid Entry Point or User System 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 or User System Entry Point, sustained for 0.5s after the event.
4	Figure 4	Pre-event voltage at the Grid Entry Point or User System 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 or User System Entry Point, sustained for 0.5s after the event.
5	Figure 4	Pre-event voltage at the Grid Entry Point or User System 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 or User System Entry Point, sustained for 0.5s after the event.
6	Figure 4	Pre-event voltage at the Grid Entry Point or User System 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 or User System Entry Point, sustained for 0.5s after the event.

Number of simulations for each solution: 6 for solutions with non-zero MW capability and 2 (Steps 5-6 with setting 0MW) for zero-MW solutions.

The Tenderer 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. Solutions must be modelled in detail to capture limitations such as inverter blocking and controller saturation.

Network configurations for voltage angle change tests

Figure 2 22 shows the single-line diagram of the system to be simulated in Test 2. The equivalent system impedance (Z_{sys}) for the connection location parameters are to be obtained from NGESO (If Transmission Connected) or the relevant DNO (If Distribution Connected).

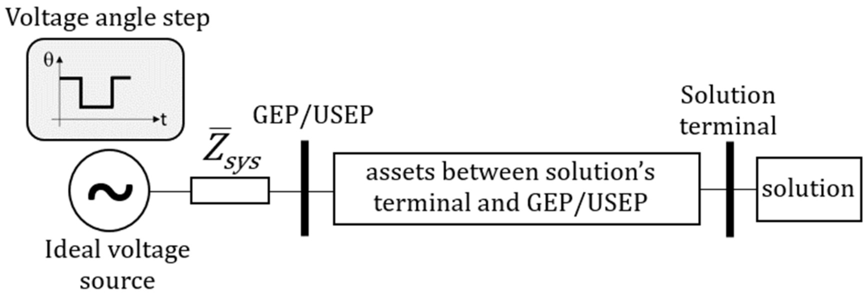

Figure 2 2: Network configuration for Test 2

Test 3. DNO Fault Ride Through Simulations

For solutions connecting at the DNO level additional simulations must be performed to demonstrate compliance against Technical Specification Clause 2.5.8. The tenderer must display that any solution connected in the distribution network is able to ride through faults the duration of the local fault clearance time at their point of connection. The fault clearance time and connection point information must be acquired by the provider from the relevant DNO with fault level at USEP (User System Entry Point) set to minimum.

3.1 Test conditions

A time series simulation of a series of balanced and unbalanced faults are needed to demonstrate this technical requirement. For these simulations GBGF-I solutions should be set to their maximum active power export and maximum leading reactive power. This test should then be repeated with the solution set to their maximum power import and maximum leading reactive power. For GBGF-S solutions they should be set to 0MW active power and maximum leading reactive power. A range of balanced and unbalanced faults should then be simulated, all lasting for the duration of the local fault clearance time. The fault should be applied to the User System Entry Point, with the fault level at the USEP set to the minimum. All tests should be simulated such that the retained voltage during the fault is 0 p.u. The faults to simulate are:

- 3-Phase Fault
- Phase-Phase Fault
- Two Phase - Earth Fault
- Single Phase - Earth – Fault

Test 4. Transmission Connected Fault Ride Through Simulations

For solutions connecting at the transmission level FRT simulations are required to show compliance with clause 2.5.8 In the Technical Specification and ECC.6.3.15 In the Grid Code. The tenderer must display that any solution connected to the transmission system Is able to ride through a fault with a retained voltage of 0 p.u. for 140ms.

4.1 Test conditions

A time series simulation of a series of balanced and unbalanced faults are needed to demonstrate this technical requirement. For these simulations GBGF-I solutions should be set to their maximum active power export and maximum leading reactive power. This test should then be repeated with the solution set to their maximum power import and maximum leading reactive power. For GBGF-S solutions they should be set to 0MW active power and maximum leading reactive power. A range of balanced and unbalanced faults should then be simulated, all lasting for 140ms. The fault should be applied to the Grid Entry Point, with the fault level at the GEP set to the minimum. All tests should be simulated such that the retained voltage during the fault is 0 p.u. The faults to simulate are:

- 3-Phase Fault
- Phase-Phase Fault
- Two Phase - Earth Fault
- Single Phase - Earth – Fault