# Stability Pathfinder RFI

# Technical Performance and Assessment Criteria (Attachment 1)

This document describes the stability support product, expected minimum technical performance and assessment criteria for tender evaluation. The document covers these sections:

## 1. Technical Performance

This section describes minimum technical performance specification for each stability support product. Each provider wishing to participate is expected to meet and demonstrate these.

## 2. Assessment Criteria

This section describes how we will assess solutions.

**Appendix A** of this document describes the expected modelling and compliance expectations.

**Appendix B** of this document states ranges of minimum short circuit levels expected across each area of the GB system.

# 1. Technical Performance

| Stability support product description |
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| Transient voltage dip, short circuit level and inertial support.<br><br>Immediate post fault response to limit voltage deviation, and contain voltage angle movement. |

Each solution must be able to meet the minimum technical performance specification at the point of delivery (i.e. connected transmission busbar) as described in Section 1.1. If the minimum capabilities are not met, then the proposed solution cannot be further assessed. These minimum capabilities will need to be demonstrated at the feasibility stage of tender evaluation.

## 1.1 Minimum technical criteria for stability support product

Duration of faults referred below are covered in ECC.6.3.15.

| | Technical criteria | Minimum expectation |
| --- | --- | --- |
| 1.1.1 | Short circuit level<br><br>(Reference Draft Grid Code VSM Expert Working Group specification) | Short circuit level contribution (MVA) ≥ 1.5 p.u. of MVA available in steady state operation<br><br>During the fault and first 0.5s after the fault clearance, the delivery of rated reactive current injection (see section 1.1.9 for further information on the characteristic of this injection) and any additional active power required to achieve the effect of this short circuit level must not degrade faster than the degradation corresponding to a 12s decay in capability. |
| 1.1.2 | Inertia<br><br>(Reference Draft Grid Code VSM Expert Working Group specification) | Solution is expected to respond inertially to the phase movement.<br><br>Inertia (MVA.s) ≥ 1.5 p.u. of MVA available in steady state operation<br><br>During the fault and first 0.5s after the fault clearance, the delivery of rated reactive current injection (see section 1.1.9 for further information on the characteristic of this injection) and any additional active power required to achieve the effect of this inertia constant must not degrade faster than the degradation corresponding to a 12s decay in capability. |
| 1.1.3 | Steady state voltage requirement<br><br>(Reference SQSS Chapter 6) | Solution is expected to withstand voltage changes following a network disturbance/fault<br><br>• +/- 10% within 15mins<br>• +5% / -10% continuous |
| 1.1.4 | Steady state frequency requirement<br><br>(Reference ECC.6.1.2) | Solution is expected to operate across the range 47Hz- 52Hz. |
| 1.1.5 | Fault ride-through requirement<br><br>(Reference Grid code ECC.6.3.15) | Solution is expected to ride-through voltage depressions<br><br>• 0-0.3p.u. within 140ms<br><br>across a family of voltage depression curves of longer duration as described in the Grid Code |

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| 1.1.6 | Transient voltage stabilisation and support capability | The solution is expected to continuously provide reactive current response with the connected voltage movement consistent with the performance of a voltage source behind an impedance.<br>After 100ms subject to further ESO connection point specification, the solution is expected to be capable of active and reactive power oscillation damping.<br>It is expected that analogous to a synchronous machine, the solution will provide continuous voltage support by reactive current injection within the voltage against time curve referred in 1.1.5. The effect of this response has the potential to either damp or add to inter-area oscillation occurring across recovery period. Dependent on the location, the device is expected to introduce a fast acting power oscillation damping control of nominated speed and frequencies of damping. The speed where required may be <500ms for appreciable damping to be achieved and its setting and tuning will be the product of detailed analysis.<br>Where the solution includes active power production prior to a voltage disturbance, the solution must ensure that the delivery of reactive current to stabilise the voltage disturbance is prioritised over active power recovery, to (at least an equivalent basis of response as would be delivered inherently by a voltage source behind a 10% or higher impedance to the point of common coupling- see section 1.1.9 below) , whilst ensuring that active power recovery by 500ms is in linear relationship with recovered voltage (as provided for by Grid Code ECC 6.3.15). The precise details of the power recovery shall be discussed and agreed with the ESO, such that the response does not unduly contribute to locally measured frequency and/or RoCoF across this period. |
| 1.1.7 | Fast fault current injection<br>(Grid Code ECC.6.3.15) | Solution is expected to<br>• provide reactive current injection into a retained voltage depression at point of connection, within 5ms of event |
| 1.1.8 | Transient angle change requirement<br>(Reference Grid Code Modification GC0079, Distribution Code GC0079) | During the fault and for the first 0.5s after fault clearance, the solution is expected to respond up to its rating with reactive current countering the initial voltage angle change.<br>Following a fault clearance, solution is expected to ride-through voltage angle deviations of<br>• at least 90 degrees as measured within 60ms<br>• up to 200 degrees as occurring within 5ms<br>• angle change up to 200 degrees across a period of up to 0.5s. Thereafter, ride-through any event greater than 90 degrees in scale<br>This voltage angle change may occur at the time of fault, the point of fault clearance or at any time up to 300ms following fault clearance. |
| 1.1.9 | Transient voltage angle movement<br>(Reference Draft Grid Code VSM Expert Working Group specification) | During any voltage or frequency disturbance, solution is expected to maintain its phase of reactive and, as relevant active power and current injection over a period of no shorter than 0.5s after fault/disturbance.<br>The phase injection of current must be delivered consistent with being modelled as the effect of a voltage source behind an impedance of no less than 10% on machine base impedance. This will ensure that in response to the voltage angle movement in a fault, as power supplied becomes more inductive (or in a frequency event where a deficit in power causes the voltage angle to move faster/ slower), the device is actively resisting that phase change across the event. This is expected |

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| | | to include supplying reactive and where applicable active current supporting both voltage and frequency recovery.<br><br>The solution is not required to provide support against voltage angle beyond 0.5s after fault clearance, but is expected to provide details of its performance beyond that point. |
| 1.1.10 | Rate of Change of Frequency (RoCoF) withstand requirement<br><br>(Reference Grid Code Modification GC0079, Distribution Code GC0079) | Solution is expected to be robust to any RoCoF<br>• occurring ≤ 1Hz/s on average or in absolute change across a sampled window of 500ms<br>• instantaneously measured exceeding this level within the sampled window period |
| 1.1.11 | Temporary Over Voltage (TOV) withstand requirement<br><br>(Reference TGN288[1] Figure 1) | Solution is expected to withstand an initial RMS overvoltage<br>• of up to 1.4p.u. (starting voltage dependent) for 100ms followed by a reduction in overvoltage towards no more than 1.05p.u. as per the requirements of TGN(E) 288 |
| 1.1.12 | Temporary Over Voltage absorption capability<br><br>(Reference Draft Grid Code VSM expert Working group specification) | During the overvoltage condition defined in 1.1.11, the solution is expected to respond near instantaneously such that within 5ms an appreciable level of reactive current absorption can be delivered (see section 1.1.9 for further information on the characteristic of this injection).<br><br>The precise level provided being determined in comparison with the performance of a voltage source behind an impedance of no less than 10% on rating between the transmission system connection point and the source, up to at least 1p.u. response against solution's steady state reactive current.<br><br>Where the solution provides active power prior to a voltage disturbance, the device is expected to ensure that the delivery of reactive current to stabilise the voltage disturbance is prioritised over its active power recovery (at least an equivalent basis of response as would be delivered inherently by a voltage source behind a 10% or higher impedance to the point of common coupling- see section 1.1.9), whilst ensuring that active power recovery is by 500ms is in linear relationship with recovered voltage (as provided for by Grid code ECC6.3.15). |
| 1.1.13 | Voltage recovery at or better than defined in codes<br><br>(Reference Grid code ECC6.3.15) | Solution, dependent on voltage level of connection and scale, is expected to remain connected across the appropriate voltage against time recovery after fault clearance. |
| 1.1.14 | Performance across range of minimum Short Circuit Levels<br><br>(Reference SOF PLL report 2017[2]) | Solution is expected to be robust to operate across a range of minimum short circuit levels expected to be within range of 3-13kA. Refer to Appendix B for GB area specific information. |
| 1.1.15 | Voltage dependent droop control/ auto switching | Solution is expected to deliver a droop response of 4% or better. |
| 1.1.16 | Flicker/ voltage distortion<br><br>(Reference GC6.1.7 and ER P28) | Solution, when switched, is expected to stay within established flicker limits, based on the minimum short circuit levels defined in 1.1.14. |
| 1.1.17 | Repeatability of performance | The provider is required to confirm their repeated ability to operate through voltage and frequency disturbances as described above. This |

[1] https://www.nationalgrideso.com/sites/eso/files/documents/TGN%28E%29_288_0.pdf

[2] https://www.nationalgrideso.com/document/102876/download

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| | | may, where appropriate, include the supplier providing details of the protection and/or control approach and further describing and agreeing where applicable an approach which avoids any limit in the repeated performance that could be achieved by the solution.<br><br>In order to maintain availability and operation across multiple disturbances, as required, provider may alternatively:<br>• limit subsequent performance in that subsequent disturbance and/or,<br>• the pre-fault operation of the solution as necessary<br><br>These aspects of control and performance would need to be detailed to the company and agreed between the company and supplier in the detailed design phase of the solution. |
| 1.1.18 | Provision of model | The model should describe the behaviour of solution. An appropriate RMS power system model will be required. Where non-synchronous in nature, further EMT model demonstration shall also be required. |
| 1.1.19 | Minimum relevant code and standards compliance as applicable across existing codes | Where otherwise not specified, the solution is expected to meet relevant Grid Code obligations of synchronous and/or non- synchronous providers |
| 1.1.20 | Availability | Solution is expected to remain available for 90% of a year. Planned closures and outages are expected to be agreed with the ESO. |

# 2. Assessment Criteria

We are proposing to assess the tender submissions in line with the assessment criteria outlined below.

The solution must be capable of meeting the minimum technical criteria as described in section 1 to qualify for a tender assessment. The tender assessment will be based on CBA method described in section 2.2.4. If two or more solutions are marginal in the CBA result, then additional technical scoring will be provided as per sections 2.1 – 2.3.

| | |
|---|---|
| **Pass/Fail** | Minimum technical criteria |
| **Commercial**<br>**100%** | Cost Benefit Analysis (CBA) |
| **Technical additional consideration between otherwise equivalent value commercial solutions** | Connection diversity |
| | Resilience of support |
| | Enhanced capability for stability support |

## 2.1 Connection diversity (20%)

Under the NETS SQSS, the ESO is required to ensure that system stability is maintained, amongst other considerations, across the loss of the largest source of reactive power support. Where the stability support provider has designed proposals which allow for partial availability such that no single failure would fully remove the capability of the solution offered, we will allocate value to the diversity afforded by that design. The table below reflects 6 levels of connection diverstity we would value.

| Criteria level | Capacity (C) available due to worse case single failure/loss | Criteria award (%) |
|---|---|---|
| 1 | After 5hrs and beyond: 0% C | 0 |
| 2 | After 5hrs and beyond: C ≥ 10% | +2 |
| 3 | After 5hrs and beyond: C ≥ 20% | +2 |
| 4 | After 5hrs and beyond: C ≥ 30% | +2 |
| 5 | After 15mins and beyond: C ≥ 60% | +6 |
| 6 | Immediately and beyond: C ≥ 90% | +8 |

Beginning at criteria level 1 and assessing each criteria in turn, we will evalute whether the provider meets that criteria. Scoring for each criteria met will be added. For example, if a provider is able to meet levels 1,2,3 but not 4 or above, score of 0+2+2 = 4% will be given.

## 2.2 Resilience of support (20%)

We will additionaly value resilience of support provided by solutions. By resilience, we mean the ability of the solution to operate across larger tolerances than the minimum requirements provided for.

| | Score (%) | Comments |
|---|---|---|
| Transient angle change requirement (Section 2.1.4) | 8 | In each case, solution providers are expected to identify and quantify this increased resilience at the feasibility stage. Based on this, we will allocate additional score to the solution.<br>Across the period of increased resilience, the score is dependent on both the device remaining connected but also either being neutral or |
| RoCoF withstand requirement (Section 2.1.5) | 6 | |
| Short circuit ratio of no higher than 0.96 p.u. (Section 2.1.8) | 6 | |

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| | | beneficial to the given condition, i.e. its presence does not exacerbate the scale of the requirement. |

## 2.3 Enhanced capability for stability support beyond minimum requirements (60%)

We will allocate additional value for inertia and short circuit level contribution beyond minimum criteria specification.

| | | Score (%) |
|---|---|---|
| Inertia H | 1.5p.u. < H ≤ 3p.u. | 10 |
| | 3p.u. < H ≤ 5p.u. | 20 |
| | H > 5p.u. | 30 |
| Short circuit level current I | 1.5p.u. < I ≤ 3p.u. | 10 |
| | 3p.u. < I ≤ 5p.u. | 20 |
| | I > 5p.u. | 30 |

For example, if a solution is able to provide inertia of 3p.u. and short circuit level of 4p.u, the total score allocated will be 10%+20% = 30% (out of 60%).

## 2.4 Commerical Assessment - Cost Benefit Analysis

Each solution will give

- the MVA it is likely to contribute
- the years in which it is available
- the cost to provide the service for each participating year

The benefits each solution provides will be discounted at the social time preference rate as laid out in the Treasury Green Book.

Example spend profile for proposed solution:

| Year | 2019/20 | 2020/21 | 2021/22 |
|---|---|---|---|
| **Cost** | 5 | 10 | 8 |

The commerical assessment of solutions will be carried out in these steps:

| | |
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| Step 1 | Each solution will be given an effective MVA that it is able to offer at the participating location to address stability needs. Solutions at specific substation locations identified for Scotland in the RFI slides will be considered 100% effective. Effectiveness of any other locations will be consiedred on case by case basis at the feasibility stage of the tender process. It is possible for a single solution to be effective at more than one location and for more than one product. Where a solution suppling the stability product is contingent on it also providing active power (MW), its effective MVA will be discounted to account for the solution displacing other generation in the market which could have been providing stability support. |
| Step 2 | The cost of providing effective MVA will be calculated for each solution. The method used for comercial solutions and Network Owner (NO) solutions are different but aim to provide a level playing field.<br><br><u>For commercial solutions:</u><br>The operational cost per effective MVA will be calculated as the operational cost per year divided by the quantity of effective MVA provided. It is expected that the capital cost for commercial solution will be included within their operational cost. |

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| | $$Cost\ per\ eff.MVA = \frac{Operational\ cost\ per\ year}{eff.MVA}$$ <br><br> For Network Owner solutions: <br><br> The capital cost will be calculated by multiplying the quantity of effective MVA by the number of years that the service will be available within the tender period. This value will then divide the present value (PV) capital cost. The sum of the operational and capital costs per effective MVA will be the cost per effective MVA for the solution. <br><br> $$Op.Cost\ per\ eff.MVA = \frac{Operational\ cost\ per\ year}{eff.MVA}$$ $$Capital\ Cost\ per\ eff.MVA = \frac{Amortised, PV\ Capital\ Cost}{eff.MVA \times Service\ Years}$$ $$Cost\ per\ eff.MVA = Op.Cost\ per\ eff.MVA + Capital\ Cost\ per\ eff.MVA$$ <br><br> NB at this stage the length of contracts has not been determined and we will be seeking feedback through the RFI. |
| Step 3 | With the cost per effective MVA calculated, the bids will be stacked, with the lowest cost per effective MVA at the top, and the highest at the bottom. Bids will be selected from the top first until the system requirement for effective MVA has been met. Where solutions are effective against more than one locational requirement, bid selection will be optimised to achieve the lowest overall cost for all requirements. <br><br> This process will be conducted for every year. A provider may submit an optimal bid in one year, but this does not guarantee the bid will be optimal in subsequent years if lower cost solutions are available. The lowest costs solution(s) over the entire tender period will be chosen. |
| Step 4 | Within each yearly stack, we will forecast the cost of procuring the system stability need through the balancing mechanism (BM). This will be done by modelling future GB electricity markets using the latest Future Energy scenarios and assessing within each settlement period which generators will be able to provide a solution to stability issues. The BM costs for procuring the need will be again converted into a cost per effective MVA which will be placed within each yearly stack to compete against the submitted solutions. |
| | An example of the stacks and the selection of winning bids is shown below. Please note that the costs shown are not reflective of any forecast, they have simply been chosen for demonstration purposes. |

**System need: 200 MVA**

| Provider Name | Provider Effective Capacity (MVA) | Cost per effective MVA (Cost/MVA) | Cost |
|---|---|---|---|
| **Provider 1** | 50 | 100 | 5000 |
| **Provider 2** | 100 | 140 | 14000 |
| **Provider 3** | 25 | 150 | 3750 |
| **Provider 4** | 50 | 160 | 8000 |
| **Provider 5** | 30 | 180 | |
| **BM** | 200 | 220 | |
| **Provider 6** | 100 | 300 | |

# Appendix A: Modelling and compliance

The solution provider must demonstrate compliance with the appropriate minimum technical requirements discussed in Section 1. Some of these will need to be demonstrated at the feasibility stage of tender.

Where possible, the process for stability support product compliance will follow our existing compliance processes and will be comparable against obligations as defined within ECP.A. section of the Grid code for synchronous and non-synchronous plant in these areas. Consistent with the process applied for new connection parties where Grid code provisions are given project specific clarity within the appendix of a connection agreement, we will seek where necessary to provide further clarity of requirements within agreements at that time. We will to consolidate this information where it is possible, into additional common guidance for future stability support tendering within the GB system.

Compliance will need to be demonstrated through:

- Statements of compliance- can existing type testing and GB relevant reference models be provided?
- Simulation evidence demonstrating performance- can the models supporting the simulation results be provided?
- Physical test evidence of performance- does the model provided align with the performance observed?

At each stage of delivery where compliance with the minimum performance is not met, we would reserve the right based upon the contract form selected to vary the terms accordingly, and penalty clauses may apply.

Additional to the minimum technical criteria, the compliance process will include the stability support provider demonstrating that their solution does not introduce additional forms of instability or third-party risk. Where appropriate, for example in meeting minimum power quality criteria, this demonstration will include both the ESO and the host network owner reviewing and specifying the requirements appropriate to the intended connection location.

Against the project delivery milestones template, there is a need for models to be exchanged across the development and compliance stages of the project. We will require the following models to be provided as a minimum.

1. A RMS reference model for the device proposed. This model shall be made available

    - at or before the point of contract, or,
    - no later than 3 months from the date of contract, or,
    - 2 years before service delivery,

    whichever of the above is the later date.

    The minimum requirements are outlined below. If these minimum requirements can also be complemented with additional models at this stage for example EMT models, this is welcome but not critical at this stage.

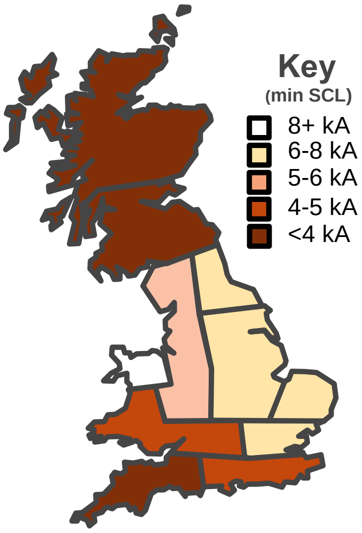
    a. This model must be submitted in a version of Digsilent PowerFactory. Where appropriate the model should be referenced to, or be consistent with recognized WEC and IEC synchronous and non-synchronous models.
    b. The model must be able to illustrate the performance capability of the solution/device. If this requires a deviation from the modelling approaches and reference model forms described above, this should be noted.
    c. If no reference model is available, further information should be provided by the solution provider on the principles against which this model has been constructed, and how they relate to the physical device/solution operation that is being modelled to evidence that the model provided is a reasonable expectation of the characteristics of the solution being proposed. As this will vary on a case by case basis, we will agree the approach on a contract specific basis.

d. The RMS model would be expected to provide an indicative performance of the device/solution. In these areas where the model is not indicative of the expected behaviour of the device, the stability support provided will be expected to note the nature and scale of the expected difference, where possible provide a short-term correction to the model which achieves such behaviour, or otherwise describe the steps that would be taken to address the discrepancy in subsequent generations of the models.

2. A project specific model
3. A final compliance validated model

To evidence any solution delivers in practice in real-time, it may be necessary to propose specific metering/ monitoring requirements to support its deployment. These will be considered at the time of tender assessment and estimates of the infrastructure associated with this identified and included within the CBA.

## Appendix B: Expected range of minimum short circuit level across GB areas




Minimum SCL range 3 -13.5 kA