System Stability Option

Medium Sized Investment Project (MSIP) Submission

31 January 2022

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Contents

1. Introduction

1.1 Executive Summary

In accordance with Part C of Special Condition 3.14 Medium Sized Investment Projects (MSIP) Re-opener, this application presents the case for addressing stability-related concerns emerging in the north of Scotland. As directed by Ofgem, we are using this MSIP submission window to demonstrate the need for this work with costs refined and submitted for consideration in advance of the MSIP window in January 2023.

Ofgem's letter of 9 December 2021[1] confirmed that an informal assessment would be undertaken of TO solutions to address sub-synchronous oscillations occurring on the system. We are therefore presenting our initial submission with a focus on the emerging and developing system need alongside our proposed option(s) designed to secure continued safe operation of our network. Within our January 2022 submission, we have included our assessment of the underlying problem and the effective technological solution needed to compensate for system oscillations, along with an early view of estimated cost and a delivery programme. Working alongside Ofgem and the ESO, we will seek to refine the submission throughout 2022 as more certainty around the increasing need for system support and the resulting technology and cost becomes available.

Since 2019, the Scottish transmission system has experienced a number of system disturbances that have caused concern for licensees and users alike. System monitoring has identified the emergence of sub-synchronous oscillations (SSO) of a frequency that hitherto has not been seen in GB. Although to date these SSO have not been unstable, they have been observable over a widespread area with evidence of some limited generation disconnection and queries from distribution licensees concerning the impact on consumer voltages. This system behaviour is considered to stem from the 'weakening' of the system arising from the retiral of synchronous machine-based generation and the greater deployment of power electronics.

Our understanding of the SSO is continuing to evolve (see Section 2 'Need' for further detail) through involvement in the Scottish System Performance Working Group (SSPWG). It is becoming clear through the work of this group that power electronic devices are suspectable to degradation in control performance under weak system conditions – a condition which is the direct result of the retiral of synchronous machine-based generation as described above. There is a consequential emergence of hitherto unseen SSO modes in the region of 5 – 10Hz which have been classified as being of the Sub-Synchronous Control Interaction (SSCI) type. [redacted]

As a Transmission Owner (TO) we are obligated under the Electricity Act 1989 and electricity transmission licence to develop, maintain, and operate the transmission system in a safe and secure manner and are required under the Security and Quality of Supply Standard (SQSS) that the network does not face any system instability or unacceptable sub-synchronous oscillations both for intact conditions and credible fault outages.

We are proposing investment in our transmission system in accordance with these obligations. Our proposal envisages the installation of three synchronous condensers at key locations in close proximity to HVDC links and substantial offshore wind farm developments to increase the electrical 'strength' of the transmission system. Our proposal is to develop projects at our existing Blackhillock, Spittal and

[redacted]

Loch Buidhe substations (with more information on the rationale for these sites provided in Section 2 and 3).

As recommended by Ofgem, we are using this MSIP submission window to demonstrate the need for this work with costs refined and submitted for consideration in advance of the MSIP window in January 2023 (as per the 'informal process' noted within Akshay Kaul's letter of 9 December 2021).

The combined cost of the proposed synchronous condensers, although at an early estimate stage, exceeds the MSIP Materiality Threshold for SSEN Transmission. These costs will be refined over the coming months and additional information will be submitted for consideration in Q3 2022. Assuming the costs continue to exceed the Materiality Threshold, we envisage submitting three separate MSIP re-opener applications (one per site) in January 2023. The cost estimates at this stage of the project have been informed by Requests For Information (RFI) from the supply chain. The next stages of refinement of the design, further system study as well as working with suppliers will refine these costs.

The costs associated with this network reinforcement is confined to costs incurred or expected to be incurred on or after 1 April 2021.

1.2 Structure and content of MSIP Submission

The MSIP submission is structured as follows (noting each section will evolve as our understanding is developed throughout 2021):

Section 2: Need

This section provides an explanation of the need for the project. It provides evidence of the drivers for undertaking the planned works and where appropriate it provides background information and/or process outputs that generate or support the "need".

Section 3: Optioneering and preferred option

This section presents all the options considered to address the "need" described in Section 2.

Section 4: Stakeholder engagement

This section includes identification of relevant stakeholders and information on how this has supported development of the project.

Section 5: Whole system

This section discusses our Whole System approach (if applicable).

Section 6: Cost information

Includes evidence of expenditure justification, cost drivers, forecasting and mitigation whilst identifying the costing approach and rationale for each element of the project. As noted above and throughout, this MSIP submission sets out only the needs case and preferred solution for assessment by Ofgem, with any costs included within this submission for information only.

Section 7: Conclusion

This section provides a summary of pertinent points from the preceding chapters, as well as providing indication of timeline and next steps.

1.3 Requirement Mapping

Table 1 details where the submission meets the minimum requirements set out in Special Condition 3.14 and associated Reopener Guidance.

In relation to

- 'Amendments requested to outputs, delivery dates or allowances' and
- 'Explanation of how expenditure which could be avoided as a result of the change has been accounted for'

We hope to work alongside Ofgem and the ESO as we seek to refine the submission throughout 2022 as more certainty around the increasing need for system support and the resulting technology and cost becomes available. This will influence the Price Control Deliverable(s), Consumer Outcome, and technical specification[2] associated with this investment.

[2]As per Ofgem's Price Control Deliverables framework for RIIO-2

Licence and Guidance Requirement	Submission Section
Statement setting out what MSIP the application relates to	Section 1
Amendments requested to outputs, delivery dates or allowances	TBC
Clear statement on needs case	Section 2
Justification of technical need and, where relevant, the consumer benefit that the MSIP is expected to deliver	Section 2
Explanation of options assessment	Section 3
Clear description of preferred option	Section 3
Explanation of how expenditure which could be avoided as a result of the change has been accounted for	TBC
Clear description of stakeholder engagement and whole system opportunities	Section 4
Statement that costs (incurred or expected) exceed the Materiality Threshold, but are less than £100m	Section 1
Statement that costs are confined to those incurred or expected on or after 1st April 2021	Section 1
Explanation of the basis of the calculation any amendments requested to allowances	Section 6

Table 1: Requirement mapping

2 Need

2.1 Context

The Future Energy Scenarios 2021 (FES)[3] recognises the rapid shift towards decarbonisation of the electricity sector being essential to meet net zero. Government support mechanisms such as the Contracts for Difference (CfD) scheme have enabled a seismic shift towards low-carbon electricity generation. This shift, and therefore the associated system impacts, will continue as we progress towards the UK's legally binding net zero targets[4].

The FES considers how much energy GB might need and where it could come from. To support us in planning our transmission network we developed a North of Scotland FES to account for additional regional energy trends in Scotland. The latest version was published in February 2021[5]. The North of Scotland FES demonstrates that the electricity system has continued to experience significant change as the energy mix becomes more renewable (consistent with the ESO's FES). In Scotland alone the shift will be more profound due to the natural resources, in particular the high average capacity factor associated with offshore wind. The annual installed generation capacity by scenario (as per our North of Scotland FES) illustrates the scale of change.

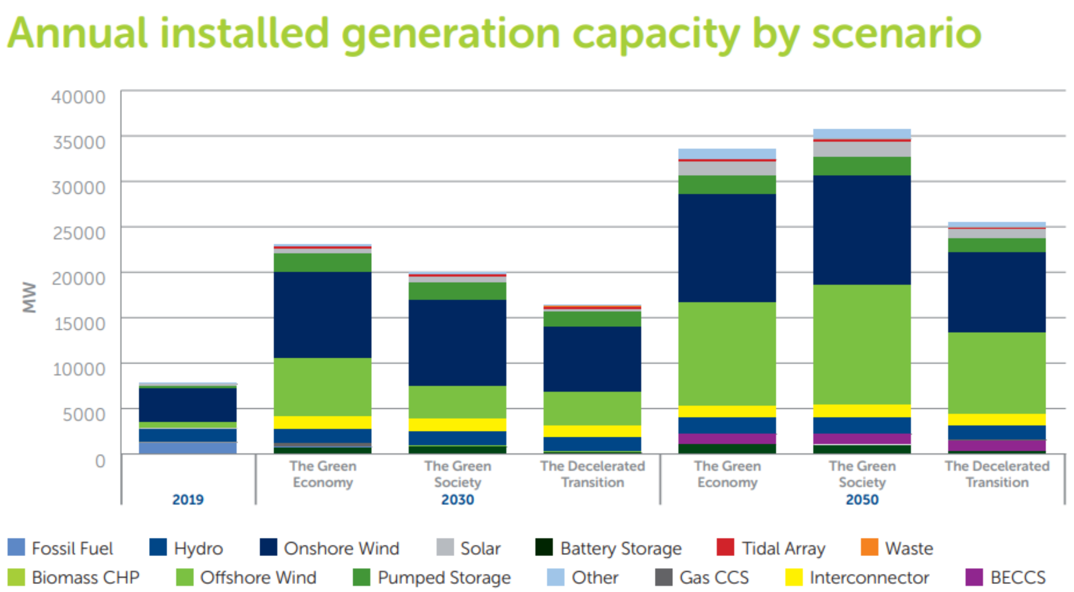

Figure 1: SSEN Transmission North of Scotland FES Scenarios 2021.

As the generation mix in Scotland changes, so too does the need to continually invest in the transmission network to maintain a safe, secure, and reliable system for all GB consumers. This shift in generation background is being supported by major network reinforcement projects and deploying new technology, coupled with further changes in consumer demand such as the emergence of electric

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[3] As produced by National Grid ESO and available here: https://www.nationalgrideso.com/document/202851/download

[4] https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

[5] https://www.ssen-transmission.co.uk/media/5280/north-of-scotland-future-energy-scenarios-summary-report-2021.pdf

vehicle charging. All of these developments are having a profound impact on the technical characteristics of the transmission system and whilst this is apparent across GB, the scale of the shift in the north of Scotland is particularly profound – with the practical impacts of this transition now being observed by system monitoring of disturbances.

2.2 System Stability

The stability of any large transmission system is complex and underpinned by a number of different classes of stability phenomena which are related to the characteristics of the system's generation, demand and geographical scale. Conventional synchronous machine-based generation has traditionally contributed to the overall stability of the system by inherently providing capabilities including inertia, substantial fault current and voltage support. A traditionally 'strong' system incorporates high levels of all three of these capabilities. Factors such as these combine to influence the stability of both individual generators and more wider phenomena such as voltage and frequency response.

The impact of increasing levels of generation sources which are not based on conventional large-scale synchronous machines fundamentally changes the nature of system behaviour. These technologies do not provide the same contribution to system stability and their bias towards being connected in the far north of GB introduces additional challenge to the stability of the system

In the north of Scotland, the system has, historically, been weakest due to lower levels of network interconnection and as a result of being remote from the bulk of the conventional large-scale generation stations. Although this region has seen the connection of significant levels of renewable projects supported by major investments in network infrastructure, these developments have not overcome effects of the more general decline in conventional synchronous machine-based generation. Moreover, it has become apparent that new forms of instability are emerging within the system which are being driven by the power electronics being used to connect renewable generation and other enabling technologies such as HVDC. The behaviour being observed in Scotland has also been observed in other comparable transmission systems – most notably within the South Australian system.

2.3 Sub-Synchronous Oscillations

Since 2019 the Scottish transmission system has experienced a number of system disturbances wherein sub-synchronous oscillations (SSO) have been observed across a widespread area. These are oscillations at frequencies lower than the fundamental frequency of 50Hz and result in equipment or areas of the system 'swinging' against each other. [redacted] The behaviour has coincided with a period in which major new equipment has been commissioned in the region by both the TO and System Users against the decline in overall synchronous machine capacity described above.

[redacted]

[redacted]

These oscillations have been the subject of much investigation between the ESO, both Scottish TOs and System Users – the culmination of this activity has been the establishment of the Scottish System Performance Working Group (SSPWG). This working group is pursuing several avenues of investigation as the root cause of the disturbances is analysed.

Although SSPWG investigations are ongoing, it is evident that the emergence of SSO is a consequence of the weakening of the GB transmission system caused by reductions in fault level contributions from traditional synchronous machines. The lost synchronous generation capacity is being more than offset by renewable connections (in terms of MWs) but these types of generation, along with other network equipment such as Flexible Alternating Current Transmission System (FACTS) and High-Voltage Direct Current (HVDC) devices, do not provide an identical level of contribution to traditional measures of system strength (see section 2.2). It is becoming clear that these devices are suspectable to degradation in control performance under weak system conditions. The result of which is the emergence of hitherto unseen SSO modes in the region of 5 – 10Hz which have been classified as being of the Sub-Synchronous Control Interaction (SSCI) type. [redacted]

As has been evidenced by system monitoring of recent disturbances, the north of Scotland is most exposed to problem and is one which will only become more acute as renewable penetration increases on our system.

As noted above, enough evidence currently exists to observe the effect of declining conventional generation such that we consider there to be a strong enough base upon which to take action to address declining system stability.

2.4 Mitigation Measures

The SSPWG is currently driving forward work to lay firm foundations for understanding the fundamental mechanisms behind the emerging behaviour. From the work completed to date there are strong signs that the root cause lies in the detail of how the control systems within power electronic based devices interact with what would be traditionally described as a weak system with low levels of conventional synchronous generation. These control systems are complex and contain highly sensitive intellectual property only available under strict confidentiality terms. It is clear even from initial work and the consensus emerging internationally[6], that further requirements may be required to be placed on power electronic based equipment to improve their performance under these system conditions. Indeed, recent work within the UK to extend the GB Grid Code to include the concept of so called "Grid Forming Converters" is an area which, in the longer term, will act to improve the operability of the transmission system (GC0137[7]). However, these types of initiatives, although vitally important, will not guarantee the security of the transmission system in the short to medium term (nor reverse the current stability problem). It will take time for requirements to be codified and then applied to projects connecting to the system.

It is apparent from system monitoring that the Scottish system is undergoing a shift in its behaviour which – in all likelihood – is a precursor to what will happen more widely across the GB system if action is not initiated. In the short-term there is a need to 'strengthen' the system now in the north of Scotland by means of applying well known solutions with high technology readiness levels. Any delay in progressing solutions will expose the system to risk which, based on consensus illustrated by the activities of the SSPWG, will only increase in the coming years. As the system continues to evolve, these solutions will play an enduring role in contributing to the base level of system stability which will be augmented by further measures driven by a continuous review of system operability needs.

System Users, TOs and the ESO all have a role to play in ensuring the stability and operability of the GB system. Within a system where equipment can connect intermittently there is a need to deliver contributions from a variety of sources and, given the context of delivering an enduring need to ensure system stability, there is a role for network-based devices to deliver such a contribution.

Options which incorporate generation or energy storage are not open to transmission licensees and other potential solutions incorporating power electronic interfaces are at significantly lower technology readiness levels. We therefore consider the delivery of system strength, in the short-term, is only achievable with the deployment of synchronous condensers, network solutions. The technology is mature and, as highlighted below, offers additional wider system benefits.

2.5 Synchronous Condensers

The strength of a system can be improved by the connection of synchronous machines acting as "synchronous condensers". In this mode these machines deliver no active power under normal conditions to the network as there is no prime mover and function like mechanically unloaded synchronous motors. However, these devices can provide reactive power to help regulate system voltages, deliver fault current and due to their inherently electro-mechanical nature contribute to system inertia. Synchronous condensers are a mature technology which have seen application around the world to support transmission systems of various scales.

There is a strong theoretical confirmation that this technology will support the system and help address the problem of power electronic devices participating in SSO modes. Moreover, practical experience has shown that the contracting on of synchronous generators that can act as condensers (e.g. pumped storage stations) has had a beneficial impact of reducing oscillatory behaviour. In the short-term, synchronous condensers represent a low risk, highly understood solution to meet the needs of the system which cannot be met other than by heavily constraining the outputs of renewable

[6] https://www.mdpi.com/1996-1073/13/13/3449

[7] GC0137: Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability (formerly Virtual Synchronous Machine/VSM Capability) | National Grid ESO

generation in the north of Scotland. It is on this basis that we intend to bring forward a proposal to develop synchronous condenser projects within the north of Scotland.

2.6 Location

The need to increase system strength in the north of Scotland can be focussed on a number of key locations where there are concentrations of power electronic devices either connected or in the development phase. These can be qualitatively assessed as being Caithness, Moray and Aberdeenshire and are all driven by the proximity of HVDC links and substantial offshore wind farm developments.

This MISP application focusses on the Caithness and Moray locations as these have been judged to be of the highest priority based on the analysis of system monitoring data and the studies within the SSPWG. There may be a need to progress further locations at a later date subject to confirmation of system development options. Further detail on the synchronous condenser option and the reasoning for specific locations is set out in Section 3.

2.7 An Integrated Solution

As a Transmission Owner (TO) we are obligated under the Electricity Act 1989 and electricity transmission licence to develop, maintain, and operate a coordinated transmission system in a safe and secure manner. Each of our proposed network investments is designed to achieve this goal with assets being specified to meet a variety of inter-related system needs.

With this in mind, the synchronous condenser projects proposed do not just address the problem of system strength. In addition to meeting this pressing system need, these projects will also deliver value added system benefits:

- Black Start: The projects will be fully designed to support the Local Joint Restoration Plan (LJRP) for the licence area by providing the ability to energise key MITS nodes. The AC network in the North of Scotland is moving towards the extensive use of 400kV circuits with high rating transformers to interconnect voltage levels and system users. The energisation of these assets under the LJPR will prove to be challenging as islands are developed during the restoration process. With this in mind, the synchronous condensers will have the capability to 'soft-start' sections of the network which will greatly open up the options available during the restoration of the system.
- System Inertia: All of the synchronous condensers will incorporate flywheels within their design such that they can provide a contribution to system inertia.

These benefits will be available for the lifetime of the assets making a long-term contribution to the needs of the system.

2.8 Alignment with Business Strategy

As noted throughout this section, the development of the transmission system in the north of Scotland is paramount to deliver net zero targets and fully dependent on the continued safe and stable operation of the GB system. It is widely recognised that connecting the forecasted levels of renewable generation will radically change the behaviour of the transmission system. The synchronous condenser projects proposed will play an important role in meeting the short-term stability needs of the system and will continue to play an enduring role in the longer term alongside enhanced requirements placed on System Users via network codes.

Linked to the above, the introduction of synchronous compensators on our network delivers the following outputs and benefits relating to the SSEN Transmission RIIO-T2 business strategy:

- increases the capability and stability in the north of Scotland network in line with our RIIO-T2 goal to transport the renewable electricity that, in total, powers 10 million homes;
- facilitates effective competition in the generation and supply of electricity in line with our licence obligations and our goal to provide network connections to meet our customer needs, on time and on budget; and
- aligns with our goal to aim for 100% transmission network reliability for homes and businesses.

3 Optioneering

3.1 High Level Optioneering

The system need for developing solutions to help increase system strength in the north of Scotland was outlined in Section 0 which identified a number of regions where support is required. As stated, this submission focusses on the Caithness and Moray regions which is driven by the presence of electrically close HVDC links and substantial offshore wind farms. Our existing major substations are ideally placed to host these solutions given their scale and network connectivity.

The optioneering for these solutions is driven by the requirement to provide regional system benefit. As the incumbent transmission owner, the availability of existing substation sites at the concentrations of power electronic device connection has minimised the need for a more traditional physical optioneering process. The early optioneering has therefore been confined to determining the civil and electrical works needed to connect this plant as well as determining the likely cost and programme of the work. The basis for the rating of the proposed devices is set out in Section 3.2 along.

The three locations forming this submission are as follows:

- Moray: The need in this region is proposed to be addressed by the development of a synchronous condenser at the Blackhillock substation. This is the location of the southern end of the Caithness – Moray HVDC link and the Beatrice offshore wind farm. The Moray East offshore wind farm is connected electrically close to this site at New Deer and in 2024 the Moray West offshore windfarm will connect directly into Blackhillock. Taken as a whole, this results in excess of 2000MVA of power electronic sources being closely coupled and in need of system strength support.
- Caithness: In this region the system strength requirement is centred around the northern end of the Caithness – Moray HVDC link with the converter at Spittal. Looking further ahead this area will see significant offshore connections as part of the ScotWind round of projects. To support this area it is proposed that synchronous condensers are developed at our Spittal and Loch Buidhe substations.
    - The rationale for the former site is straightforward as it is the location of the northern HVDC converter station and the participation of this device in SSO has been confirmed by the SSPWG study work.
    - The justification for developing a solution at Loch Buidhe is best understood by reference to the electrical single line diagram shown in
    - Figure 3. The network in this region essentially consists of 275kV high rating and 132kV low rating double circuits in parallel with connections between the two voltage levels at Beauly, Loch Buidhe and Spittal. A double circuit fault on the 275kV network will effectively split the system in the region with connection only remaining through the relatively high impedance 132kV circuits. This cuts the fault current contribution from either the rest of the system via Beauly or any sources connected at the remote end at Spittal. The synchronous condenser proposal at Loch Buidhe is intended to provide an additional contribution in the middle portion of the Caithness region to mitigate the loss of contribution resulting from 275kV double circuit outages.

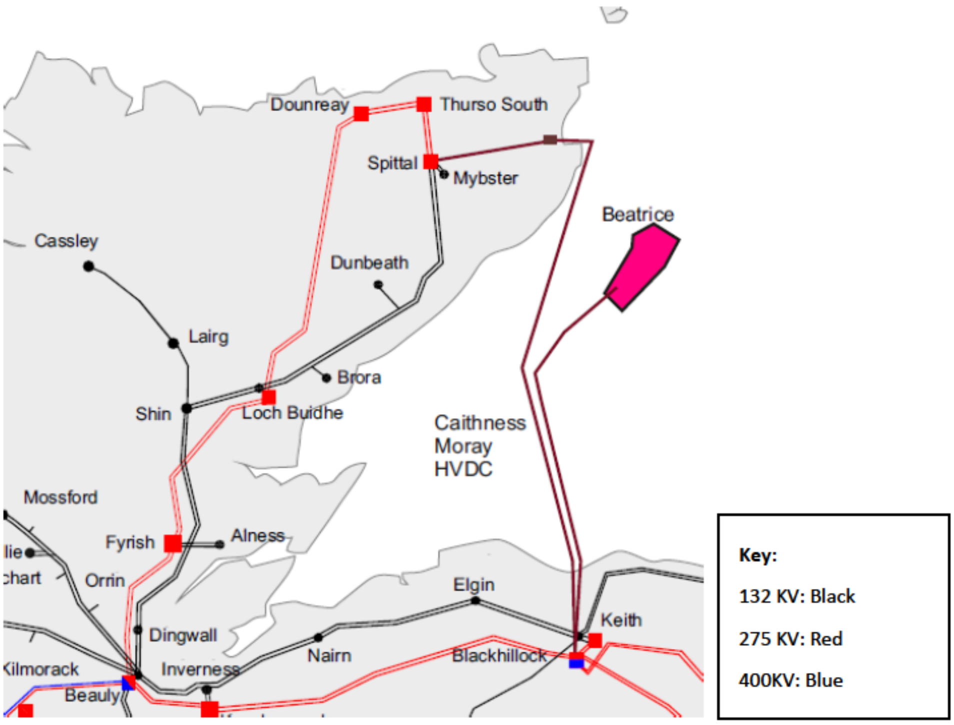

Figure 3: Caithness region electrical single line diagram.

Appendix D provides a map of Caithness and Moray regions showing the location of the three proposed synchronous condenser sites. A set of indicative site layouts are provided in Appendix E.

3.2 System Strength Requirement

As the SSO related behaviour of the system has evolved over the past few years, so too has the understanding of the level of support that will be required to mitigate the impact of this type of phenomena. At the time of this submission the exact system need is still subject to investigation by the SSPWG. However, to provide a working basis for progressing solutions the fault level requirements set out by the ESO in the 2019 Stability Pathfinder invitation to tender has been used to derive initial project cost and programmes.

- Blackhillock: 1300MVA
- Spittal: 600MVA
- Loch Buidhe: 600MVA

As the technical understanding has improved – backed up by practical experiences of actual disturbances – it is expected that the needs of the system will increase from these levels. Factors such as access to better equipment models for power electronic devices, a need to factor in reductions in contributions from sources caused by machine or network outages must all be a factor in confirming the support needs. After this submission we will continue to refine our solutions to reflect the SSPWG outputs and work collaboratively with the ESO to improve the operability of the system in the north of Scotland.

3.3 Blackhillock

[redacted]

[redacted]

3.4 Spittal

[redacted]

3.5 Loch Buidhe

[redacted]

3.6 Project Refinement

The next stage of refinement of the solutions at Spittal, Loch Buidhe and Blackhillock will involve the detailed engineering required to inform works information packages to engage our framework contactors as well as initiate the tender process for the synchronous condenser plant.

At the same time the necessary environmental works will be undertaken to support a planning application for Loch Buidhe as well as develop detailed programmes. These programmes will be used to inform the outage submissions and works coordination at Blackhillock as well as start the development of the commissioning programmes to support the connection of these three synchronous condenser solutions in 2025.

An indicative programme for the delivery of the synchronous condenser projects is provided in Appendix F.

4 Stakeholder Engagement

4.1 Engagement

We are a stakeholder-led business which delivers leading stakeholder engagement standards through our work with global consulting and standards firm, AccountAbility. AccountAbility works with organisations internationally to adopt responsible business practices and transform long-term performance and as committed to in our Stakeholder Engagement Strategy, we aim to achieve the externally accredited AA1000 Stakeholder Engagement Standard. This is considered the 'gold standard' in stakeholder engagement accreditation. As of December 2021, following its latest AA1000 Follow-up Consultation, we achieved a further uplift in stakeholder engagement performance, now operating at 76% within the 'Accomplished' level of AccountAbility's Stakeholder Engagement Maturity Ladder. We have increased our score overall by 14% since our initial 2019/20 review and we hope this strong performance provides stakeholders with confidence in the quality of our stakeholder engagement and our commitment to continuous improvement.

4.2 Our Stakeholder Engagement Activities

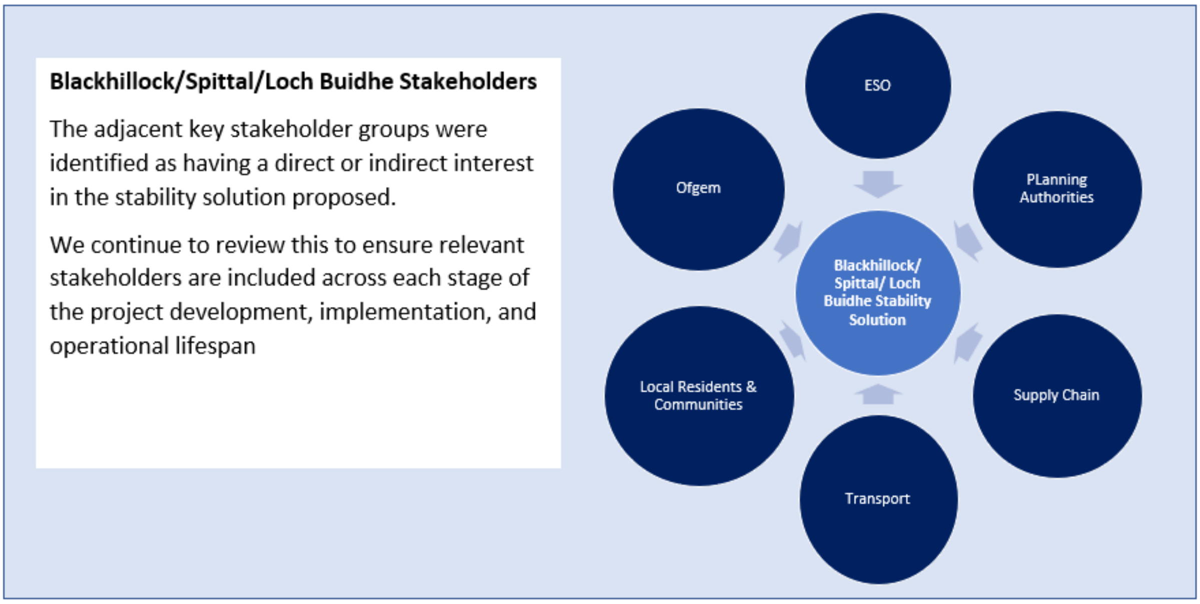

Figure 4: Stability solution stakeholders

The system stability infrastructure will sit within the footprint of the existing Spittal and Blackhillock substations, causing minimum, if any disruption in its installation and maintenance. The main theme of engagement with local residents and planning authorities will be around security of supply and reassurance on noise levels.

At Loch Buidhe, planning permission will be required. Early engagement with planning authorities and local communities to review any impacts will be included in our plans.

The key themes of stakeholder engagement relating to the stability solution are outlined below. Our RIIO-T2 Business Plan has Five Clear Goals, developed with and on behalf of our stakeholders. All our engagement activities link to these Clear Goals, ensuring we always act in the best interests of our stakeholders. We have highlighted the relevant goal within our engagement themes below:

1. **Theme – Security of Supply. Goal - Aim for 100% transmission network reliability for homes and businesses**

The major system disturbance, identified in August 2021, has been assessed. This system abnormality has been found to have the potential to filter from local to national level, risking causing major disruption of the electricity network and potentially causing a security of supply risk to our customers, including both end consumers and our generation customers who rely on connecting to our network.

This stability solution is proposed in order to mitigate this risk and contribute to our goal of 100% transmission network reliability for homes and businesses.

2. **Theme – Delivering the Pathway to Net Zero. Goal - Transport the renewable energy that powers 10 million homes**

With the development and construction timeline on network upgrade projects of the scale required to transport this capacity of renewable energy being up to ten years, we knew that action was needed now to identify requirements and propose an efficient approach to planning, development and delivery.

Identifying the challenges and subsequent solutions is key for us to ensure stable and reliable renewable energy connections and the supporting network infrastructure which will deliver increased renewable energy and contribute to our goal to transport the renewable electricity that powers 10 million homes by 2026.

4.3 Stakeholder Engagement Next Steps

Current planning consents allow for development within our Blackhillock and Spittal site perimeters. These consents are being assessed to ensure all conditions are adhered to.

At Loch Buidhe, as planning consent is required, we will ensure early engagement with statutory consultees to review any potential impacts of the solution.

We have committed to deliver biodiversity net gain on all future projects, leaving a positive lasting legacy for the communities and significant improvement in local biodiversity. We will engage with the local community regarding this commitment and our compensatory planting plans.

Next steps regarding stakeholder engagement on the stability solution are primarily around:

- Undertaking noise modelling and sharing the results with planning authorities and local communities, undertaking noise mitigation if necessary, to ensure minimal disruption to nearby residents.
- Working with the supply chain to mitigate any disruption around any potential abnormal transport load visits to site. Road improvements are already in place due to both sites hosting HVDC converter stations.
- Working in partnership with and sharing knowledge on the system outage with the ESO.
- Continuing to work on behalf of both local and national stakeholders to ensure stability of the transmission network, with minimal disruption to local residents and communities.

We will continue to evolve our engagement activities based on the feedback of our stakeholders.

5 Whole System

5.1 Whole System Considerations

Our MSIP application has been informed by learning derived from work carried out by the Scottish System Performance Working Group (SSPWG). This collaboration between the ESO and the two Scottish TOs is investigating the root cause the recent SSO disturbances. Due to the strategic nature of this activity, it is inherently broad in scope and covers both licensee and system user owned equipment. If the root cause of the SSO is not identified and remedial action taken then, as described in Section 0, it will have an ultimately detrimental impact on the quality and security of supply for consumers at the distribution level.

6 Cost Information

6.1 Costing Approach & Cost Breakdown

This section presents an overview of current position of the costing approach and cost breakdown being applied to our stability proposals. This chapter also identifies the key assumptions and exclusions which have been made to the Project costs.

The table below shows the initial estimates for each site. These estimated costs include all pre-construction and construction costs. The costs associated with this network reinforcement is confined to costs incurred or expected to be incurred on or after 1 April 2021.

6.2 Cost Summary (in 2018/19 prices)

[redacted]

Table 2: Initial cost estimates

- [redacted]
- Our procurement and contracting strategy is still being developed however it will consider all potential options to drive efficiency and will deliver the most competitive prices that the current international market has to offer.

6.3 Cost Drivers

6.3.1 Key Unit Cost Comparison/Benchmarking

We engaged with the market and obtained cost intelligence from three suppliers for design, supply, installation and commissioning of the equipment proposed. These cost submissions have been assessed and the most appropriate, comprehensive and compliant costs have been used in the development of this estimate.

6.3.2 Regional Variations and Site-Specific Factors Driving Costs

Brexit and Covid impacts have not been allowed for in the preparation of the estimates.

6.3.3 Risk Strategy

Our System Stability Project Team will manage risk in accordance with ISO31000, the International Standard on Risk Management, and the agreed SSE Large Capital Projects (LCP) Governance Manual.

The development of the project risk register follows the LCP Governance Gated Process, and the risk register is a live tool that evolves through continuous updates and contributions from the project team over the life of the project.

Within the Risk Management Plan are the key risks (threats and opportunities) the project faces, the risk process that the project will follow to manage risk, project team's roles and responsibilities in respect of managing risk, and that the Project is using KERIS, the SSE LCP Risk Management Information System (RMIS) for managing risk and focussing the risk needs going forward for the Project.

This project is in the early stages of development and as such an identified percentage allowance has been included to account for all risk. The percentage applied is in line with the approach used for the RIIO T2 Business Plan. As the project progresses through its development specific risks will be identified and addressed, in line with our risk management strategy.

6.4 Project Costing - Next Steps

Following the submission of the January 2022 MSIP application for these projects we will continue to develop and refine the costs for the projects in line with SSE's Large Capital Project governance framework (available upon request).

We expect to continue engaging with the supply chain throughout 2022 and to have market tested estimates during Q3 2022.

While further studies are carried out assessing system performance (and the impact of SSO) as collaborative approach via the SSPWG, development work will continue progress the Works Information Packages for issue to our framework contractor and potential suppliers. The procurement process will remain flexible to the possible changing needs as identified by the system studies up to the point of the work packages being issued in Q4 of 2022.

We will continue to engage with Ofgem, following the submission in January 2022, on project costs.

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7 Conclusion

The continued connection of renewable generation is having a profound impact on the technical characteristics of the transmission system and, whilst this is apparent across GB, the scale of the shift in the north of Scotland is particularly profound. It is therefore clear that a requirement to address the issue of system stability in the north of Scotland is needed, with a particular emphasis on the Caithness and Moray regions.

It is also clear that the collective drive to achieve net zero will result in an ever-increasing requirement to support safe and continued operation of the GB transmission network. Renewable technologies do not provide the same contribution to system stability as conventual generation and an inherent bias towards being connected in the far north of GB provides another challenge to the stability of the system.

[redacted]

As a Transmission Owner (TO) we are obligated under the Electricity Act 1989 and electricity transmission licence to develop, maintain, and operate the transmission system in a safe and secure manner and are required under the Security and Quality of Supply Standard (SQSS) that the network does not face any system instability or unacceptable sub-synchronous oscillations both for intact conditions and credible fault outages.

It is with the above in mind, that we must progress a viable and technically feasible option to protect the system now but also allow for flexibility within those solutions to further enable the connection of additional renewables to the system – without further compromising the overall safety and security of transmission system within the north of Scotland.

There is a strong theoretical confirmation that this technology will support the system and help address the problem of power electronic devices participating in SSO modes. Moreover, practical experience has shown that the contracting on of synchronous generators that can act as condensers (e.g. pumped storage stations) has had a beneficial impact of reducing oscillatory behaviour. In the short-term, synchronous condensers represent a low risk, highly understood solution to meet the needs of the system which cannot be met other than by heavily constraining the outputs of renewable generation in the north of Scotland. It is on this basis that we are bringing forward proposals to develop synchronous condenser projects within the north of Scotland.

As noted within Section 3, the optioneering for these solutions is driven by the requirement to provide regional system benefit. As the incumbent transmission owner, the availability of existing substation sites at the concentrations of power electronic device connection has minimised the need for a more traditional physical optioneering process.

In order to address the evident stability issues that are being experience on our network the proposed solution is the installation of synchronous compensation plant at the existing substation sites of Spittal, Loch Buidhe and Blackhillock:

The options presented in this document are for the addition of:

- 600MVA at Spittal [redacted]
- 600MVAR at Loch Buidhe [redacted]
- 1300MVA at Blackhillock [redacted]

We therefore submit to Ofgem in accordance with Part C of Special Condition 3.14 Medium Sized Investment Projects (MSIP) Re-opener, this application presents the case for addressing stability-related concerns emerging in the north of Scotland. The cost of the proposed synchronous condensers, although at an early estimate stage, exceeds the MSIP Materiality Threshold for SSEN Transmission. These costs will be refined over the coming months and additional information will be submitted for consideration in Q3 2022. Assuming the costs continue to exceed the Materiality Threshold, we envisage submitting three separate MSIP re-opener applications (one per site) in January 2023 (whilst engagement with Ofgem continues throughout 2022).

We note that our understanding of the phenomena described within this submission will continue to grow as the SSPWG investigates this issue further. Working alongside Ofgem and the ESO, we will seek to refine the submission throughout 2022 as more certainty around the increasing need for system support and the resulting technology and therefore cost becomes available. The inherent benefit of the regulatory framework, and our proposed procurement processes will allow for the flexibility to react to new information/system need over the course of 2022. We will of course keep Ofgem aware of any developments in this regard that could support the need (or otherwise) for investment in our transmission network.

7.1 Next Steps

Ofgem's letter of 9 December 2021 (as noted above) confirmed that it would proceed with an informal assessment of TO solutions to address sub-synchronous oscillations occurring on the system. On this basis we are submitting our proposed solutions which will continue to develop over the coming year. Within our January 2022 submission, we have included our assessment of the underlying problem and the effective technological solution needed to compensate for system oscillations, along with an early view of estimated cost and a delivery programme. Working alongside Ofgem and the ESO, we will seek to refine the submission throughout 2022 as more certainty around the increasing need for system support (via SSPWG and our own analysis) and the resulting technology and cost becomes available and more certain.

We are keen to maintain the positive and constructive dialogue with Ofgem with regard to our MSIP submissions throughout 2022.

Appendix A List of supplementary documents and evidence

[NO SUPPORTING DOCUMENTATION PROVIDED AT THIS STAGE]

Inveralmond House, 200 Dunkeld Road, Perth PH1 3AQ ssen.co.uk
Scottish and Southern Electricity Networks is a trading name of: Scottish and Southern Energy Power Distr bution Limited Registered in Scotland No. SC213459; Scottish Hydro Electric Transmission plc Registered in Scotland No. SC213461; Scottish Hydro Electric Power Distribution plc Registered in Scotland No. SC213460; (all having their Registered Offices at Inveralmond House 200 Dunkeld Road Perth PH1 3AQ); and Southern Electric Power Distribution plc Registered in England & Wales No. 04094290 having their Registered Office at No. 1 Forbury Place 43 Forbury Road Reading RG1 3JHwhich are members of the SSE Group www.ssen.co.uk

Appendix B Map of proposed site locations

Key:

132 KV: Black

275 KV: Red

400KV: Blue

Appendix C Indicative Site Layouts

[redacted]

[redacted]

7.2 [redacted]

Appendix D Indicative Programme of Synchronous Compensator Delivery

[redacted]