# Neilston Greener Grid Park- Statement of Need

## 1. *Proposed Greener Grid Park and services for System Operation*

The proposed Greener Grid Park at Neilston will include two technology types: 14 Synchronous Compensators (SC) and 49.9MW Battery Energy Storage Systems (BESS). These technologies are required to allow the Great Britain (GB) electricity system, generally termed "the national grid", to operate at zero carbon, i.e. without burning fossil fuels.

By building projects such as Neilston, Statkraft is enabling more or our electricity to be supplied by renewables, reducing fossil fuel use and carbon emissions and reducing the cost of electricity – hence the name Greener Grid Parks (hereinafter referred to as GGP).

The Synchronous Compensator and Battery Energy Storage System technologies, and the need for these technologies, is described below.

## 2. *Zero Carbon Energy, Grid and Grid System Operation.*

There are a number of key zero carbon targets and dates:

2050 - Net Zero UK[1]
means no net carbon emissions in the UK. Given there will be some emissions remaining (e.g. from agriculture) an equal amount of carbon removal will be required.

2045 - Net Zero in Scotland[2].
Scotland has already largely decarbonised electricity production, so the big challenge is to replace fossil fuels used in industry, heating of buildings and transport, which will mostly require substitution of fossil fuels with zero carbon electricity, meaning a big expansion of generation, transmission, distribution and supply of renewable energy.

2035 - Zero Carbon Electricity in UK[3]
The UK Government Target is for all electricity in 2035 to be generated zero carbon, i.e. with no unabated fossil generation. In 2020 fossil fuels generated 38% of UK electricity[4], hence a large increase in renewables is required for this target.

2030 - 50% renewable energy in Scotland
Scottish ministers want renewable energy generation to account for 50% of energy demand across electricity, heat and transport[5]. This will mean a

[1] https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law
[2] https://www.gov.scot/policies/climate-change/
[3] Plans unveiled to decarbonise UK power system by 2035 - GOV.UK (www.gov.uk)
[4] https://www.edie.net/news/10/UK-s-fossil-fuel-generation-reached-a-record-low-in-2020--as-renewable-generation-reached-new-heights/
[5] https://www.bbc.co.uk/news/uk-scotland-59837782

significant expansion of renewable energy sources and associated needs for energy storage, flexibility and stability services.

2025 - Zero Carbon Electricity System Operation in GB[6]
National Grid Electricity System Operator (NGESO) has set a target to be able to operate the GB system with no fossil generation for a period (e.g. 1 hour or more) in 2025. Once this has been achieved the number of hours and durations of such operations can be increased as we shall explain below.

2020 - 100% renewable electricity in Scotland
The Scottish Government narrowly missed its target for 100% of electricity used in 2020 to be generated from renewable sources[7]. It is arguable that the services provided by GGP, i.e. stability, flexibility and storage could have enabled more renewable electricity to have been generated in Scotland to meet the target.

Statkraft's Neilston GGP is focussed on delivering services to NGESO to enable them to reach their 2025 target and the facility will develop over time to meet the growing needs for services to achieve 2030, 2035, 2045 and 2050 targets.

## *3. Electricity System Operation & System Services*

There is a market for electricity in GB in which generators compete to supply power. In this market renewable power and other low carbon sources have the lowest marginal costs and therefore generate when available. Fossil generation, interconnectors (to other countries & markets) and storage (batteries or pumped hydro) supply additional energy to meet the required demand of electricity consumers. As renewable generation increases over time, GB will have more and more periods when low carbon sources meet and also exceed demand. This surplus renewable power can be used to charge storage and to export to other markets on interconnectors.

The electricity system needs to ensure that generation equals demand and if not the system is said to be "out of balance". The market balances supply and demand generally quite effectively, however there is also the balancing market which operates to correct the remaining imbalances. As renewables generation increases and variations due to wind and solar also increase, NGESO requires more flexible resources which it can turn on and off quickly, easily and cost-effectively to operate in this balancing market.

However, neither the electricity market nor the balancing market necessarily ensures a stable and secure supply of electricity. NGESO is responsible for operating the national grid to ensure that the grid system (transmission and distribution) is able to move power from where it is generated to consumers and ensure that the system is stable, especially in the case of unusual and unexpected events, such as faults. To ensure that the system is stably operable at all times and in all circumstances NGESO procures

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[6] What is net zero and zero carbon? | National Grid ESO

[7] https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2018/10/quarterly-energy-statistics-bulletins/documents/energy-statistics-summary---march-2021/energy-statistics-summary---march-2021/govscot:document/Scotland+Energy+Statistics+Q4+2020.pdf

"system services" (also called ancillary services) which ensure NGESO can fulfil its function. NGESO procure these services through various mechanisms with increasing focus on ensuring all are efficient and competitive markets[8].

### *4. System services for Stability and Flexibility*

The SCs and BESS planned for the Neilston GGP offer both stability and flexibility services.

Stability services include the provision of inertia, short-circuit current and reactive power.

- Inertia is provided by the rotating mass of electrical machines – historically fossil fuel generators and steam turbines and directly connected large motors and loads. A minimum level of inertia needs to be maintained otherwise a large loss of power infeed with result in a rapid drop in frequency and risk of blackout. Events such as the 9th August 2019 partial blackout[9] would be more frequent and severe without sufficient inertia.

- Short circuit current is required during faults, for example during a lightning strike on a 400kV tower line – the systems to detect and disconnect faults rely on abnormally high levels of current flowing during faults. High levels of fault current have been historically provided by large fossil fuel and nuclear power stations. A minimum level of short circuit current is required, otherwise a fault on the networks may not be cleared, propagating the fault through the networks and resulting in a blackout. Insufficient short circuit current can also result in some power stations or loads connected to the grid becoming unstable and tripping.

- Reactive power is historically provided by large fossil fuelled and nuclear power stations. It is required to control voltage which varies with power flows; the system needs to have different amounts of reactive power at different times, for example with high wind generation and Scotland exporting power south, versus low demand and low wind with low power flows. Without sufficient reactive power, flows must be restricted, renewable energy must be curtailed, and carbon emission and costs to the consumer rise.

BESS and SCs provide these stability services both technologies are open to participate in the current live contract tender by NGESO (Stability Pathfinder Phase 2).

Flexibility is provided by the BESS as it can rapidly and easily change state to import power (acting to increase demand) or to export power (acting to increase generation). Unlike fossil power stations which have to be given hours of notice and need to operate for minimum run time of a few hours, a BESS can act and respond in one second to such changing demands on the system and has no such minimum run time. Therefore the BESS reduces the cost of operating the system and reduces carbon emissions.

[8] https://www.nationalgrideso.com/news/increasing-competition-markets-we-operate
[9] https://www.ofgem.gov.uk/sites/default/files/docs/2020/01/9_august_2019_power_outage_report.pdf

## 5. *GB need for System Services*

Renewable generation from wind and solar is connected to the grid via power electronic converters. Traditional power stations, e.g. coal, gas and nuclear connected to the grid with rotating machines known as synchronous generators. The synchronous generators provided stability services as a by-product of their power generation. As the need for these traditional generators reduces, there are increasing periods where there is an insufficient level of these stability services to operate the GB national grid.

As an example, on 20th April 2020[10], low carbon generation (primarily wind and solar renewable technologies) was sufficient to supply 100% of the demand on the GB national grid. However, due to the need for stability, NGESO had to turn on 17 gas powered plants. In order to deliver their stability, these power stations also had to produce power. And so to balance the grid, NGESO had to curtail renewable generation to "make space" on the system for these 17 stations. As a result of these actions, carbon emissions were increased and additional costs were incurred in operating the system[11].

NGESO has recognised the need for zero carbon stability services and has launched a series of tenders call Stability Pathfinders[12] to secure additional stability services for low carbon system operation. Statkraft were one of two bidders in Scotland to secure contracts in Stability Pathfinder Phase 1[13] with a GGP at Keith, Moray, which commenced operation in December 2021[14] and a GGP at Lister Drive Liverpool which will commission in 2022.

Following Phase 1 Stability Pathfinder NGESO are in process with Phase 2[15] and Phase 3[16]. NGESO are also developing a market for stability services to satisfy increasing future needs[17].

Statkraft's GGP at Neilston will also provide these stability services without generating power when it is not needed. As a result there will be reduced need for fossil generation to provide stability, increasing the use of renewable generation, lowering carbon emissions and lowering costs for consumers.

## 6. *Scotland & need for services for System Operation*

Whilst the need for grid system services is growing in GB as a whole, the need is even more acute in Scotland. Following the closure of Longannet, Cockenzie and recently Hunterston, Scotland has only two large power stations with synchronous generation at Peterhead and Torness. These stations also require outages for repairs and maintenance.

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[10] https://data.nationalgrideso.com/plans-reports-analysis/covid-19-preparedness-materials/r/ngeso_covid-19_preparedness_webinar_22-04-20_-_slides Slide 8 of 15

[11] Reference to find [GN in ENCC].

[12] https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability

[13] Ref for SPP1 results

[14] First reference to Keith GGP – e.g. guardian…

[15] https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-2

[16] https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-3

[17] https://www.nationalgrideso.com/future-energy/projects/stability-market-design

The Scottish Government has a target to phase out nuclear generation[18], so unlike England and Wales, in future there will be no stability services provided by nuclear power stations in Scotland.

There are also a number of hydro plant with synchronous machines, however many of these hydro plants are optimised for the energy market to maximise the value of stored water. If these have to be run for stability instead, there is an opportunity cost and again a sub-optimal outcome for carbon and cost of electricity.

In addition, the growth of onshore and offshore wind generation in Scotland is particularly strong, for example the recently announced 25GW of Crown Estate Scotland offshore leases[19].

These developments will help Scotland and the UK meet its targets but will also require additional stability, storage and flexibility services to successfully integrate this generation to the grid.

Scotland currently has only one interconnector, the Moyle interconnector from Dumfries and Galloway to Northern Ireland. There is only one other interconnector currently planned[20] which is NorthLink. Therefore surplus renewable energy generation in Scotland has limited routes to market, as transmission to England is limited and there is limited route to export that power. This will drive the need for additional energy storage which the Neilston GGP provides.

In the early hours of 24 August 2021, two unprecedented grid voltage oscillation events occurred on the Scottish transmission grid. At the same time, it was reported that traffic lights in Glasgow went out of service. NGESO are still investigating and modelling the grid, generators and other equipment with the aim to understand exactly what happened. In the meantime NGESO have scheduled a number of synchronous hydro generators to run 24/7 to manage the risk of this voltage oscillation repeating.

NGESO have recognised the growing need for stability services in Scotland by focussing the current Phase 2 Stability Pathfinder totally in Scotland[21]. Statkraft have submitted a number of bids for SCs and BESS at Neilston into this tender[22].

## *7. Neilston as a location for services for System Operation*

Statkraft selected the Neilston site as a strategic site for delivering system services to NGESO because it is very strongly interconnected in the Scottish transmission grid, because there are strategic plans by ScottishPower Transmission to increase transmission connections at Neilston, and because it has a range of transmission connection voltages options at 132kV, 275kV and 400kV.

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[18] https://www.gov.scot/policies/nuclear-energy/

[19] https://www.crownestatescotland.com/news/scotwind-offshore-wind-leasing-delivers-major-boost-to-scotlands-net-zero-aspirations

[20] https://data.nationalgrideso.com/connection-registers/interconnector-register/r/interconnector_register

[21] https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-2

[22] The details of these bids are subject to confidentiality requirements in the NGESO tender.

The Neilston substation is undergoing reinforcement to increase the strength of its interconnections. These plans include the "HNNO" scheme to turn in two additional 400kV circuits to the substation and add a new 400/275kV supergrid transformer[23]. This project by Scottish Power Transmission has been assessed by NGESO in its NOA (Network Options Assessment) and recommended to "proceed".[24] The project has been approved by the regulator Ofgem following consultation[25] and ScottishPower Transmission has applied to the Scottish Government for Section 37 consent[26].

The connections at Neilston following these reinforcements which are due to complete in 2024 are shown in Figure 3 and comprise 3x400kV, 3x275kV and 2x132kV interconnecting circuits and 4x132kV radial circuits. In addition there are 2x400kV circuits routed adjacent to the substation that can be turned in for additional reinforcement.

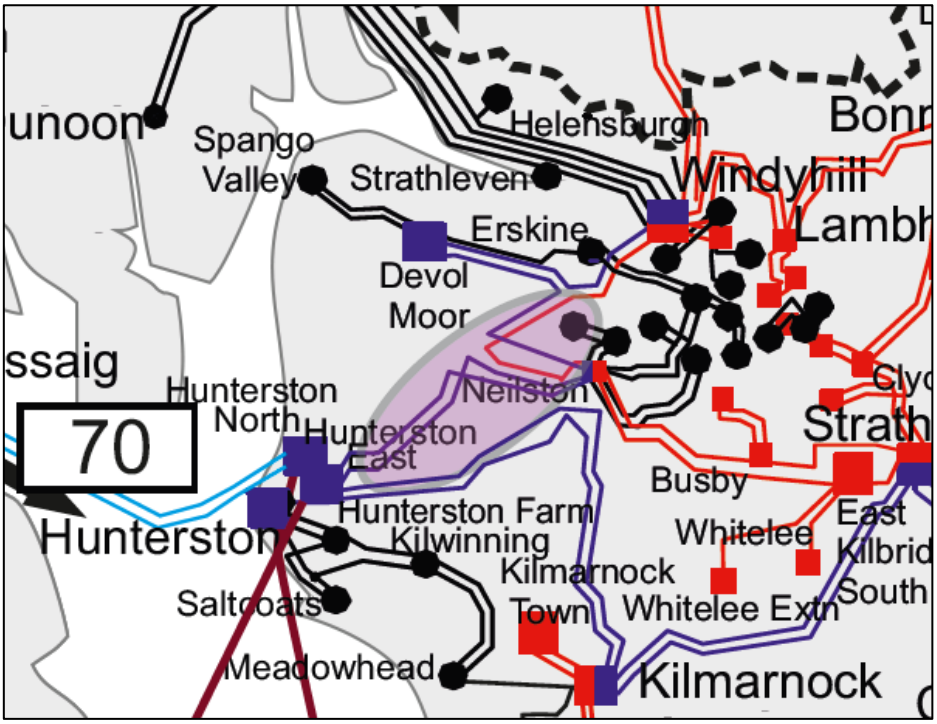


*Figure 3. Extract from NGESO ETYS2021 Appendix C Page 6 showing HNNO network reinforcements at Neilston (with purple overlay)[27]*

As part of its stability Pathfinder Phase 2 tender NGESO published effectiveness factors ranging for 0-100% for all Scottish transmission substations. The Neilston substation was rated at 93% effective in delivering stability.

[23] https://www.spenergynetworks.co.uk/userfiles/file/RIIO-T2_EJP_SPT_SPT200112_FINAL_PUB.pdf
[24] https://www.nationalgrideso.com/document/185881/download
[25] https://www.ofgem.gov.uk/sites/default/files/docs/2020/07/draft_determinations_-_spt_annex_0.pdf
[26] https://www.spenergynetworks.co.uk/pages/hunterston_east_1_2.aspx
[27] https://www.nationalgrideso.com/document/181726/download

Neilston has also been selected by ScottishPower Transmission for its Phoenix project to demonstrate an innovative stability project also utilising a synchronous compensator[28]. This choice of site further indicates Neilston's key location in the electricity grid for locating these services.

Neilston substation is close to a critical transmission zone boundary (B5) (see Figure 2). Transmission boundaries represent common bottlenecks in the transmission networks which restrict flows and result in curtailment of renewables. These bottlenecks can be alleviated by the additional stability provided at adjacent substations and therefore are another indicator of value of stability services in this location. The Phoenix study of hybrid synchronous compensators (very similar to a SC and a BESS) shows the technology roll out would facilitate an additional 662MW of renewable generation through reducing these boundary constraints[29].

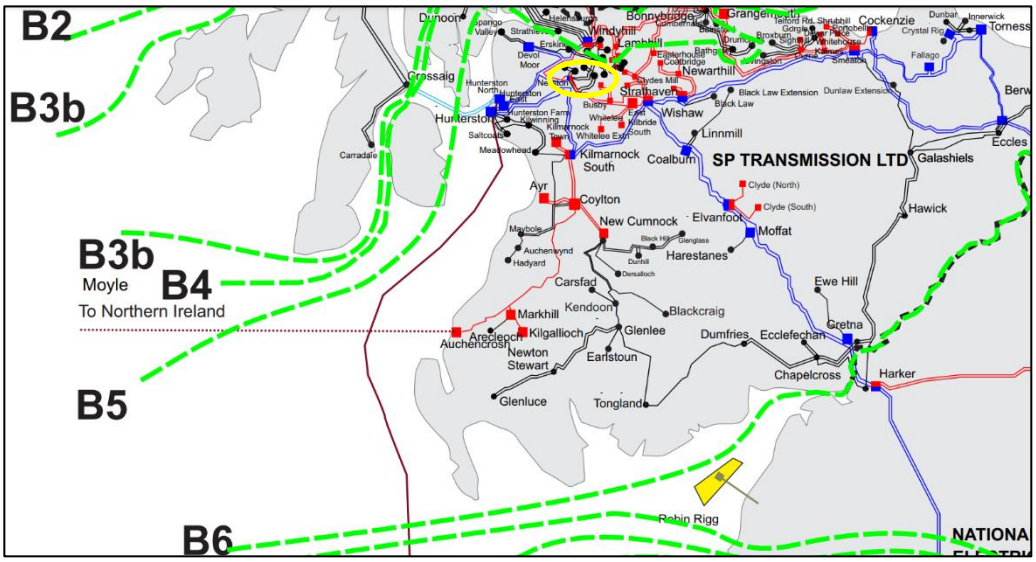


*Figure 2. Transmission System Boundaries around Neilston substation[30]*

These characteristics of Neilston substation mean that it is a prime location in Scotland for stability services, both in Stability Pathfinder Phase 2, in future stability tenders and in the planned stability market.

## *8. Synchronous Compensators*

Synchronous machines are used as synchronous generators on traditional power stations such as hydro, coal, gas and nuclear. The electricity grid system was developed using these synchronous machines which have inherent stability features,

[28] https://www.spenergynetworks.co.uk/pages/phoenix.aspx

[29] https://www.ofgem.gov.uk/sites/default/files/docs/2016/11/riio_nic_2016_spten03_phoenix_fullsubmission_v2.0_redacted.pdf

[30] Source: https://www.nationalgrideso.com/document/181446/download

providing inertia, short circuit current and voltage control as described above. Synchronous machines are also used for large motors to drive pumps or fans. A synchronous compensator (also called a synchronous condenser) is a synchronous machine with no prime mover or load attached. A SC draws in a small amount of power from the grid to keep it turning overcoming its windage, bearing and electrical losses. When there is a fault on the grid the SC provides short circuit current and inertia and in steady state operation it controls voltage on the grid by importing or exporting reactive power.

Synchronous machines come in many different types and sizes which are designed and selected for their performance, efficiency, cost effectiveness and the optimal mix of stability services which are required at any point in time. The design of Neilston GGP has taken into account different potential SC designs.

## *9. Battery Energy Storage System (BESS)*

Battery energy storage systems have been around for many years but the technology has recently evolved and costs have reduced largely due to development and production of electric vehicles. BESS made their initial impact on the GB grid when NGESO launched a new product called Enhanced Frequency Response (EFR) in 2016[31]. The EFR tender launched BESS into the GB market and they proved highly competitive with conventional power stations to control the frequency of the grid, cutting the cost of providing this service and saving consumers money. As well as providing frequency response (using only some of the energy storage capability), BESS can import and store energy for export at a later time. This role will be particularly important in Scotland as there are often bottlenecks in the transmission network which prevent potential wind generation reaching consumers in the south of GB. NGESO has to turn down (constrain) some wind power generation during these bottlenecks, however BESS can be used to store this surplus wind energy instead and release it back into the grid when the grid constraints are relieved.

In recent developments BESS with Grid Forming Capabilities (GFC) are being developed and deployed. These GFC BESS can provide similar services to SCs (short circuit current, voltage control and very fast frequency response akin to an inertial response and so NGESO has included GFC BESS as an option in its Stability Pathfinder Phase 2 tender.

BESS is a modular technology with the overall project being made up of many smaller units. The physical size of the project depends not only on the power of the project but also on the number of hours of storage. As battery module prices fall over time, and as renewable energy availability increases, the optimal size of energy storage will increase. In addition, new battery technologies are expected to emerge which may require more physical space than current battery technology which has been developed primarily for the electric vehicle market where space and weight are at a premium.

BESS projects can be developed in different locations including within windfarms and solar parks and connected to the distribution networks and also in commercial and domestic premises. However, to provide vital stability services to the transmission system the BESS must be connected at transmission voltages (132, 275 or 400kV).

[31] https://www.nationalgrid.com/sites/default/files/documents/8589937157-06_EFR.pdf

## *10. Innovation and competition*

The development of highly cost effective renewable energy production has been the result of ongoing competition and innovation driving technology development forward, building scale and driving down prices.

In a similar way NGESO have a mantra to secure services in a competitive manner driving innovation and cost reduction[32].

Statkraft design and develop our GGP to be flexible to the evolving technologies in order to have the most cost effective solutions which will lead to lower costs to consumers.

## *11. Neilston Greener Grid Park*

Neilston GGP will deploy SCs and BESS, bringing increased benefits by combining the two technologies on the one site.

For example, when there is a fault on the grid, such as the loss of large generator, and the frequency of the grid falls, the SC exports a burst of energy from its stored inertia. This instantaneous energy is vital slow down the fall in frequency and allow time for the BESS to detect the fall in frequency and export extra power to make up for the lost energy infeed maintaining the grid frequency at close to 50 Hertz.

There is also a cost and efficiency saving by using one set of grid connection infrastructure (cables, circuit breakers, transformers etc) to connect both technologies in one location.

Statkraft has secured a 132kV connection with an energisation date of July 2023 which allows early connection of a first project. A 400kV grid connection with a later energisation date, which will provide for greater capacity to deliver more grid services on future, is under negotiation.

## *12. Conclusion*

Neilston GGP has been selected as it is adjacent to the existing Neilston substation which is already a strong and central location on the Scottish grid and is being reinforced to make it an even better place to locate the new grid services which are required to enable integration of large amounts of renewable energy that are needed to meet Scottish and UK Government targets.

[32] https://www.nationalgrideso.com/news/increasing-competition-markets-we-operate