Knocknagael/Farigaig Area High Voltage Project

SSEN Transmission

Document Classification | **Confidential**

Scottish & Southern Electricity Networks

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Executive Summary

This paper is an addendum to the Steady State Voltage Engineering Justification Paper T3BP-EJP-086 (EJP) submitted in our Clean Power 2030 Supplementary submission in February 2025. It has been prepared in response to the Draft Determinations[1] categorisation of optioneering as 'not justified' and Scope Confidence as 'Low Confidence'. Notably, the need was categorised as 'justified' on the basis of the evidence included in the EJP submission and support for this investment being confirmed by the National Energy System Operator (NESO).

This addendum presents the detailed, multi-disciplinary optioneering work undertaken since the February 2025 submission. Its purpose is to demonstrate how the optimal solution has been identified to meet the approved system need.

Steady-state system analysis was conducted to assess the requirement for voltage support across our network through to 2030 and beyond. This analysis ensures compliance with planning and operational voltage limits in accordance with the (National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS). The original EJP submission included investment proposals for both High Voltage (HV) (EJP Lite 1) and Low Voltage (LV) (EJP Lite 2) interventions.

The HV assessment identified a minimum requirement of 500 MVAr of inductive reactive compensation in the Knocknagael area, connected at 275 kV. It was acknowledged that further optioneering would be necessary to determine the most effective solution. The original EJP submission proposed high-level solution to address this high voltage need comprised the following:

- One 250 MVAr STATCOM, connected to the extended 275 kV Knocknagael busbar
- Two 125 MVAr switched shunt reactors, connected at 275 kV

For further detail regarding the identified need, please refer to the Steady State Voltage Engineering Justification Paper (Scheme Reference: T3BP-EJP-086).

This EJP addendum focuses on the detailed optioneering of the inductive reactive compensation solution required in the Knocknagael and Farigaig area to address the High Voltage need under lightly loaded system conditions. The optioneering analysis has considered a range of material factors, including:

- The technical effectiveness and system performance of available technologies,
- Spatial and bay availability constraints at existing substations,
- The impact of contracted customer connections, and
- Supply chain deliverability and associated timescales.

Following completion of the optioneering analysis, the preferred solution is to implement the required reactive compensation in the Knocknagael area in two phases;

[1] RIIO-3 Draft Determinations – Scottish Hydro Electric Transmission (SHET), Table 1: Summary of SHET Engineering Recommendations

Phase 1 - 2030 Earliest in Service Date:

- 2x 100MVAr switched shunt reactors connected to the 132kV Knocknagael busbar
- 1 x 60MVAr switched shunt reactors connected to the 33kV tertiary winding of the existing 275/132kV, 240MVA Super Grid Transformer (SGT) at Knocknagael
- 1 x 60MVAr shunt reactor connected to the 33kV tertiary winding of the **proposed replacement** 275/132kV, 240MVA SGT at Farigaig

Phase 2 - 2033 Earliest in Service Date: (Keeping optionality at the stage to develop both sides of the 275kV Knocknagael busbar)

- 1 x 250MVAr STATCOM connected to the extended 275kV Knocknagael busbar

The total initial project cost for this solution is [redacted]. Following notional approval of need in the Draft Determinations, we are requesting through this addendum the preferred option approval for this project within the RIIO-T3 delivery plan. Costs will be submitted under the Load Related Reopener (LRR) mechanism.

Project Summary Table

Name of Scheme	Knocknagael/Farigaig Area High Voltage Project			
Associated Strategy	[redacted]			
Investment Driver	CP2030 – Voltage Compliance			
Scheme Reference Number	SHT20687			
Outputs	**Phase 1 – 2030:** • 2x 100MVAr switched shunt reactors connected to the 132kV Knocknagael busbar • 2 X 60MVAr shunt reactors connected to the tertiary windings of existing Knocknagael and proposed Farigaig 240MVA SGTs (• **Phase 2 – 2033** • Extend the existing 275kV double busbar at Knocknagael to connect the 250MVAr STATCOM situated within a new 275kV satellite site.			
Cost	[redacted]			
Delivery Year	Phase 1 - 2030 Phase 2 – 2033			
Applicable Reporting Tables	6.1 Scheme C&V Load Actuals			
Historic Funding interactions	[redacted]			
Spend Apportionment	**ET1**	**ET2**	**ET3**	**ET4**
		[redacted]	[redacted]	[redacted]

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1.Introduction

This Engineering Justification Paper (EJP) addendum sets out our optioneering for the capital investment of reactive compensation equipment in the Knocknagael and Farigaig area of our network during the RIIO-T3 period (April 2026 to March 2031). This investment will ensure continued safe, secure, and reliable operation of the SSEN Transmission network and contribute to UK Net Zero and Clean Power 2030 targets.

This paper is an addendum to the Steady State Voltage Engineering Justification Paper (EJP) submitted in our Clean Power 2030 Supplementary submission in February 2025. It has been prepared in response to the Draft Determinations[2] categorisation of optioneering as 'not justified' and Scope Confidence as 'Low Confidence'. Notably, the need was categorised as 'justified' on the basis of the evidence included in the EJP submission and support for this investment being confirmed by the NESO.

This addendum presents the detailed, multi-disciplinary optioneering work undertaken since the February 2025 submission. Its purpose is to demonstrate how the optimal solution has been identified to meet the approved system need.

2. Investment Needs Case

Steady-state system analysis was conducted to assess the requirement for voltage support across our network through to 2030 and beyond. This analysis ensures compliance with planning and operational voltage limits in accordance with the NETS SQSS. The original EJP submission included investment proposals for both HV (EJP Lite 1) and LV (EJP Lite 2) interventions.

The HV assessment presented identified a minimum requirement of 500 MVAr of inductive reactive compensation in the Knocknagael and Farigaig area, connected at 275 kV. It was acknowledged that further optioneering would be necessary to determine the most effective solution.

For further detail regarding the identified need, please refer to the Steady State Voltage Engineering Justification Paper (Scheme Reference: T3BP-EJP-086).

3. Optioneering

The HV assessment presented in the original EJP submission identified a minimum requirement of 500 MVAr of inductive reactive compensation in the Knocknagael and Farigaig area, connected at 275 kV. It was acknowledged that further optioneering would be necessary to determine the most effective solution.

[2] RIIO-3 Draft Determinations – Scottish Hydro Electric Transmission (SHET), Table 1: Summary of SHET Engineering Recommendations

Figure 1 illustrates the current network configuration in the Knocknagael and Farigaig area. Knocknagael is a 275/132 kV Main Interconnected Transmission System (MITS) substation located on the east–west 275 kV corridor between Beauly and Blackhillock.

The Foyers pumped hydro station is radially connected via a 275 kV double circuit Overhead Line (OHL). Farigaig substation was introduced along this route to support onshore wind connections at Dunmaglass and Corriegarth. Tomatin substation is also radially connected to Knocknagael via a 275 kV double circuit OHL. Additionally, the Inverness Grid Supply Point (GSP) connects radially to the Knocknagael 132 kV double busbar.

Figure 1 also highlights Beauly substation as a critical site for network voltage support. Existing reactive assets at Beauly include two 90 MVAr tertiary-connected shunt reactors, two 45 MVAr Mechanically Switched Capacitor with Damping Network (MSCDN)s at 132 kV, and a 150 MVAr Static Var Compensator (SVC).

The 132kV double circuit OHL between Beauly and Knocknagael notated in Figure 1 by the Circuit IDs BC3/BC4 is included for decommissioning in the scope of the Beauly – Blackhillock – Peterhead 400kV Accelerated Strategic Transmission Investment (ASTI) Project.

Both the Beauly SVC and the Beauly and Knocknagael 132kV Double circuit are key considerations in the optioneering of an enduring reactive compensation solution for the network. A replacement strategy for the Beauly SVC is currently being developed. Indicative timescales for the 132kV OHL de-commissioning are between 2031 and 2033.

The original EJP submission proposed high-level asset solution to address the high voltage system requirements comprised the following:

- One 250 MVAr STATCOM, connected to the extended 275 kV Knocknagael busbar
- Two 125 MVAr switched shunt reactors, connected at 275 kV

The optioneering analysis in this paper has considered a range of material factors, including:

- The technical effectiveness and system performance of available technologies,
- Engineering, spatial, consenting and bay availability constraints at existing substations,
- Contracted customer connections in the Knocknageal/ Farigaig area (detailed in Appendix A),
- Supply chain deliverability and associated timescales.

1.1. Option Combinations

System and deliverability factors considered in the process of defining feasible options are:

System Requirements

- The **minimum system requirement** of inductive reactive compensation in the Knocknagael and Farigaig area shall comprise of an approximately 50/50 split of both static and dynamic reactive compensation solutions. This is required to address the exceedances of the NETS SQSS steady state voltage limits and voltage step limits in 2030 and beyond.
- The minimum requirement of 500 MVAr at 275kV is indicative of the total reactive compensation required for an enduring solution. Note that combinations of asset options including 33kV and 132kV connections are considered and assessed to determine if operation within voltage limits can be achieved.
- Sensitivity analysis undertaken concluded that the Beauly 275kV, 150MVAr SVC and 132kV double circuit OHL between Beauly and Knocknagael must remain in operation until the enduring reactive compensation solutions for both static and dynamic are complete.
- Required in service dates
    - Static reactive compensation, approx. 50% of total MVAr requirement by 2030
    - Dynamic reactive compensation, approx. 50% of total MVAr requirement between 2031 and 2033 aligned with the decommissioning of the Beauly to Knocknagael 132kV OHL and Beauly SVC.

Bay availability

- Space for two 132kV feeder bays at Knocknagael 132kV Double Busbar
- Any connection at Knocknagael 275kV will require the extension of the 275kV busbar to either the North-West or South-East. Noting that the South-East busbar extension works for the connection of Loch na Cathrach (LNC)[3] (previously Red John) Pumped Storage Hydro (PSH) are in advanced stages of planning consents with an energisation date of April 2029, and any variation to accommodate the reactive compensation may require a resubmission of the planning consent currently with the Highland Council for approval, which would have negative implications on the customers contracted connection date.
- Two SGTs at Knocknagael and Two SGTs at Farigaig have provision for a 33kV, 60MVAr tertiary rated connection.

Technology

Taking into consideration the system requirements, the following reactive compensation asset options are available. These are based on utilisations of SSEN Transmission frameworks to avoid increased costs and connection delays associated with bespoke solutions. The framework assets available to meet the system requirements are;

- 33kV, 60MVAr switched shunt reactor
- 132kV, 100MVAr switched shunt reactor

[3] Projects | Loch na Cathrach Pumped Storage Hydro - Statkraft UK

- 275kV, switched shunt reactor of any MVAr rating would sit outside of SSEN Transmission frameworks and be a bespoke one-off design / tender event
- 132kV, 250MVAr STATCOM
- 275kV, 250MVAr STATCOM

Existing site footprint constraints

The bay availability, technology options and the existing site drawings were assessed to determine what could be physically accommodated within the exiting substation footprint.

- Space available within Knocknagael substation footprint for two 100MVAr switched shunt reactors
- Only sufficient space within the existing substation footprints to accommodate one 33kV tertiary connected switched shunt reactor at Knocknagael and one at Farigaig.
- The STATCOM, regardless of connection voltage, shall be located within a satellite site and connect to the existing substation via approximately 1km of single circuit underground cable (UGC).

Alternative sites

- **Farigaig Extension** - Extend 275kV Farigaig site, currently single busbar, to a new double busbar arrangement to accommodate all required reactive compensation equipment at Farigaig.
- **New Site** - Construct a new 275kV double busbar at a satellite site located ~1km from the existing Knocknagael substation to accommodate all required reactive compensation equipment at new site. This option also requires the Knocknagael 275kV busbar extension.

Earliest In Service Dates

The Earliest In Service dates (EISDs) of the technology which has been considered to address the system requirement is shown in **Table 1**. These have been developed by our project development teams with consideration of the system requirements, bay availability, technology, supply chain and existing/new site constraints.

EISD	Equipment	Connection / Location
2030	60MVAr switched shunt reactor	Knocknagael SGT1 Farigaig SGT2
2030	100MVAr switched shunt reactor	Knocknagael 132kV
2031	250MVAr STATCOM	Knocknagael 132kV

2031	250MVAr STATCOM	South-East extended busbar Knocknagael 275kV
2033	250MVAr STATCOM	North-West extended busbar Knocknagael 275kV
2035	275kV Double Busbar Reconfiguration	Rebuild Farigaig to new 275kV double busbar)
2035	New 275kV Double Busbar	Satellite site (~1km from existing Knocknagael substation)

Table 1: Earliest in Service Dates

1.2. Option Appraisal

Table 2 sets out the combined asset solution options that can achieve the system requirements in line with the required in service dates and whether it has been progressed to detailed analysis and the rationale for this.

Options for 275kV switched shunt reactors were considered but discounted early, as their implementation is dependent on the completion of a 275 kV busbar extension at Knocknagael. This constraint results in an Earliest In-Service Date (EISD) beyond the required 2030 timeline for static reactive compensation in the area.

System analysis[4] confirms that steady-state voltages remain within NETS SQSS limits with the following installed by 2030.

- 2x 100MVAr switched shunt reactors connected to the 132kV Knocknagael busbar
- 1x 60MVAr switched shunt reactors connected to the 33kV tertiary winding of the existing 275/132kV, 240MVA Super Grid Transformer at Knocknagael
- 1x 60MVAr shunt reactor connected to the 33kV tertiary winding of the **proposed replacement** 275/132kV, 240MVA Super Grid Transformer at Farigaig

This configuration is the only proposed combination of assets capable of meeting static compensation system requirements by 2030 and is therefore applied consistently across all options presented in Table 2.

Operational measures have been considered alongside asset-based solutions to manage high voltage levels in the region, including the potential switching out of high-capacity overhead lines under lightly

[4] High Voltage assessment for the 2030 ASTI Network Optioneering study report

loaded conditions. However, this approach may have wider system implications and requires further evaluation in collaboration with the NESO before it can be considered a credible operational strategy.

Options 1a, 1b, and 1c are variations of connecting the 275kV STATCOM to the Knocknagael 275kV double busbar. 1a and 1b present the sole option to extend and connect the proposed 275kV STATCOM to one side of the busbar or the other. Option 1c proposes to continue development of the extension of both sides of the busbar, retaining optionality contingent on the coordination with the contracted customer connection of Loch na Cathrach Pump Storage Hydro (PSH) and to also facilitate potential future connections to the Knocknagael 275kV busbar.

For Option 2, our Subject Matter Experts (SMEs) have advised against this configuration there are no guarantees that the 132kV connected STATCOM can effectively control the 275 kV busbar voltage set point. The main concern is that there may be voltage stability issues and oscillations seen on the 132kV busbar which could potentially require further investment to mitigate. Furthermore, this solution requires a third bay to be available at 132kV Knocknagael busbar, thus interacting with the decommissioning of the 132kV OHL between Beauly and Knocknagael.

Options 3 & 4 have costs that are far in excess of the other options and significantly later EISDs due to the amount of construction activities and consenting. Option 3 has particularly impactful construction outage requirements impacting existing customers on the Knocknagael – Farigaig – Foyer 275kV circuit. For both Options 3 & 4, no reactive compensation can be accommodated by the required in service date of 2030.

From the system requirement, deliverability, cost and programme assessment, 1a, 1b and 1c were identified as preferred options and are detailed in the following section of this paper.

Option	33kV, 60MVAr switched shunt reactor at Knocknagael	33kV, 60MVAr switched shunt reactor at Farigaig	2x 132kV, 100MVAr switched shunt reactor at Knocknagael	132kV, 250MVAr STATCOM at Knocknagael	275kV, 250MVAr STATCOM at Knocknagael North-West	275kV, 250MVAr STATCOM at Knocknagael North-East	Extend 275kV Farigaig site	New Site
Options 1a	Y	Y	Y	N	Y	N	N	N
Options 1b	Y	Y	Y	N	N	Y	N	N
Options 1c	Y	Y	Y	N	Y*	Y*	N	N

Options 2	Y	Y	Y	Y	N	N	N	N
Options 3	Y	Y	Y	N	N	N	Y	N
Options 4	Y	Y	Y	N	N	N	N	Y

Table 2: Summary of options

***Option 1c retains optionality for connection of the 275kV STATCOM to either side of the Knocknagael 275kV Busbar.**

1.3. Knocknagael 275kV Busbar Extension

This section takes forward the three options (Options 1a, 1b and 1c) which were identified in **Table 2** as being the preferred solutions on the basis of system, technical, deliverability and cost.

A key difference between these options is the cost implications and delivery challenges associated with the direction of the 275kV double busbar extension required at Knocknagael substation to accommodate the STATCOM connection. Regardless of option, the STATCOM will be located approximately 1km away and situated within a new 275kV satellite site. For all options, this will be completed as an offline build to optimise the delivery timescales. The switched shunt reactive compensation solution is consistent to all options.

Extending the 275kV Knocknagael busbar Northeast (Option 1b) has a greater impact on contracted customer connection in comparison to a Southwest extension. LNC PSH has a Transmission Owner Construction Agreement (TOCA) to connect into Knocknagael 275kV with a final completion date of 2029. The developer has sufficiently met Gate 2 Readiness Criteria and Strategic Alignment Criteria resulting in them being a Gate 2 protected scheme.

Option 1c is shown in **Figure 2** and enables the 275kV Knocknagael busbar to extend to its maximum capability future proofing this site and providing a spare bay which could be utilised for generator connection or strategic demand. It also provides the opportunity for a single contractor to co-ordinate works at both sides of the busbar [redacted]

[redacted]

Option	Benefits	Challenges	EISD
Option 1a Northwest Extension	[redacted] • Provides the contractor with the opportunity to phase works helping pressures with delivery.	• Significant costs associated with infill requirements to build up the platform and rerouting Tomatin 275kV UGC. • Land acquisition and environmental challenges to facilitate the platform extension. • Additional Town and Country Planning application. • Outage co-ordination with busbar extensions to both ends of the busbar.	2032

Option 1b Southeast Extension (LNC)	[redacted] • Lower cost solution.	[redacted] • Contract availability/interface. • No future provision leaves another large project for any future bay requirements.	2031
Option 1c Northwest Extension and Southeast Extension	• If a single contractor is engaged opportunity to undertake all works under one contract with contractor able to plan and phase works effectively. • Opportunity to sequence works, construct Option 1B first to connect LNC and Statcom • Provides spare bay for future connection, strategic demand. • For minimal work and minimal additional cost, it provides future access to the system.	• If a single contractor not engaged there will be significant challenges in managing multiple contractors on site at the same time providing a major CDM management concern. • [redacted]	2033

Table 3: Options for STATCOM connection to 275kV busbar at Knocknagael

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	

Table 4: Cost comparison of options

*The Loch Na Cathrach Connection works costs do not form part of the ask and are only here for illustrative purposes.

Table 4 shows the high-level block costing elements of the Knocknagael 275kV connection and the deltas between the options. As shown by the cost comparison between Option 1C and Option 1A, it is only [redacted] more to develop an additional bay on the opposite side of the 275kV Knocknagael busbar.

Through this optioneering process we have recognised the interdependencies of meeting the LNC connection date and the requirement to connect the STATCOM in an efficient manner as quickly as possible. We have shown that extension of the 275KV Knocknageal busbar on the opposite side limits the impacts to the connection date [redacted]

We recommend that we proceed with development of Option 1c, this will:

- Ensure any change to the connection date of LNC is minimal
- Enable optimal timing for the delivery of the STATCOM
- Develop a further 275KV bay at Knocknagael for a future generator or Strategic Demand Connection

Keeping the optionality open at this stage ensures we do not commit to an option that may later be regretted if the LNC connection is significantly delayed or does not proceed. The phasing of the delivery aspects of Option 1c will be dependent on any changes to the LNC and potentially any strategic Demand Connection[5] which may arise from the G2tWQ and may require the additional 275kV bay at Knocknagael. As a result, Option 1c is our preferred solution.

1.4. Preferred Option

As a result of the information provided, our proposed final solution for the Knocknagael/Farigaig Area High Voltage Project is Option 1c.

The project scope comprises of the following works, which will be delivered in a phased approach to ensure continued NETS SQSS compliance in HV scenarios on the SSEN Transmission network

[5] NESO's Beyond 2030 plan (March 2024) assumes major strategic demand in the north of Scotland through the 2020s and early 2030s and shows that placing up to 5 gigawatts of flexible demand behind transmission bottlenecks could bring significant consumer value through avoided reinforcements

between 2030 – 2032 and beyond. The works associated with Phase 1 and Phase 2 are outlined below and are shown in Table 5, the System Design Table.

Phase 1 - 2030 Earliest in Service Date (Figure 3)

- 2x 100MVAr switched shunt reactors connected to the 132kV Knocknagael busbar
- 1 x 60MVAr switched shunt reactors connected to the 33kV tertiary winding of the existing 275/132kV, 240MVA Super Grid Transformer at Knocknagael
- 1 x 60MVAr shunt reactor connected to the 33kV tertiary winding of the **proposed** 275/132kV, replacement 240MVA Super Grid Transformer at Farigaig

Phase 2 - 2033 Earliest in Service Date (Figure 4): (Keeping optionality at the stage to develop both sides of the 275kV Knocknagael busbar)

- 1 x 250MVAr STATCOM connected to the extended 275kV Knocknagael busbar

The proposed solution is dependent on the following key system requirements:

- The 150MVAr SVC at Beauly 275kV substation shall remain operational until completion of Phase 2.
- The 132kV OHL circuits (BC3/BC4) between Beauly and Knocknagael substations remain operational until completion of Phase 2.

		Current Network	Preferred Solution	Comments
Thermal and Fault Design	Voltage	275/132kV	275/132kV	N/A
	Continuous Rating	N/A	UGC - 300MVA 275kV busbar bay – 4000A 132kV busbar bays – 3150A	
	Fault Rating	N/A	275kV bay – 63kA 132kV bays - 40kA	N/A
ESO Dispatchable Services	MVAR Rating	N/A	• 2 x 100MVAr switched shunt reactors on the **132kV Knock ngael** busbar • 1 x 60MVAr switched shunt reactors connected to the 33kV tertiary winding of the existing 275/132kV, 240MVA Super Grid Transformer at Knocknagael • 1 x 60MVAr shunt reactor connected to the 33kV tertiary winding of the **proposed** 275/132kV, 240MVA Super Grid Transformer at Farigaig • 1 x 250MVAr STATCOM connected to the extended 275kV Knocknagael busbar	
	GVA.s Rating	N/A	N/A	N/A
System Requirements	Present Demand (if applicable) (MW)	N/A	N/A	N/A
	2050 Future Demand (MW)	N/A	N/A	N/A
	Present Generation (if applicable) (MW)	N/A	N/A	N/A
	Future Generation Count (MW)	N/A	N/A	N/A
Initial Design Considerations	Limiting Factor	Double circuit outage of 400kV/275kV OHLs around Beauly and Knocknagael area.	N/A	N/A
	AIS / GIS	AIS	AIS	N/A
	Busbar Design	Double	N/A	Busbar extension to existing 275kV double busbar

	Cable / OHL / Mixed	N/A	Cable	~1km of UGC circuit from 275kV satellite site to Knocknagael 275kV double busbar.
	Strategic Investment	N/A	Yes	N/A

Table 5: System Design Table

4. Cost Information

4.1. Cost Summary

A summary of our cost breakdown can be found in **Table 6** below:

Project Name	Description	Cost (£m)
Phase 1 Knocknagael/Farigaig Area High Voltage Project	• 2x 100MVAr switched shunt reactors connected to the 132kV Knocknagael busbar • 1 x 60MVAr switched shunt reactors connected to the 33kV tertiary winding of the existing 275/132kV, 240MVA Super Grid Transformer at Knocknagael • 1 x 60MVAr shunt reactor connected to the 33kV tertiary winding of the **proposed replacement** 275/132kV, 240MVA Super Grid Transformer at Farigaig	[redacted]
Phase 2 Knocknagael/Farigaig Area High Voltage Project	• 1 x 250MVAr STATCOM connected to the extended 275kV Knocknagael busbar	

Table 6: Project Cost Breakdown

As shown in **Table 6**, the total project cost for the Knocknagael/Farigaig Area High Voltage Project is [redacted]

5. Project Delivery

5.1. Project Plan

The preferred solution adopts a phased approach:

Phase 1 is due to be energised by 2030 and a Level 1 Programme is shown in Appendix B.
Phase 2 is due to be energised in 2033 and a Level 1 Programme is shown in Appendix B.

5.2. Risk Mitigations

Key risks and mitigations associated with this project are set out in Appendix C.

6. Conclusion

This EJP outlines the preferred option to install ~500MVar inductive reactive compensation equipment within the Knocknagael/ Farigaig area. This will enable sufficient voltage support on our network to maintain voltages within planning and operational limits in accordance with NETS SQSS as we develop the ASTI network and beyond.

Following detailed optioneering and analysis, our recommended solution will be delivered in two phases:

Phase 1 - 2030 Earliest in Service Date:

- 2x 100MVAr switched shunt reactors connected to the 132kV Knocknagael busbar
- 1 x 60MVAr switched shunt reactors connected to the 33kV tertiary winding of the existing 275/132kV, 240MVA Super Grid Transformer (SGT) at Knocknagael
- 1 x 60MVAr shunt reactor connected to the 33kV tertiary winding of the **proposed replacement** 275/132kV, 240MVA SGT at Farigaig

Phase 2 - 2033 Earliest in Service Date: (Keeping optionality at the stage to develop both sides of the 275kV Knocknagael busbar)

- 1 x 250MVAr STATCOM connected to the extended 275kV Knocknagael busbar

The solution proposed is dependent on the following key system requirements:

- The 150MVAr SVC at Beauly 275kV substation shall remain operational until completion of Phase 2.
- The 132kV OHL circuits (BC3/BC4) between Beauly and Knocknagael substations remain operational until completion of Phase 2.

The total initial project cost for this solution is [redacted] Following notional approval of need in the Draft Determinations, we are requesting through this addendum the preferred solution option approval for this project within the RIIO-T3 delivery plan. Costs will be submitted under the Load Related Reopener (LRR) mechanism.

We believe our preferred solution is the most efficient technical solution to ensure continued safe, secure, and reliable operation of the SSEN Transmission network whilst contributing to UK Net Zero and Clean Power 2030 targets.

Appendix A: Generator Connections in the Knocknagael/Fairgaig Area

Those generators forecasted for a Gate 2 offer have been assessed based on NESO Target Model Option 4 (TM04+) criteria and developer Request for Information (RFI) responses where available. This has been used in combination with the current insight on queue orders, planning consents, readiness and strategic alignment criteria, including alignment to the capacities within the Clean Power 2030 Action Plan to inform our best view and is a key consideration when assessing option viability.

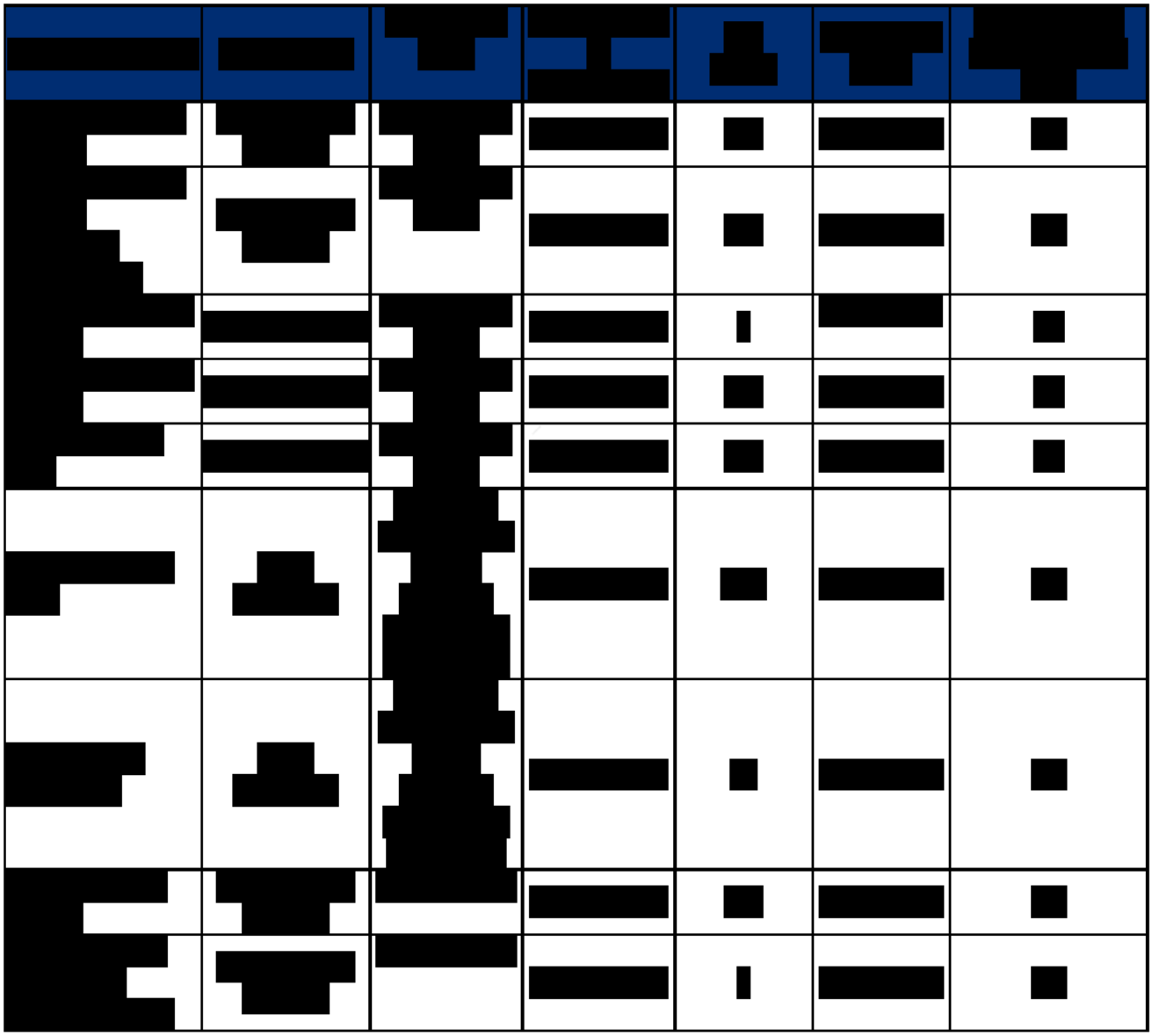

Table 7: Generator connections

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Appendix B: Project Plan

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Appendix C: Key Risks

The key risks identified for the programme and their associated mitigating actions are outlined below. The colour coding identifies the level of risk, with green representing low risk, amber representing medium risk and red representing high risk.

Risks

Risk Description	Pre-Control RAG (LxI)	Risk Control Action	Post-Control RAG (LxI)
Delay to obtaining consents There is a risk that there may be a delay to obtaining town and country planning consent due to long determination times for planning consents. 9 months are currently proposed in the programme. This is particularly pertinent considering the planning application for the Loch na Cathrach connection has already been submitted, and any subsequent submissions would need to allow for this as part of the cumulative assessment.		Undertake detailed consultation pre submission. Engage with The Highland Council during the development process. Consider all proposed works at Knocknagael in any future submissions.	
Interface between other projects and in particular Loch na Cathrach PSH The Loch na Cathrach and Knocknagael BESS projects are proposed to be connected to Knocknagael substation. There is also 400kV Beauly – Peterhead line project proposed in the close proximity of Knocknagael substation including decommissioning of existing Beauly – Knocknagael line. This will require interface management during the design and construction phase. There is a risk that any delays/change to design to these interfacing projects would delay the connection date of Knocknagael HV project. Conversely there is a risk that the works for this project could impact these interfacing projects and in particular Loch na Cathrach PSH connection which is also looking to extend the 275kV busbar and is already significantly advanced having already achieved LCP Gate 2, submitted its planning application and commenced Contractor engagement. Therefore,		Regular interface meeting between projects. Ensure information/data are shared effectively. Regular communication with the Developers of these interfacing schemes. Further mitigations to be explored to mitigate impacts on Loch na Cathrach existing work.	

Risk Description	Pre-Control RAG (LxI)	Risk Control Action	Post-Control RAG (LxI)
any works proposed on the Southern end of the 275kV Busbar will impact the Loch na Cathrach PSH proposal and energisation date.			
Procurement delays There is a risk that delays in procurement or delivery to site of key long lead time items caused by supply chain issues, contractor availability or delivery issues result in delay to construction completion date.		Project Team to monitor lead times on key items of equipment and programme in purchase of these as required, accounting for advanced funding if required.	
Landowner negotiations delays There is a risk that SSEN cannot secure voluntary agreement for the project. It would be required to secure necessary wayleaves/CPO which would result in a delay to the start on site date.		Design to reach acceptable standard ASAP in order to seek agreement over design and price with landowner ahead of Gate 2. Draft necessary wayleave/CPO in event that voluntary agreement cannot be reached.	
Contractor availability There is a risk that qualified contractors for the works are engaged in other large scale capital projects (transmission, onshore wind or other sectors) across Scotland and wider UK. This could result in delays to start on site and extended durations for works. This is also applicable given the scale of the works required when considered alongside Loch na Cathrach extension works.		Early engagement with contractors to understand availability. Working with contractors to provide strategic resourcing approach and wider SSEN investments.	
Unable to book preferred outages Due to the need for outages on multiple projects in the UK simultaneously there is a risk that this could cause delays to the programme.		Prepare Stage-by-Stage drawings and detailed Outage Plan and submit to Outage Planning / System Operations for agreement / acceptance ASAP. Agreement on construction programme in order to derisk established enabling works outages as well as establish the	

Risk Description	Pre-Control RAG (LxI)	Risk Control Action	Post-Control RAG (LxI)
		tie in dates for the final connection in order to allow those outages to also be booked.	
Environmental challenges of any extension on the North Western side of Knocknagael An extension here would be within Native Woodland and also in closer proximity to properties along the Essich Road.		To be considered during the design stage to look to minimise any footprint within this area. Impact to be assessed as part of an EA/EIA.	
Loch na Cathrach PSH falling away If Loch na Cathrach PSH will not progress, there is a risk that LNC cost will be added onto Knocknagael/Farigaig Area High Voltage Project.		Regular meetings with the Developer regarding LNC progress.	

Table 8: Key Risks