Glenmuckloch to ZV Route Reinforcements

Site Strategy EJP
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11/12/2024

SP Energy Networks
RIIO-T3 Business Plan

SP Energy Networks

GLENMUCKLOCH TO ZV ROUTE REINFORCEMENTS				
Name of Scheme	Glenmuckloch to ZV Route Reinforcements			
Investment Driver	Local Enabling (Entry)			
BPDT / Scheme Reference Number	SPT200326			
Outputs	• 132kV CB (Air Insulated Busbar) – 6 units • 400kV CB (Air Insulated Busbar) – 4 units • 400kV OHL (Tower Line) Conductor – 48.30km (2 x 24.15km) • 400kV Overhead Line Fittings – 146 units • 400kV Overhead Tower – 73 units			
Cost	£139.55m			
Delivery Year	2028			
Applicable Reporting Tables	BPDT (Section 5.1 - Project Meta Data, Section 6.1 - Scheme C&V Load Actuals, and Section 11.10 Contractor Indirects)			
Historic Funding Interactions	N/A			
Interactive Projects	N/A			
Spend Apportionment	**ET1**	**ET2**	**ET3**	**ET4**
	£0.13m	£11.11m	£128.30m	£0.00m

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[redacted]

1. Executive Summary

This engineering justification paper (EJP) sets out the need case for:

- development of a new Glenmuckloch 400kV substation in south west Scotland (SWS) area of SP Transmission's (SPT) network;
- construction of approximately 25km of 400kV double circuit overhead line (OHL) with twin GZTACSR Matthew 'GAP' conductor between the new Glenmuckloch substation and the planned Redshaw 400kV substation on ZV route;
- installation of four 400/132kV 360MVA supergrid transformers (SGTs) at the new Glenmuckloch substation; and
- installation of a load management scheme (LMS) to monitor the loading across the SGTs.

There are multiple drivers behind this project (ref. SPT-RI-236) which entail:

- enabling connection of generation applications received in the area – circa 0.9GW;
- creating a new 'exit route' from the SWS area towards the existing ZV route;
- providing a new point of interconnection between New Cumnock and the main west coast onshore Scotland-England connection; and
- facilitating future wider reinforcements in the region.

The proposed scheme is executed in a sequence of staged investments to reflect the growing needs in the area and ensure project delivery in a timely manner in advance of future network development in the region.

The Glenmuckloch 400kV substation will be initially built to accommodate the new 400kV double circuit OHL to the point of connection on the existing ZV route, enabling new connection capacity in the area. From the first stage of the project, land and building space will be established to accommodate all foreseen future requirements.

One of the key future stages for the project will be the establishment of two new double circuits to New Cumnock North and to Dumfries North, ultimately forming part of a new 400kV double circuit corridor between Scotland and the North of England delivering much needed B6 capability. This project was identified by the ESO within the Beyond 2030 report (with the project reference WCN2) as required to facilitate an increase in B6 boundary capability. Additional future bays will be also included within the substation planning to accommodate future requirements based on Net Zero.

The expected project delivery year for Stage 1 is 2028. The estimated project cost for this stage is £139.55m.

This EJP is submitted for Ofgem's assessment of the need case for the project and the selection of the preferred option in order to provide sufficient funding for pre-construction and early construction activities. A cost assessment submission for the project will be made to Ofgem under the Load Related Reopener at an appropriate time.

2. Introduction

This EJP sets out SPT's plans to establish:

(i) a double circuit L8 400kV overhead line (circa 25km) between the new Glenmuckloch 400kV substation and the planned Redshaw 400kV substation (ref. SPT-RI-2060), north of Elvanfoot substation, on ZV route;

(ii) a new Glenmuckloch 400kV substation including four 400/132kV 360MVA SGTs; and

(iii) a LMS to monitor the loadings across these 400/132kV SGTs under N-1 conditions.

The proposed Glenmuckloch 400kV substation will be established at the location of the planned Glenmuckloch 132kV substation to facilitate connection of four 400/132kV 360MVA SGTs. Approximately 9.3km of double circuit 132kV OHL connect the planned Glenmuckloch 132kV substation to the existing Glenglass 132kV substation. These works are planned under SPT-RI-173 and are outside the scope of this EJP.

For reference ZV route is an L8 construction OHL between Strathaven and Harker 400kV substations and is the west coast onshore interconnector between Scotland and the North of England. The diagram indicating geographical location of the proposed scheme can be found in Figure 1. The current schematic configuration of transmission network in the area is shown in Figure 2. Figure 3 depicts the development of the system including the new SPT-RI-236 works creating the new 400kV circuit between Glenmuckloch and Redshaw substations, these are shown in yellow.

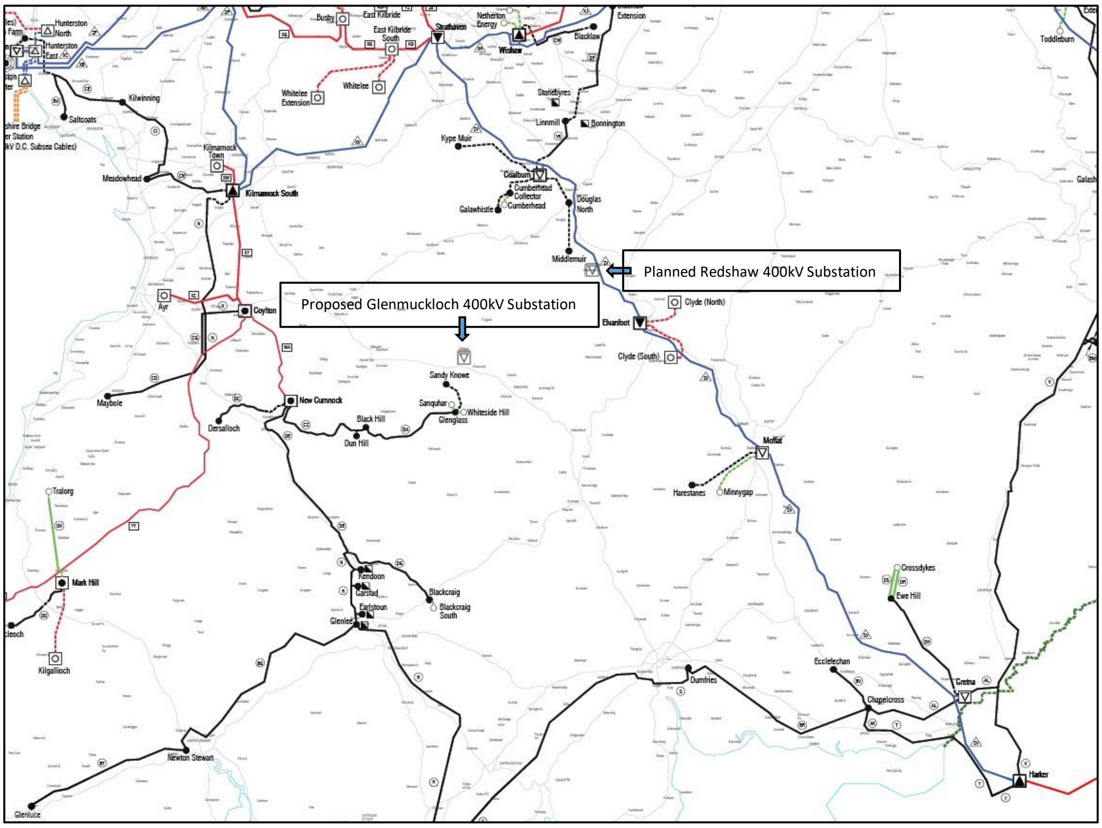

Figure 1: Geographical location of the proposed scheme with respect to the wider network in South-West Scotland area - extracted from Networks Diagram Geographical Layout shown in Appendix A (Figure A-1).

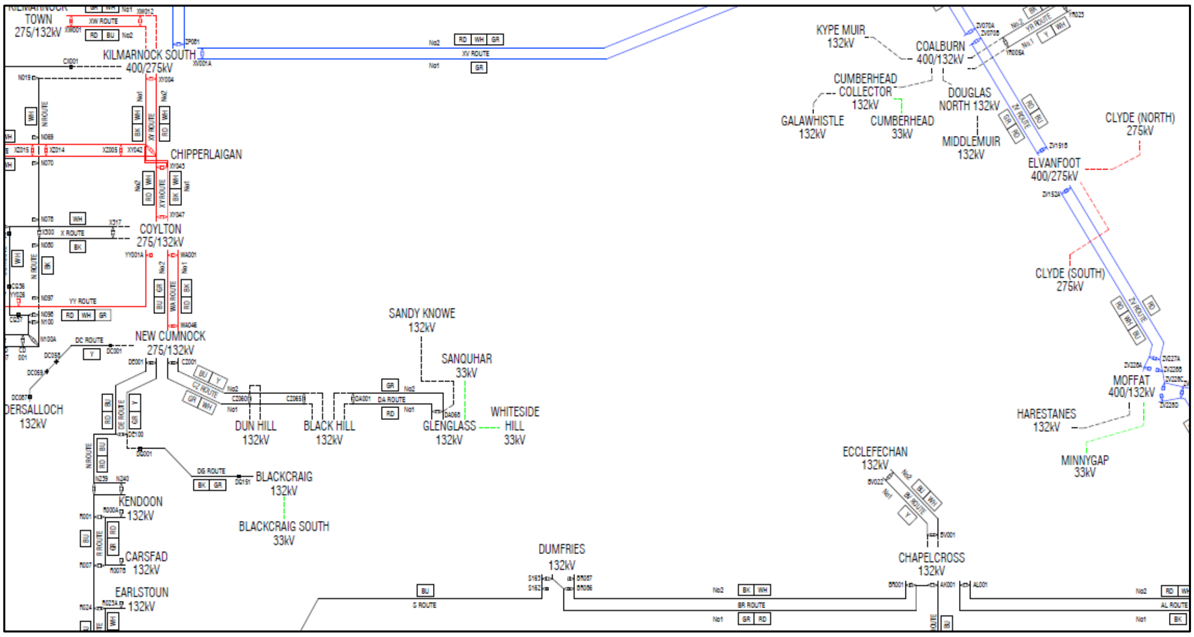

Figure 2: The existing transmission network in the area – extracted from Networks Diagram of the Existing SPT Systems shown in Appendix A (Figure A-2).

The driver behind this project is the generation applications received into this part of the system and the need to create a new 'exit route' from the New Cumnock area towards the existing ZV Route which forms part of the SPT 400kV system. This part of the network between Glenglass, Blackhill and New Cumnock substations has reached the upper limits in terms of thermal capability across the SGTs at New Cumnock. Beyond New Cumnock, the system heading north to Coylton and Kilmarnock South substations (via the WA and XY routes respectively) is significantly constrained due to the high volume of connected and contracted generation. To facilitate the contracted generation applications, it is proposed to extend the transmission system from the planned Redshaw 400kV substation to the Glenmuckloch area in south west Scotland (SWS). The planned Redshaw 400kV substation (under SPT-RI-2060) is proposed to connect to the ZV route between Elvanfoot and Coalburn 400kV substations, the scope of which is outside this paper.

New Cumnock 275/132kV substation comprises 275kV single busbar arrangement connecting the 275kV OHL circuit (WA Route) towards Coylton and the associated 275/132kV SGTs to three separate 132kV boards (NECU1A, NECU1B and NECU1C as shown in Figure 3). The reinforcements outlined in this paper will help to alleviate the overloads across the NECU1A SGTs. NECU1A uses three 275/132kV 240MVA SGTs to export the generation from this area to the 275kV system. However, with the existing 1,216MW of connected/contracted generation on this board, system reinforcement is needed to provide the required capacity. The reinforcement under SPT-RI-236 will transfer 750MW from the NECU1A board.

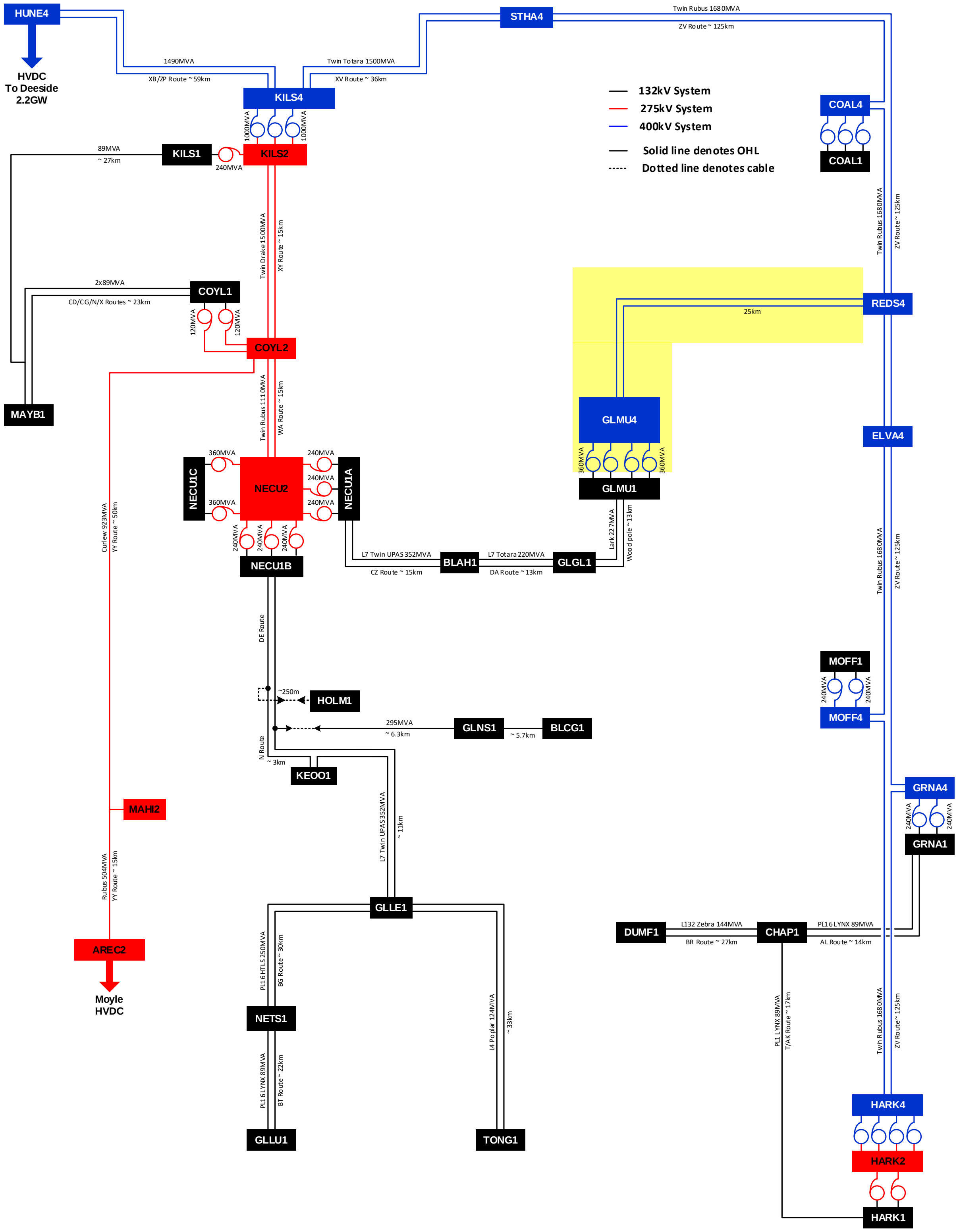

Figure 3: Single Line Diagram of the proposed scheme with respect to the wider electrical system in the area[1].

1 The focus of this diagram and subsequent versions is TORI 236. The rest of the network shown is subject to change as driven by other network needs.

The completion of Glenmuckloch to Redshaw 400kV double circuit provides the following benefits set out below – some of which extend beyond the SPT system:

1. Reduces the loading on the wider network beyond New Cumnock on the WA (New Cumnock to Coylton) and XY (Coylton to Kilmarnock South) routes to ensure compliance with the National Electricity Transmission System Security and Quality of Supply Standards (SQSS). Considering the infrequent infeed loss risk in planning timescales is 1800MW, the current contracted position on the WA route is significantly above this limit – approximately 1284MW higher. The loading on XY route has also already exceeded the limit permitted by SQSS. The system is currently derogated on these boundaries and the proposed reinforcements will help to reduce the constraints.
2. Provides an alternative route for the demand at the Galloway grid supply point (GSP) network (i.e., Glenlee (GLLE1), Newton Stewart (NETS1), Glenluce (GLLU1) and Tongland (TONG1) GSPs as shown in Figure 3). The supplies to this group post completion of Kendoon to Tongland 132kV Reinforcement (KTR) project will be secured by the Main Interconnected Transmission System (MITS) from Kilmarnock South. The proposed reinforcements within this paper will provide alternative supplies in the event of the loss of infeed from the system at Kilmarnock South.
3. The Glenmuckloch to ZV Route reinforcement accommodates the transmission works required for the development of a new circuit between South West Scotland and North West England. The WCN2 project, which is a joint scheme between SPT and NGET, increases the capability of network by constructing a new 400kV onshore circuit over the B6 boundary, and plays a key role in enabling wider reinforcements in the region.

   Following a recommendation in the 7th Network Options Assessment (NOA7) for a 'notional' west coast reinforcement, the WCN2 project was developed and has subsequently received a proceed signal from the NOA7 Refresh, which supports the Holistic Network Design (HND). It was further recommended by the Transitional Centralised Network Plan 2 (tCSNP2), or Beyond 2030 report, published by the ESO in March 2024[2].

A complete description of the needs case for Glenmuckloch 400kV to ZV Route project (TORI 236) and a full justification for the selected reinforcement option are provided in the following sections. At a high level, the scheme will comprise the following:

- Develop a new L8 400kV OHL circuit, approximately 25 km in length, between the Redshaw 400kV substation and the Glenmuckloch 400kV.
- At Redshaw 400kV substation, install two 400kV SF_6-free Gas Insulated Switchgear (GIS) bays (Redshaw 400kV substation is being established as part of SPT-RI-2060).
- Establish the substation platform for the new Glenmuckloch 400kV substation (this will be an extension to the substation platform originally created under SPT-RI-173).
- Establish the electrical infrastructure as described below.

Glenmuckloch accommodates multiple system drivers resulting from numerous generation connection applications and also future 'wider' system needs to establish new power corridors, for these reasons Glenmuckloch substation is a key node. The drivers require the establishment of

[2] Link to ESO Beyond 2030 Report – March 2024.

infrastructure at different times, as such the development of Glenmuckloch 400kV substation will occur in three discrete stages. These are as follows:

1. Establish the new substation platform at Glenmuckloch, terminate the incoming 400kV OHL circuits from Redshaw substation, install four 400/132kV SGTs and connect into the 132kV double busbar substation constructed under SPT-RI-173.
2. Incorporate the proposed new 400kV circuit from New Cumnock North 400kV substation into Glenmuckloch 400kV substation. This new 400kV OHL circuit will be constructed as the first section of the WCN2 project. This would connect into the busbar arrangement established under Stage 1 and will enable the connection of generation sites in the New Cumnock area.
3. Given the proposed WCN2 corridor as signalled via the NOA, HND and tCSNP2 initiatives, establish a 400kV double busbar GIS (SF_6-free) substation such that this new 400kV double circuit corridor can be connected in and out of Glenmuckloch. At this stage the 400kV double circuit to Redshaw would be connected into this new GIS board as well as the four SGTs. This GIS substation would be made up with the following bays:
    - 2 x bays towards Redshaw
    - 4 x bays for 400/132kV SGTs
    - 2 x bus couplers
    - 2 x bus sections
    - 4 x bays for WCN2 circuits (the New Cumnock North circuit under SPT-RI-3315 would be transferred into the new GIS)
    - Space would also be left within the substation footprint to accommodate two traction transformers to provide Network Rail the ability to electrify their rail system which is approximately 4km from Glenmuckloch substation. Network Rail have not formally requested this from SPT, however, given their own decarbonisation targets, it is appropriate for SPT to make provisions for new traction transformers at the Glenmuckloch substation. Should the Network Rail's need for these two traction transformers not arise, this space can be used for other equipment. In addition, there is a requirement for 2x 33kV shunt reactors to be accommodated via the tertiaries of the proposed SGTs.

Employing a staged delivery strategy for the new Glenmuckloch substation limits the initial upfront investment and allows the contractual obligations of the generation connections to be met before establishing the new double busbar substation, which would only be required in line with the delivery of the new WCN2 400kV circuit.

The expected project delivery year for stage 1 of the reinforcement scheme is 2028, with a total estimated cost of £139.55m.

This EJP is submitted for Ofgem's assessment of the project's needs case and the selection of the preferred option. This will enable funding for pre-construction and early construction activities. A full cost submission will be made at the appropriate time. This approach has been taken as costs are uncertain at this time; therefore, it is appropriate to have the needs only assessment at this stage, and cost assessment once costs are more certain (post tender return).

3. Background Information

ZV route forms a strategic North-South power corridor between the South of Scotland and North of England. It consists of 126km of 400kV, L8 construction, double circuit OHL route which connects the SPT Strathaven 400kV substation, southeast of Glasgow, to the NGET Harker 400kV substation, north of Carlisle. Between these points, the Coalburn, Elvanfoot, Moffat and Gretna substations are connected to the ZV Route, enabling approximately 3.3GW of generation connections across these substations.

Redshaw 400kV substation (ref. SPT-RI-2060) is planned to connect into the ZV Route between Coalburn and Elvanfoot 400kV substations where circa 2.9GW of generation applications have become contracted in the South Lanarkshire area. The volume of existing generation developments in the area is presented in Appendix A, Figure A-3. The Figure A-4 in Appendix A indicates the scale of currently contracted and the existing generation developments.

The proposed 400kV reinforcement between Glenmuckloch and Redshaw substations provides an ability to export power out of the New Cumnock / South West Scotland groups, as well as enabling operational flexibility in the running arrangements spanning from the New Cumnock to the ZV route.

Bilateral Connection Agreements are in place between NESO and the developers of the generation projects detailed in Table 1. In each case, the SPT-RI-236 Glenmuckloch to ZV Route project is identified as the Enabling Works, in combination with SPT-RI-173, SPT-RI-302, and SPT-RI-2060, corresponding to Transmission Owner Construction Agreements that are in place between NESO and SPT. The works as outlined in Section 5.2, noted as ‘Stage 1’, would facilitate the connection of these generators to the SPT system.

Table 1 - Contracted Generation Dependent Upon SPT-RI-236 (Stage 1 Works at Glenmuckloch)

Connecting Substation	Contracted Development	Consent Status	TECA Score[3]	Contracted Energisation Date	SPT-RI-236, SPT-RI-173, SPT-RI-302 & SPT-RI-2060
[redacted]					

3 Transmission Economic Connections Assessment (TECA) – this assessment represents SPT’s best view of the contracted generation landscape to 2036 and forms the basis for evaluating the timely delivery of reinforcement works. This regular assessment activity provides updated projections of renewable development in Scotland, and feeds into SPT’s plans, ensuring the investment best meets the needs of users and customers.

Connecting Substation	Contracted Development	Consent Status	TECA Score[3]	Contracted Energisation Date	SPT-RI-236, SPT-RI-173, SPT-RI-302 & SPT-RI-2060
[redacted]					
	Total Capacity (GW)	-	[redacted]	-	**0.9GW**

† *The SPT-RI-236 project is also independently identified as Enabling Works facilitating change in access (RAA[4] to non-Firm[5]) for [redacted] Wind Farm.*

[4] Restricted Available Access (RAA) - when the transmission network is intact, network conditions may be such that the network becomes overloaded, requiring generation to be disconnected. Available on an interim basis only for developments with planning permission.

[5] Non-Firm - for an intact transmission network, no overloading may occur and thus generation will not be disconnected. Following a single transmission circuit outage (planned or unplanned), generation will be disconnected if overloading of the transmission network results. This will be dependent upon the particular network conditions (e.g., maximum generation and minimum load).

‡ *Connections to Glenglass, New Cumnock and Black Hill enabled by virtue of the commissioning of the Glenmuckloch to Redshaw connection offloading the New Cumnock 275/132kV SGTs.*

TECA Legend

TECA Probability	Designated Colour
High	
Medium	
Low	

The Glenmuckloch 400kV to ZV Route project, along with the SPT-RI-173 Glenglass to Glenmuckloch 132kV OHL, SPT-RI-302 Glenglass 132kV substation, and SPT-RI-2060 Redshaw 400kV substation, serve as Enabling Works for the connection of 0.9GW of renewable generation to the transmission network.

Additional connection applications have been received into the SPT system further upstream at New Cumnock substation and beyond which require further reinforcement to the SPT system given the overloads that could occur with the existing arrangement. Therefore, a new 400kV circuit is required between New Cumnock substation and Glenmuckloch to allow export through the Glenmuckloch to Redshaw circuits and to ZV Route. Table 2 below details the generation connection contingent on these works which are noted under SPT-RI-3315 and form the 'Stage 2' elements of work as outlined in Section 5.3.

Table 2 - Contracted Generation Dependent Upon SPT-RI-3315 (Stage 2 Works at Glenmuckloch)

Connecting Substation	Contracted Development	Consent Status	TECA Score	Contracted Energisation Date	Contingent on SPT-RI-3315
[redacted]					
Total Capacity (GW)		-	-	-	1.2GW

During the process of identifying and evaluating options for each connection offer, due regard has been given to the development of an efficient, co-ordinated, and economical system of electricity transmission. In addition to determining the most appropriate connection location, the optimal method of connection (e.g., overhead line, underground cable, wood pole vs. steel tower, connection voltage etc.) has also been considered.

The system requirements and design parameters of the Glenmuckloch 400kV to ZV Route reinforcements are summarised in Table 3.

Table 3: System Requirements and Design Parameters of Glenmuckloch to ZV Route Reinforcements

System Design Table	**Circuit/Project**	**Glenmuckloch to ZV Route Reinforcements**
Thermal and Fault Design	Existing Voltage (if applicable)	N/A
	New Voltage	400kV
	Existing Continuous Rating (if applicable)	N/A
	New Continuous Rating	3590A (Summer Rating)
	Existing Fault Rating (if applicable)	N/A
	New Fault Rating	50/55kA
ESO Dispatchable Services	Existing MVAR Rating (if applicable)	N/A
	New MVAR Rating (if applicable)	N/A
	Existing GVA Rating (if applicable)	N/A
	New GVA Rating	N/A
System Requirements	Present Demand (if applicable)	N/A
	2050 Future Demand	N/A
	Present Generation (if applicable)	N/A
	Future Generation Count	17
	Future Generation Capacity	0.9GW
Initial Design Considerations	Limiting Factor	Land availability
	AIS / GIS	GIS
	Busbar Design	Double Busbar
	Cable / OHL / Mixed	OHL
	SI	Strategic planning for land take – Railway feeder transformers and additional feeder bays for future connections in stage 3 have been included in layouts and platform at stage 1. Also, conductor sizing for future development of stage 3 has been included at stage 1.

4. Optioneering

This section provides a description of the options that have been considered to accommodate connection of renewable generation developments in the South-West Scotland area. A summary of each option is described, at the end of this section, in Table 3, while the system requirements and design parameters for the considered options are outlined in Table 4**.**

4.1. Baseline – Do Nothing or Delay

A 'Do Nothing' or 'Delay' option is not viable for this project and would be inconsistent with SPT's statutory duties and licence obligations, including Licence Conditions D3 and D4A. These require SPT to comply with the NETS SQSS and to offer to enter into an agreement with the system operator upon receipt of an application for connection, in line with the System Operator Transmission Owner Code (STC) and the associated Construction Planning Assumptions provided by NESO. The proposed works are identified as Enabling Works in the connection agreements relating to the projects in Table 1.

4.2. Option 1 – Glenmuckloch 400kV to Kilmarnock South 400kV

This option is to establish a 400kV system from Glenmuckloch substation to Kilmarnock South substation. As shown in Appendix A, Figure A-5, this option mainly entails the following:

- Extending the existing Kilmarnock South 400kV GIS substation and installing two 400kV feeder bays in order to terminate the two new 400kV circuits from the Glenmuckloch substation.
- Establishing a new Glenmuckloch 400kV substation, at the location of the planned Glenmuckloch 132kV substation, to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the HV side) and also terminate two new 400kV circuits from the Kilmarnock South substation.
- Extending the planned Glenmuckloch 132kV Air Insulated Switchgear (AIS) substation (constructed under SPT-RI-173) to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the LV side).
- Constructing a 400kV L8 double circuit OHL between Kilmarnock South and Glenmuckloch 400kV substations, approximately 45km in length. Each circuit would be twin GZTACSR Matthew GAP conductor operating at 170 degrees.

The estimated total cost for this option is approximately £215.14m. This option would not enable the future connection of the new 400kV double circuit constructed under WCN2 into the ZV route, reducing the interconnection and flexibility benefits of the new 400kV circuit with the existing MITS.

4.3. Option 2 – Glenmuckloch 132kV to Kilmarnock South 132kV

This option is to extend the 132kV network from Glenmuckloch substation to Kilmarnock South substation. As shown in Appendix A, Figure A-6, this option mainly entails the following:

- Extending the existing Kilmarnock South 400kV GIS substation to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the HV side).
- Establishing a new Kilmarnock South 132kV substation, at the location of the existing Kilmarnock South 400kV substation, to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the LV side) and also terminate new 132kV circuits from Glenmuckloch substation.
- Extending the planned Glenmuckloch 132kV AIS substation (SPT-RI-173) to terminate new 132kV circuits from Kilmarnock South substation.

- Constructing a new 132kV OHL double circuit between Kilmarnock South and Glenmuckloch 132kV substations, approximately 45km in length.

The standard conductor systems at 132kV do not meet the capacity required to match the proposed four 360MVA SGTs at Kilmarnock South. To meet this capacity either two 132kV L7 tower routes would need to be established utilising twin UPAS conductor on each, or a tower route using a larger tower suite typically used for 275kV or 400kV operation that could accommodate a larger conductor bundle. Constructing a route with a larger tower suite would add cost to the project that is being developed at 132kV level. Given the significant additional infrastructure required, this option is discounted in advance of detailed cost estimating exercise. This approach does not offer the most economic, efficient, or coordinated solution comparing to the other considered options.

Additionally, this option does not allow for the future development of the new 400kV double circuit in WCN2, therefore preventing achievement of the project's strategic goal.

4.4. Option 3 – Glenmuckloch 400kV to Elvanfoot 400kV

This option is to extend the 400kV network from Glenmuckloch to the existing Elvanfoot substation. As shown in Appendix A, Figure A-7, this option mainly entails the following:

- Extending the existing Elvanfoot 400kV AIS substation to terminate two new 400kV circuits from the Glenmuckloch substation.
- Establishing a new Glenmuckloch 400kV substation, at the location of the planned Glenmuckloch 132kV substation, to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the HV side) and also terminate two new 400kV circuits from the Elvanfoot substation.
- Extending the planned new Glenmuckloch 132kV AIS substation (SPT-RI-173) to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the LV side).
- Installing a 400kV L8 OHL double circuit between the Elvanfoot and Glenmuckloch 400kV substations, approximately 46km in length.

Based on the Elvanfoot 400kV substation layout, there are no spare bays available within the existing substation footprint. The geographical location of the Elvanfoot substation can be found in Appendix A, Figure A-12. At the east side of the substation, the area marked within the yellow lines is reserved for the delivery of the Elvanfoot 275/132kV transformer project (SPT-RI-226), which is due in end of 2026. This area cannot be extended further given the existing 275kV cable circuit serving the customer's connection, and regardless would not serve to extend the 400kV busbars as required. The associated standoff corridors are located further east of the discussed area.

Considering this, the only direction in which the substation could be extended, is to the west of the. Creating space at the west of the substation would require diversion of the Elvan Water to the south which is a significant civil engineering exercise. Additionally, the proximity of the compound to the river and based on experience from previous excavations, the water table is noted to be very high in the area.

Therefore, extending the Elvanfoot substation platform to the west will require dewatering wells and drainage installation which would add significant cost to the solution along with the associated risks with this type of activity. Also, the total level difference between the river and the existing compound is approximately 2.5-3m. Extension of the Elvanfoot substation to the west would need the land to be infilled with a Class 1 imported fill. Slope design for this would further increase the overall intake by an extra 9m toward west, which means the extended substation would be at capacity with no room for further extension. Given the civil engineering and associated environmental planning challenges this option is discounted in advance of detailed cost estimating exercise.

4.5. Option 4 – Glenmuckloch 132kV to Elvanfoot 132kV

This option is to extend the 132kV network from Glenmuckloch substation to Elvanfoot substation, as shown in Appendix A, Figure A-8. This option involves extending the existing Elvanfoot 400kV AIS substation in order to establish a new Elvanfoot 132kV substation. As detailed in Section 4.4, it is not possible to extend the Elvanfoot substation due to the layout of the substation, terrain, and new equipment at the substation.

Also, as detailed in Section 4.3, the standard conductor systems at 132kV do not provide the capacity required to match the proposed super grid transformers at the substation. It should be noted that this option does not allow for the future development of the new 400kV double circuit in WCN2, therefore preventing achievement of the project's strategic goal.

Due to these reasons, this option was discounted in advance of detailed cost estimating exercise.

4.6. Option 5 – Glenmuckloch 400kV to planned Redshaw 400kV

This option is to establish a 400kV system from the Glenmuckloch to the ZV Route. Multiple options to enable connection of a 400kV circuit between the Glenmuckloch and Redshaw substations have been analysed following with an evaluation of AIS and GIS equipment to construct the Glenmuckloch 400kV substation.

The connection of this new 400kV circuit to the ZV Route was one of the triggers behind the new Redshaw 400kV substation under SPT-RI-2060. The location of the planned Redshaw 400kV substation has been selected to balance the connections activity in the area with the new 400kV double circuit route from the Glenmuckloch area.

4.6.1. Option 5a – Glenmuckloch 400kV to planned Redshaw 400kV via OHL (twin Matthew GAP conductor)

As shown in Appendix A, Figure A-9, this option mainly entails the following:

- The installation of two 400kV GIS bays at Redshaw 400kV substation to accommodate termination of two new 400kV circuits from the Glenmuckloch substation.
- Establishing a new Glenmuckloch 400kV substation, at the location of the planned Glenmuckloch 132kV substation, to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the HV side) and also terminate two new 400kV circuits from the Redshaw substation.
- Extending the planned new Glenmuckloch 132kV AIS substation (constructed under SPT-RI-173) to facilitate connection of four 400/132kV 360MVA inter-bus auto transformers (at the LV side).
- Installing a 400kV L8 OHL double circuit between the planned Redshaw and Glenmuckloch 400kV substations, approximately 25km in length. Each circuit would be twin GZTACSR Matthew GAP conductor operating at 170 degrees.

Comprehensive details on the project's delivery stages and requirements are provided in Section 5.

4.6.2. Option 5b – Glenmuckloch 400kV to Planned Redshaw 400kV via OHL (twin Totara conductor)

Alternatively, an OHL conductor with lower thermal capacity could be used as the 400kV double circuit between the Redshaw and Glenmuckloch 400kV substations. At the current stage, the most suitable OHL conductor system to accommodate the SGT capacity at the Glenmuckloch 400kV substation (i.e., 2 x 360MVA on each circuit) is the twin AAAC Totara conductor operating at 90 degrees.

At the current development stage, the cost associated with utilising this type of conductor is approximately £11.29m cheaper than using twin Matthew GAP conductor as the OHL system between the Glenmuckloch and Redshaw substations (i.e., Option 5a).

However, considering the introduction of the WCN2 reinforcement project and the expected increase in power flow through the substations in the area, it is anticipated that there will be a need for conductors with higher thermal capacity between the Glenmuckloch and Redshaw substations. Should twin Totara conductor be selected as the OHL system at the current development stage, approximately £39.52m (2023/24 price) additional investment will be required to replace the conductor system upon construction of the WCN2 project, as well as the requirement for an early disposal of the assets.

Considering these, from a long-term perspective, utilisation of twin Totara conductor as the OHL circuit between these two substations will be approximately £28.23m more expensive than Option 5a on completion of the future WCN2 reinforcement project. Additionally, future reconductoring of these OHL circuits, which are necessary for the system upgrade, will require long outages, affecting system access for generation developments whose connection depends on the Glenmuckloch to ZV Route reinforcement project (i.e., as listed in Table 1).

Considering these reasons, employing this OHL conductor system was discounted. Further details are provided in Section 5.2.

4.6.3. Option 5c – Glenmuckloch 400kV to Planned Redshaw 400kV via Underground Cable

An alternative method of achieving a 400kV double circuit between the Redshaw and Glenmuckloch 400kV substations would be via underground cable (UGC). The installation of sections of underground cable within a project must balance economic, technical, and environmental considerations.

The works to connect the double circuit at both the Redshaw and Glenmuckloch substations would be largely unchanged from the option outlined above in Section 4.6.1; however, considering the required length of cable, there would likely be the requirement for reactive compensation equipment (i.e., shunt reactors) to be installed at both the substations to ensure maximised power flow in the UGC. This additional required equipment would result in a significant increase in the overall size of substation footprint.

Also, maintenance and inspection of UGCs are significantly more challenging than that of overhead infrastructure. Although the minor faults on cables are less common than on OHLs when cable faults do happen detecting fault and restoring the power in them will require extensive works and result in major disruptions. The UGCs might visually be less intrusive in comparison to the OHLs; however, they may not represent the best interest of the landowners (i.e., project stakeholders) due to the greater footprint and associated impact on the agricultural and forestry lands in the area. Installing 400kV UGCs requires excavating significant trenches to ensure safety and security of the cable. Additionally, significant number of overground infrastructures, in the form of manholes, need to be constructed to connect sections of cable and allow for any future maintenance access. These will have a permanent impact on the landscape and usability of the ground surrounding the trenches and manholes, especially over such a long cable route between Glenmuckloch to Redshaw.

At a high level, a like for like comparison of cable purchase cost for the same circuit length as OHL is estimated to be approximately £223.87m more expensive than the OHL circuit, without considering the additional cost for purchasing reactive compensation equipment and associated cable installation.

For this option, multiple cable routes have been considered and constructability of them have been assessed. The most preferred route is approximately 21km long. The incremental cost for this option, due to the difference in cost between cable and overhead line, is significant. As discussed, the disadvantages of utilising UGC overweigh its advantages from all perspectives, hence, this option is discounted.

4.6.4. Discussion – Glenmuckloch 400kV to Planned Redshaw 400kV Connection Circuit

Comparing the possible options to facilitate connection of a 400kV circuit between the Glenmuckloch and the Redshaw substations (i.e., Options 5a, 5b and 5c) the most optimum solution is employing a 400kV double circuit OHL with twin Matthew GAP conductor. Recognising the requirement for development of a 400kV substation to enable the 400kV double circuit OHL to be routed into Glenmuckloch, two sub-options have been evaluated, weighing up the relative advantages and disadvantages of using AIS or GIS equipment to install the 400kV substation in the following.

4.6.5. Option 5d – Glenmuckloch 400kV AIS to Planned Redshaw 400kV via OHL (twin Matthew GAP conductor)

The Glenmuckloch 400kV substation will be established at the location of Glenmuckloch 132kV AIS substation (constructed under SPT-RI-173) with an approximate OS coordinate of [redacted] as shown in Figure 1.

The Glenmuckloch 132kV substation was initially contracted following the connection application of [redacted] which triggered the establishment of a 132kV double busbar substation and 132kV OHL circuit towards Glenglass substation. This has been the design position since October 2017. Generation applications continued to be received in this area of the system and initially SPT-RI-236 was considered for a 132kV double circuit from Glenmuckloch to Redshaw substation. However, with consideration of the volume of new connections activity this plan was quickly upgraded to a 400kV solution - which was issued in September 2019. Given the short amount of time between the Glenmuckloch 132kV and 400kV substations being triggered, these have been considered in parallel in terms of determining an appropriately sized substation platform. Hence, initially air insulated switchgear was considered to develop the 400kV substation at Glenmuckloch. With respect to the 132kV substation, the size of the substation platform is dominated by the installation of the 400/132kV SGTs. Although, the use of GIS equipment has been considered at the time, it has been ultimately discounted due to the higher initial cost and lack of significant space saving given the required SGTs.

However, considering the introduction of the WCN2 reinforcement project, four additional feeder bays are required to accommodate the WCN2 connection, as well as the 400kV bus sections and bus couplers to provide the required operational flexibility and security. To utilise AIS equipment, the substation platform size for these requirements is [redacted] as shown in Appendix A, Figure A-13. The available land size to develop the platform for the Glenmuckloch compound is [redacted] which is shown with red boundary in Appendix A, Figure A-14. The geographical location of the available land (i.e., red boundary) with respect to the surrounding environment has been shown in Appendix A, Figure A-15, and Figure A-16. This land has been chosen as the only possible site for this substation that meets all of the project's objectives when considered with the requirements of the [redacted] generator which is one of the initial drivers for the substation itself. The land boundary is to ensure zero to minimum impact on the surrounding environment and natural habitat in the area, recognising [redacted] (which will ultimately become [redacted]). The final stage design for a 400kV AIS substation cannot be accommodated in the available land area. The space limitation within the substation red line boundary ultimately leads to the need for a GIS substation at Glenmuckloch 400kV. This will be undertaken during Stage 3 of the proposed works in this EJP.

Additionally, should an AIS equipment be selected for Glenmuckloch 400kV substation, ensuring compliance with Chapter 4 of the NETS SQSS can only be achieved by extensive cable works with the associated cost impacts.

A cost estimate for the AIS option - if land had been available - is £172.93m which is approximately £33.38m more expensive than the GIS option proposed in this EJP and does not include the cost of [redacted] that would be required to facilitate at this site, which would be significant.

4.6.6. Option 5e – Glenmuckloch 400kV GIS to Planned Redshaw 400kV via OHL (twin Matthew GAP conductor)

Considering the requirement for a long-term investment in the area and the need to facilitate the WCN2 reinforcement project in near future, utilising a GIS equipment for the Glenmuckloch 400kV will ensure the future requirements of the substation can fit within the optimal location identified for it.

Installing GIS equipment at the Glenmuckloch 400kV substation can provide additional space to accommodate strategic investment in the form of traction transformers for future connections. This is especially important given that the substation site is near railway infrastructure and would provide a strategic option to support Transport Scotland's ongoing electrification programme. This option also provides a number of additional spare 400kV bays for future connections in the area[6]. Utilising GIS equipment, the substation platform size required for all these will be [redacted], which accommodated by the available land within the red boundary (i.e., [redacted]). In comparison to Option 5d, AIS equipment does not provide any room for any future possible connections, traction transformers or any other reactive compensation devices.

In addition to a reduced land footprint requirement for switchgear compared to an AIS option, utilising a GIS equipment also facilitates flexibility in the alignment of overhead line entries and the correct disposition of circuit to busbar sections to ensure compliance with Chapter 4 of the NETS SQSS.

6 SP Distribution (SPD) is not expected to have a future requirement for connections at this location.

The use of 400kV GIS equipment also provides enhanced switchgear ratings which will be important as Glenmuckloch 400kV substation is planned to become a key node on a new export corridor between SPT and NGET. This connection would require switchgear to be rated at 5000A which can be readily achieved using GIS equipment as the available standard products such as instrument transformers are rated to this level.

A cost estimate for the GIS option is £139.55m which is approximately £33.38m cheaper than the AIS equipment discussed in Option 5d.

At this time (i.e., Stage 1 of the project delivery which is discussed in Section 5.2), the establishment of a 400kV double busbar GIS substation is not required, and instead includes the future platform and layout requirements only. By the time the GIS substation will be established under Stage 3 (expected no earlier than 2036), there will be more certainty around the exact requirements at the site which limits the risk around substation layout on day one.

4.7. Option 6 – Glenmuckloch 132kV to Redshaw 132kV

This option is to extend the 132kV network from Glenmuckloch to the planned Redshaw substation, as shown in Appendix A, Figure A-10. This option involves extending the planned Redshaw 400kV GIS substation and establish a new Redshaw 132kV substation.

As detailed in Section 4.3, the standard conductor systems at 132kV do not provide the capacity required to match the proposed super grid transformers at the substation. It should be noted that, this option does not allow for the future development of the new 400kV double circuit in WCN2, therefore preventing achievement of the project's strategic goal. As the result, this option does not provide an efficient system and is discounted in advance of detailed cost estimating exercise.

4.8. Option 7 – Glenmuckloch 275kV to Redshaw 275kV

This option is to construct a 275kV network from Glenmuckloch to the planned Redshaw substation. As shown in Appendix A, Figure A-11, this option mainly entails the following:

- Extending the planned Redshaw 400kV GIS substation (SPT-RI-2060) to facilitate connection of four 400/275kV 360MVA inter-bus auto transformers (at the HV side).
- Establishing a new Redshaw 275kV substation, at the location of the planned Redshaw 400kV substation, to facilitate connection of four 400/275kV 360MVA inter-bus auto transformers (at the LV side) and also terminate new 275kV circuits from the Glenmuckloch substation.
- Establishing a new Glenmuckloch 275kV substation, at the location of the planned Glenmuckloch 132kV AIS substation (SPT-RI-173) to facilitate connection of four 275/132kV 360MVA inter-bus auto transformers (at the HV side) and also terminate new 275kV circuits from the Redshaw substation.
- Extending the planned Glenmuckloch 132kV AIS substation (SPT-RI-173) to facilitate connection of four 275/132kV 360MVA inter-bus auto transformers (at the LV side).
- Installing the 275kV OHL circuits between the Redshaw and Glenmuckloch 275kV substations, approximately 25km in length.

In this option, there will be more transmission equipment required to step down the voltage from 400kV to 275kV level on the ZV Route as well as more switchgear and land. Developing 275kV infrastructure in this part of the network also limits further development of the system when compared with 400kV options, as well as adding another voltage level into the Redshaw substation alongside the contracted 132kV substation. This would also require a larger substation footprint at Redshaw to accommodate all the associated equipment for 400kV, 275kV and 132kV voltage levels. This option does not allow for the future development of the new 400kV double circuit in WCN2, therefore the project's strategic goal cannot be achieved.

Additionally, the standard conductor systems provide lower capacity at the 275kV voltage level compared to 400kV. The pre-fault continuous summer rating for the proposed OHL structure at 400kV (i.e., twin Matthew GAP on L8 steel lattice tower) provides only 1710MVA capacity at 275kV voltage level compared to 2490MVA at 400kV. Employing this type of conductor does not enable utilising the full capacity provided by the super grid transformers at the substation.

Due to these reasons, this option does not represent the most economic and efficient system; hence, is discounted in advance of detailed cost estimating exercise.

4.9. Selected Option - Glenmuckloch 400kV GIS to planned Redshaw 400kV via OHL (Option 5e)

The most appropriate option to enable the economic, efficient, and co-ordinated connection of the proposed renewable generation developments in the area spanning from Kilmarnock South to the ZV route, as well as facilitating a future strategic 400kV corridor, is to extend the 400kV OHL network from the proposed Glenmuckloch 400kV GIS substation to the planned Redshaw 400kV substation located on the ZV route (i.e., Option 5e).

4.10. Whole System Outcomes

Our optioneering approach has identified 'Whole System' interactions with other electricity network in the area, i.e., SP Distribution (SPD), in the development of our proposed solution and has considered the appropriate 'Whole System' outcome. SPT's proposed layout in this EJP has considered the expansion of the future network rail infrastructure in the nearby area.

Table 3 – Summary of Considered Options

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
Preferred – Option 5e: Glenmuckloch 400kV GIS to planned Redshaw 400kV via OHL (twin Matthew GAP conductor)	Refer to Appendix A, Figure A-9	Refer to Appendix A, Figure A-17	N/A	N/A	Early engagement with landowners, environmental bodies and employing low bearing pressure ground vehicles and trackway where possible to minimise extents of stone tracks.	Eleven[7] options have been reviewed in terms of scope feasibility, cost, delivery timescales, land requirements, system limitations and restoring SQSS compliant limit. Option 5e demonstrates a wider network capacity reinforcement while presenting the least risk to project deliverability.	N/A
Rejected – Baseline: Do Nothing / Delay	N/A	N/A	N/A	N/A	N/A	N/A	Inconsistent with SPT's various statutory duties and licence obligations.
Rejected – Option 1: Glenmuckloch 400kV to Kilmarnock South 400kV	Refer to Appendix A, Figure A-5	N/A	N/A	N/A	N/A	N/A	The required OHL for this option is around twice the length of the preferred scheme. Hence, it will be more expensive and challenging to consent in comparison with the proposed scheme. The estimated cost of this option is £215.14m. Additionally, it would not enable the future connection of the new 400kV double circuit constructed under WCN2 into the ZV route.
Rejected – Option 2: Glenmuckloch 132kV to Kilmarnock South 132kV	Refer to Appendix A, Figure A-6	N/A	N/A	N/A	N/A	N/A	The standard conductor systems at 132kV do not provide capacity required to match the proposed transformers at the substation. Also, the project's strategic goal will be missed as this option does not

7 NB: Option 5a - Glenmuckloch 400kV to planned Redshaw 400kV via OHL (twin Matthew GAP conductor) has been considered as a sub-option for the preferred Option 5e; hence, it has not been included in Table 4 separately.

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
							enable accommodating development of 400kV corridor in WCN2. This option will not be the most economic and efficient system; hence, was discounted in advance of detailed cost estimating exercise.
Rejected – Option 3: Glenmuckloch 400kV to Elvanfoot 400kV	Refer to Appendix A, Figure A-7	N/A	N/A	N/A	N/A	N/A	It is not possible to extend the Elvanfoot 400kV substation due to the layout of the substation, terrain, and new/existing equipment at the substation (MSCDN, cables and new connections). This option was discounted in advance of detailed cost estimating exercise.
Rejected – Option 4: Glenmuckloch 132kV to Elvanfoot 132kV	Refer to Appendix A, Figure A-8	N/A	N/A	N/A	N/A	N/A	This option requires extending the existing Elvanfoot 400kV AIS substation to establish a new Elvanfoot 132kV substation. It is not possible to extend the Elvanfoot 400kV substation due to the layout of the substation, terrain, and new equipment at the substation (MSCDN, cables and new connections). Also, the standard conductor systems at 132kV do not provide capacity required to match the proposed transformers at the substation. Additionally, by employing this option the project's strategic goal will be missed as this option does not enable accommodating development of 400kV corridor in WCN2. Considering these reasons, this option was discounted in advance of detailed cost estimating exercise.

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
Rejected – Option 5b: Glenmuckloch 400kV to planned Redshaw 400kV via OHL (twin Totara conductor)	N/A	N/A	N/A	N/A	N/A	N/A	The proposed conductor type in this option does not provide adequate thermal headroom for future reinforcements in the area, especially with respect to the need for accommodating WCN2 project in near future. Hence, this option was discounted.
Rejected – Option 5c: Glenmuckloch 400kV to planned Redshaw 400kV via Underground Cable	N/A	N/A	N/A	N/A	N/A	N/A	The installation of sections of underground cable within a project must balance economic, technical, and environmental considerations. This option was discounted as the incremental cost of utilising underground cable for the proposed scheme in comparison with the OHL is significant.
Rejected – Option 5d: Glenmuckloch 400kV AIS to planned Redshaw 400kV via OHL (twin Matthew GAP conductor)	N/A	N/A	N/A	N/A	N/A	N/A	Utilising an AIS equipment requires a larger substation platform size, in comparison with the GIS equipment (i.e., the preferred option in this EJP). An AIS equipment cannot be accommodated when considered within the available land boundary. The cost estimate for the AIS option – if land had been available – is approximately £33.38m more expensive than the proposed solution in this EJP (i.e., Option 5e).
Rejected – Option 6: Glenmuckloch 132kV to planned Redshaw 132kV	Refer to Appendix A, Figure A-10	N/A	N/A	N/A	N/A	N/A	The standard conductor systems at 132kV do not provide capacity required to match the proposed transformers at the substation. Additionally, by employing this option the project's strategic goal will be missed as this option does not enable accommodating development of 400kV corridor in WCN2.

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
							This option does not provide an efficient system; hence, was discounted in advance of detailed cost estimating exercise.
Rejected – Option 7: Glenmuckloch 275kV to Redshaw 275kV	Refer to Appendix A, Figure A-11	N/A	N/A	N/A	N/A	N/A	This option requires more transmission equipment at the planned Redshaw 400kV substation to step down the voltage to 275kV as well as more switchgear and land. Additionally, by employing this option the project's strategic goal will be missed as this option does not enable accommodating development of 400kV corridor in WCN2. Also, the standard conductor systems provide less capacity at the 275kV voltage level compared to 400kV. Extending the 275kV transmission network between Glenmuckloch and Redshaw will not be the most economic and efficient system; hence, this option was discounted in advance of detailed cost estimating exercise.

Table 4 – System Requirements and Design Parameters for the considered options

System Design Table	Circuit/Project	**Preferred – Option 5e[8]:** Glenmuckloch 400kV GIS to Planned Redshaw 400kV via OHL (twin Matthew GAP conductor)	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 1:** Glenmuckloch 400kV to Kilmarnock South 400kV	**Rejected – Option 2:** Glenmuckloch 132kV to Kilmarnock South 132kV	**Rejected – Option 3:** Glenmuckloch 400kV to Elvanfoot 400kV	**Rejected – Option 4:** Glenmuckloch 132kV to Elvanfoot 132kV
Thermal and Fault Design	Existing Voltage (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	New Voltage	400kV	N/A	400kV	132kV	400kV	132kV
	Existing Continuous Rating (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	New Continuous Rating	3590A (Summer Rating)	N/A	3590A (Summer Rating)	1150A (Summer Rating)	3590A (Summer Rating)	1150A (Summer Rating)
	Existing Fault Rating (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	New Fault Rating	50/55kA	N/A	50/55kA	20/25kA	50/55kA	20/25kA
ESO Dispatchable Services	Existing MVAR Rating (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	New MVAR Rating (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	Existing GVA Rating (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	New GVA Rating	N/A	N/A	N/A	N/A	N/A	N/A
System Requirements	Present Demand (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	2050 Future Demand	N/A	N/A	N/A	N/A	N/A	N/A
	Present Generation (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A
	Future Generation Count	17	17	17	17	17	17
	Future Generation Capacity	0.9GW	0.9GW	0.9GW	0.9GW	0.9GW	0.9GW
Initial Design Considerations	Limiting Factor	Land availability	N/A	It is more expensive and challenging to consent in	It does not enable the most economic and efficient electricity	It is not possible to extend the Elvanfoot 400kV substation due	It is not possible to extend the Elvanfoot substation due to the

8 NB: Option 5a – Glenmuckloch 400kV to planned Redshaw 400kV via OHL (twin Matthew GAP conductor) has been considered as a sub-option for the preferred Option 5e; hence, it has not been included in Table 5 separately.

System Design Table	Circuit/Project	**Preferred – Option 5e[8]:** Glenmuckloch 400kV GIS to Planned Redshaw 400kV via OHL (twin Matthew GAP conductor)	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 1:** Glenmuckloch 400kV to Kilmarnock South 400kV	**Rejected – Option 2:** Glenmuckloch 132kV to Kilmarnock South 132kV	**Rejected – Option 3:** Glenmuckloch 400kV to Elvanfoot 400kV	**Rejected – Option 4:** Glenmuckloch 132kV to Elvanfoot 132kV
				comparison with the proposed scheme. Does not enable WCN2 into ZV route.	system in the area. Does not enable WCN2 into ZV route.	to the layout of the substation, terrain, and new/existing equipment at the substation.	layout of the substation, terrain, and new equipment at the substation. Also, the standard conductor systems at 132kV do not provide capacity required to match the proposed transformers at the substation. Additionally, it does not enable WCN2 into the ZV route.
	AIS/ GIS	GIS	N/A	GIS	AIS	GIS	AIS
	Busbar Design	Double busbar	N/A	Double busbar	Double busbar	Double busbar	Double Busbar
	Cable/ OHL/ Mixed	OHL	N/A	OHL	OHL	OHL	OHL
	SI	- Inclusion of rail track feeder transformers and additional feeder bays for future connections in Stage 3. - Conductor sizing at Stage 1 for future development of Stage 3.	N/A	- Inclusion of rail track feeder transformers and additional feeder bays for future connections in Stage 3. - Conductor sizing at Stage 1 for future development of Stage 3.	No development of 400kV substation reduces strategic investment options.	- Inclusion of rail track feeder transformers and additional feeder bays for future connections in Stage 3. - Conductor sizing at Stage 1 for future development of Stage 3.	No development of 400kV substation reduces strategic investment options.

System Design Table	Circuit/Project	**Rejected – Option 5b:** Glenmuckloch 400kV to planned Redshaw 400kV via OHL (twin Totara conductor)	**Rejected – Option 5c:** Glenmuckloch 400kV to planned Redshaw 400kV via Underground Cable	**Rejected – Option 5d:** Glenmuckloch 400kV AIS to planned Redshaw 400kV via OHL (twin Matthew GAP conductor)	**Rejected – Option 6:** Glenmuckloch 132kV to Redshaw 132kV	**Rejected – Option 7:** Glenmuckloch 275kV to Planned Redshaw 275kV
Thermal and Fault Design	Existing Voltage (if applicable)	N/A	N/A	N/A	N/A	N/A
	New Voltage	400kV	400kV	400kV	400kV	132kV
	Existing Continuous Rating (if applicable)	N/A	N/A	N/A	N/A	N/A
	New Continuous Rating	2170A (Summer Rating)	3590A (Summer Rating)	3590A (Summer Rating)	1150A (Summer Rating)	3590A (Summer Rating)
	Existing Fault Rating (if applicable)	N/A	N/A	N/A	N/A	N/A
	New Fault Rating	50/55kA	50/55kA	50/55kA	20/25kA	40/40kA
ESO Dispatchable Services	Existing MVAR Rating (if applicable)	N/A	N/A	N/A	N/A	N/A
	New MVAR Rating (if applicable)	N/A	N/A	N/A	N/A	N/A
	Existing GVA Rating (if applicable)	N/A	N/A	N/A	N/A	N/A
	New GVA Rating	N/A	N/A	N/A	N/A	N/A
System Requirements	Present Demand (if applicable)	N/A	N/A	N/A	N/A	N/A
	2050 Future Demand	N/A	N/A	N/A	N/A	N/A
	Present Generation (if applicable)	N/A	N/A	N/A	N/A	N/A
	Future Generation Count	17	17	17	17	17
	Future Generation Capacity	0.9GW	0.9GW	0.9GW	0.9GW	0.9GW
Initial Design Considerations	Limiting Factor	The proposed conductor type in this option does not provide adequate thermal headroom for future reinforcements in the area, especially with respect to the need for accommodating WCN2 project in near future. Hence, this option was discounted.	The incremental cost of utilising underground cable for the proposed scheme in comparison with the OHL is significant.	- Land availability. - The incremental cost of utilising an AIS equipment for the proposed scheme in comparison with the GIS equipment is significant, and not feasible within available land.	It does not enable the most economic and efficient electricity system in the area. Additionally, it does not enable WCN2 into the ZV route.	It does not enable the most economic and efficient electricity system in the area. Additionally, it does not enable WCN2 into the ZV route.
	AIS/ GIS	GIS	GIS	AIS	AIS	GIS

System Design Table	Circuit/Project	**Rejected – Option 5b:** Glenmuckloch 400kV to planned Redshaw 400kV via OHL (twin Totara conductor)	**Rejected – Option 5c:** Glenmuckloch 400kV to planned Redshaw 400kV via Underground Cable	**Rejected – Option 5d:** Glenmuckloch 400kV AIS to planned Redshaw 400kV via OHL (twin Matthew GAP conductor)	**Rejected – Option 6:** Glenmuckloch 132kV to Redshaw 132kV	**Rejected – Option 7:** Glenmuckloch 275kV to Planned Redshaw 275kV
	Busbar Design	Double Busbar	Double Busbar	Double Busbar	Double busbar	Double busbar
	Cable/ OHL/ Mixed	Underground Cable	OHL	OHL	OHL	OHL
	SI	- Inclusion of rail track feeder transformers and additional feeder bays for future connections in Stage 3. - Conductor sizing at Stage 1 for future development of Stage 3.	- Inclusion of rail track feeder transformers and additional feeder bays for future connections in Stage 3. - Conductor sizing at Stage 1 for future development of Stage 3.	Option not feasible within land available, including no additional space for spare bays or proposed rail track connection.	No development of 400kV substation reduces strategic investment options.	No development of 400kV substation reduces strategic investment options.

5. Proposed Works & Associated Cost

5.1. Project Summary

The recommended option to enable economic, efficient, and coordinated connection of generation development connections in the New Cumnock / Blackhill / Glenglass area of the SPT system is to establish a new Glenmuckloch 400kV GIS substation. This includes installation of approximately 25km of 400kV OHL from Glenmuckloch to the planned Redshaw substation which is being formed under SPT-RI-2060 and will connect into the existing 400kV corridor between Strathaven and Harker substations on the existing ZV Route.

At the time this scheme was initially proposed (circa October 2017), installing three 240MVA SGTs at the Glenmuckloch 400kV GIS substation was sufficient to enable the connection of the generation developments in the area. However, the continual growth in this area has increased this need to four 360MVA SGTs, as well as the need to split the 132kV double busbar substation into two to manage the fault levels.

Future network reinforcement in the area (i.e., the WCN2 project) requires the incorporation of the proposed new 400kV double circuit, which would be constructed from northwest towards Glenmuckloch and continue south through the SPT system. As briefly introduced in Section 2, the WCN2 project focuses on constructing a new 400kV corridor from Kilmarnock South 400kV substation, in SWS area, down to cross the SPT/NGET border (i.e., B6 boundary). The WCN2 scheme, by increasing network capability and connectivity, plays a key role in enabling other reinforcements in the region and over the B6 boundary. Although this project is not within the scope of this proposal, the appropriate engineering decisions need to be considered as part of the establishment of the 400kV substation under SPT-RI-236 such that the ability to incorporate this new double circuit into Glenmuckloch is feasible when required.

In advance of future network development in the area, and to ensure project delivery in a timely manner in order to support the current generation development connections, it is proposed that required interventions are executed in a sequence of staged investments.

Stage 1 is currently being progressed. As related projects develop, and the delivery programme firms-up, the substation layouts under Stage 1 will be continually reviewed to ensure it efficiently meets the needs of subsequent Stages 2 and 3.

5.2. Stage 1

In the Stage 1 delivery phase the entire Glenmuckloch 400kV substation platform will be established to provide a point of connection for the double circuit OHL to the Redshaw 400kV substation as well as four 400/132kV 360MVA SGTs to feed the Glenmuckloch 132kV substation. The Glenmuckloch 400kV substation will be established with the minimum required switchgear as an interim solution to facilitate connection of the contracted generation ahead of the development of the WCN2 project which will bring further 400kV circuits into the Glenmuckloch area.

To ensure the proposed reinforcement scheme provides a solution in respect of all of the main project drivers, the full 400kV GIS double busbar Glenmuckloch substation will be constructed in Stage 3 of the project delivery. This approach minimises the need for extension of the GIS substation to accommodate future 400kV circuits/new connections, but not constructing the GIS substation until 2036 at the earliest. Under Stage 1 of the works, the Glenmuckloch substation platform will be established such that the future stages can be developed and delivered in accordance with the longer-term programme of work, which will address all of the future drivers.

The proposed electrical layout of Glenmuckloch substation for Stage 1 can be found in Appendix A, Figure A-17.

The associated Stage 1 works are summarised as follows:

Pre-Engineering Works

The following list is indicative based on previous experience of such sites. The following surveys will be carried out[9]:

- Topographical survey of the site.
- GPR survey of areas to be excavated to validate approximate locations of buried services.
- Ground-bearing capacity checks.
- Geo environmental investigation to identify the relevant geotechnical parameters to facilitate the civil engineering design works.
- Earthing study.
- Insulation co-ordination study.
- Define final tower positions for Redshaw to Glenmuckloch circuits.
- Transport survey to assess access for the new equipment.
- Environmental study.

Glenmuckloch 132kV substation

Glenmuckloch 132kV AIS substation will be delivered as part of the SPT-RI-173 project to accommodate the new connection projects in advance of the requirement for SPT-RI-236, but with the platform and substation laid out with a view to accommodate the future works. At the Glenmuckloch 132kV substation, it will be necessary to extend the 132kV double busbar for the following items[10]:

- Spare bay for a future connection.
- SGT1 bay.
- SGT3 bay. This bay will comprise busbar disconnectors to minimise future outage needs.
- Spare bay for a future connection.
- 2 bus sections to create flexible 132kV double busbars.
- SGT2 bay. This bay will comprise busbar disconnectors to minimise future outage needs.
- SGT4 bay.

The works at the Glenmuckloch 132kV substation shall include:

- Extending the AIS substation.
- Installing two bus sections within the Glenmuckloch 132kV substation.
- Connecting the four 400/132kV 360MVA inter-bus auto transformers to the Glenmuckloch 132kV substation.
- All control and protection work.

9 Any surveys that have been undertaken for the site under SPT-RI-173 and are still suitable and relevant will be reused.

10 These are based on the order from left to right of the Glenmuckloch 132kV substation shown in Appendix A, Figure A-17).

- All environmental and civil works.

Glenmuckloch 400kV substation

As shown in Appendix A, Figure A-17, the works at the interim Glenmuckloch 400kV substation shall include:

- Terminate each of the Glenmuckloch – Redshaw 400kV OHL circuits (i.e., Redshaw 1 & Redshaw 2 circuits) into the Glenmuckloch 400kV substation.
- Install appropriate lengths of 400kV busbar between the OHL gantries and the 400/132kV SGTs.
- Install Disconnecting-Circuit Breakers (DCBs) at the HV side of each SGT.
- Install four 400/132kV, 360MVA inter-bus auto transformers. The transformers will be configured such that two units will be connected to each 400kV circuit towards Redshaw.
- Install LMS across the four 400/132kV SGTs and interface this with the relevant generators such that the post-fault loading across the units can be managed[11].
- All control and protection work.
- All environmental and civil works.

The civil engineering works associated with Stage 1 of this element of the project are set out below. These works include layout for the full 400kV GIS substation, including space for all future potential GIS bays, and development of the interim 400kV substation.

- The design of foundations and structures necessary to construct the site civil platform in the Glenmuckloch substation area.
- The design and construction of the civil platform in the area of the Redshaw overhead line entry to accommodate termination of the 400kV OHL.
- The design and construction of foundations and structures necessary to support the equipment within the substation area.
- Enabling works to achieve the above requirements to facilitate temporary and/or enduring accesses for construction, operation, and maintenance purposes.

Space shall be retained within the wider site design for the connection of one 33kV 60MVAr air-cored shunt reactor to the 33kV winding of one 400/132kV 360MVA transformers on each of the Glenmuckloch – Redshaw No.1 and No. 2 400kV circuits (i.e., two shunt reactors). The installation of the shunt reactors and associated equipment shall be subject to separate authorisation.

Redshaw 400kV substation

The Redshaw 400kV GIS substation will be delivered as part of the SPT-RI-2060 project. At the Redshaw 400kV substation there will be requirement for two GIS bays to be installed for connection of the 400kV double circuit OHL from Glenmuckloch. The works at Redshaw are summarised as follows:

- Extend the planned GIS substation to install two 400kV bays for connection of the 400kV double circuit OHL.

[11] The installation of LMS equipment is required to ensure in the event of losing one of the SGTs supplying the Glenmuckloch 132kV switchboard, generation can be tripped off to avoid an overload on the remaining unit(s). This LMS installation is also consistent with the contractual agreements of those renewable generations that requested a non-firm connection, as described in Table 1.

- Terminate the two 400kV OHL circuits from the Glenmuckloch substation.
- All control and protection work.
- All environmental and civil works.

Glenmuckloch to Redshaw 400kV OHL

A 400kV OHL double circuit will be established between two new feeder bays at the Redshaw 400kV GIS substation and two AIS bays at the interim Glenmuckloch 400kV substation. As can be found in Appendix A, Figure A-17, DCBs will be installed on the 400kV AIS busbar to enable connection of the 400kV OHL to SGTs. At Stage 3, when the SGTs and OHL circuits will be separately connected to the 400kV GIS double busbar, these DCBs will be recovered and reused elsewhere in the transmission network.

The proposed route for this OHL circuit is approximately 25km in length and will be constructed using new 400kV L8 towers. The conductor system to be installed on this route has been subject to change given the evolving background of generation and network connectivity in this area. When SPT-RI-236 was originally triggered, Glenmuckloch 400kV substation was a radial connection fed from Redshaw substation therefore the conductor system needed to be specified in line with the SGT capacity at Glenmuckloch (2 x 360MVA on each circuit). However, given the introduction of the WCN2 circuit in recent months and Glenmuckloch's connectivity changing from simply being a radial feed to connecting three double circuits means that the 400kV circuits between Redshaw and Glenmuckloch need to be designed for higher flows. As a result, it is the intention to install a conductor system between Redshaw and Glenmuckloch which would be in line with the conductor system on ZV Route[12] which would be a 2 x 620mm^2 GZTACSR Matthew 'GAP' conductor system as also described in Section 4.6.2.

The overhead line works are summarised as follows:

- Establish a 400kV L8 double circuit OHL between Glenmuckloch and Redshaw 400kV substations, approximately 25km in length.
- String each circuit with twin Matthew GAP conductor operating at 170°C. The rating of twin GAP conductors operating at this temperature is as follows:

Table 5 – Rating of Twin GAP Conductor at 400kV and Operating at 170°C

Season / State	Amps	MVA
Winter Pre Fault	3760	2610
Winter Post Fault	4480	3100
Spring/Autumn Pre Fault	3700	2560
Spring/Autumn Post Fault	4400	3050
Summer Pre Fault	3590	2490
Summer Post Fault	4270	2960

The proposed 400kV OHL route from the Redshaw 400kV substation to the Glenmuckloch 400kV substation is indicated in Appendix A, Figure A-20. The route is subject to change based on planning and consenting processes.

12 Post completion of SPT-RI-231 – Elvanfoot to Harker Uprating, and SPT-RI-1797 – Strathaven to Elvanfoot 400kV Reinforcement projects.

5.2.1. Estimated Total Project Cost (Stage 1 only)

A Business Plan provision and estimated cost of the project is indicated in Table 6. Costs provided include direct, indirect and risk contingency costs.

Table 6 – Project cost estimate breakdown

Item	Description	Estimated CAPEX (£m 23/24)
[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
Total		£139.55

Expenditure incidence is summarised in Table 7.

Table 7 – Summary of expenditure incidence

Energisation Year	RIIO-T1 Total: CAPEX	Yr. 2022: CAPEX	Yr. 2023: CAPEX	Yr. 2024: CAPEX	Yr. 2025: CAPEX	Yr. 2026: CAPEX	Yr. 2027: CAPEX	Yr. 2028: CAPEX	Yr. 2029: CAPEX	RIIO-T2 Total: CAPEX	RIIO-T3 Total: CAPEX	Total: CAPEX
2028	£0.13m	£0.35m	£0.10m	£0.59m	£0.47m	£9.61m	£56.70m	£70.12m	£1.49m	£11.11m	£128.30m	£139.55m

5.2.2. Regulatory Outputs

The indicative primary asset outputs for Stage 1 are identified in Table 8.

Table 8 – Indicative Primary Asset Outputs

Asset Category	Asset Sub-Category Primary	Voltage	Forecast Additions[13]	Forecast Disposal
Circuit Breaker	CB (Air Insulated Busbar)	132kV	6 units	-
Circuit Breaker	CB (Air Insulated Busbar)	400kV	4 units	-
Substation Platform	Platform Creation	400kV	1 unit	-
Overhead Tower Line	400kV OHL (Tower Line) Conductor	>2550MVA	48.3km (2 x 24.15km)	-
Overhead Tower Line	Tower	400kV	73 units	-
Overhead Line Fittings	Fittings	400kV	146 units	-

5.3. Stage 2

Currently Stage 2 and Stage 3 are subject to the completion of future planning for network needs and as such may change in in terms of delivery and physical scope.

In Stage 2 of the scheme one leg of the New Cumnock – Glenmuckloch 400kV OHL double circuit will be connected into the Glenmuckloch 400kV substation. This will enable the connection of the contracted generation as set out in Table 2.

13 Forecast Additions are indicative pending further detail design.

The currently contracted date for the completion of Stage 2 is October 2033. Given the proposed configuration under Stage 1 (Section 5.2) a DCB will be installed on the HV side of SGT1 to terminate the New Cumnock North 2 OHL at the Glenmuckloch 400kV substation. The installation of the New Cumnock – Glenmuckloch 400kV OHL double circuit is triggered and fully captured under SPT-RI-3315 and is outside of the scope of this scheme.

The proposed electrical layout of the Glenmuckloch substation for Stage 2 can be found in Appendix A, Figure A-18.

Glenmuckloch 400kV substation

The associated works at the interim Glenmuckloch 400kV substation shall include the following items:

- Terminate one leg of the New Cumnock North – Glenmuckloch 400kV OHL circuit at the Glenmuckloch substation.
- Install a DCB on the 400kV busbar run between the OHL termination and the HV side of the SGT.
- All control and protection work.
- All environmental and civil works.

The civil engineering works associated with Stage 2 of this element of the project are as follows:

- The design and construction of the civil platform in the area of the New Cumnock North overhead line entry to accommodate termination of the New Cumnock North No. 2 OHL 400kV circuit.
- The design and construction of foundations and structures necessary to support the equipment within the substation area.

Enabling works to achieve the above requirements to facilitate temporary and/or enduring accesses for construction, operation, and maintenance purposes.

5.4. Stage 3

To fully accommodate the connection of the WCN2 route 400kV double circuit OHL, with a current earliest in-service date (EISD) of 2036, the Glenmuckloch 400kV substation will require a 400kV switchboard to be installed to create an appropriate bussing point on the network. Given the space constraints around the site, it is proposed to establish a 400kV GIS double busbar substation connecting the three 400kV double circuits – double circuit east towards Redshaw (Redshaw 1 & 2 circuits), double circuit northwest towards New Cumnock North (New Cumnock North 1 & 2 circuits) and double circuit southeast towards NGET border (Dumfries North 1 & 2 circuits).

The Stage 3 works focus on establishment of the 400kV GIS double busbar at the Glenmuckloch substation, along with the associated bus sections and bus couplers. At this stage, the 400/132kV 360MVA Glenmuckloch SGTs, as well as the Redshaw 1, Redshaw 2 and New Cumnock North 2 OHLs will be disconnected from the interim Glenmuckloch AIS busbar and will be separately connected to the new 400kV GIS double busbar.

The DCBs that were installed during the previous stages of the project to connect these circuit to the interim Glenmuckloch 400kV substation will be recovered and reused elsewhere in the transmission network. The new 400kV GIS substation will also accommodate the new 'New Cumnock North' 400kV double circuit (i.e., New Cumnock North 1), two new 400kV circuits that will continue south making up the WCN2 double circuit as well as space for future connections.

The full Glenmuckloch 400kV GIS substation will be configured to accommodate 15 bays which includes the space for future extensions to two spare bays at each end of the busbar, should the need for future connections arise.

The expected project delivery date for Stage 3 of the scheme is based upon the current EISD of WCN2.

The proposed electrical layout of the Glenmuckloch substation for Stage 3 can be found in Appendix A, Figure A-19. Space will be allocated within the Glenmuckloch substation to accommodate the future connection of traction supplies in this area which can be seen on the layout drawing. Whilst this has not been formally requested by Network Rail at this time, SPT believes this is a prudent strategic decision to make. Should the Network Rail's need for these two traction transformers does not arise, this space can be used for other equipment.

The associated works in this stage are summarised in the following -

Glenmuckloch 400kV substation
The full Glenmuckloch 400kV GIS double busbar substation shall be configured as follows:

- 2 x 400kV bays for Redshaw circuits.
- 2 x 400kV bays for New Cumnock North circuits.
- 2 x 400kV bays for Dumfries North circuits.
- 4 x 400kV bays for SGT connections.
- 2 x 400kV bus couplers.
- 2 x 400kV bus sections.
- 4 x spare bays' space provision (2 at each end of the building).

The GIS building shall be designed for the future extension of a minimum of two bays, should the need arise. The civil engineering works associated with the Stage 3 elements of works should be largely already accommodated given the substation platform will be designed to accommodate the GIS substation. However, some specific items will still be required, as follows:

- The design and construction of the civil platform near to the New Cumnock North overhead line entry, to accommodate termination of the New Cumnock North No. 1 OHL 400kV circuit.
- The design and construction of the civil platform near to the Dumfries North overhead line entry to accommodate termination of the double circuit 400kV OHL (southern sections of the WCN2 circuits).
- The design and construction of foundations and structures necessary to support the equipment within the substation area.
- Enabling works to achieve the above requirements to facilitate temporary and/or enduring access for construction, operation, and maintenance purposes.

5.5. Environmental and Consents Works

Section 37 consent will be sought from the Scottish Ministers to install the new double circuit L8 400kV OHL. Deemed planning permission will be sought for the 400kV OHL and the proposed Glenmuckloch substation, as well as the ancillary development. Relevant landowner agreements will also need to be put in place where required.

The Section 37 application to the Energy Consents Unit will be accompanied by an Environmental Impact Assessment Report (EIA Report). The information contained in the EIA Report fulfils the requirements of the EIA Regulations and will enable Scottish Ministers as the decision-making authority, to make their decisions on the application for Section 37 consent and deemed planning permission.

The EIA Report details the findings of the assessment of the likely significant effects of the proposals on the environment in terms of its construction and operation. The assessment forms part of the wider process of EIA, which is undertaken to ensure that the likely significant effects, both positive and negative of certain types of development are considered in full by the decision maker prior to the determination of an application for Section 37 consent and for deemed planning permission.

The main strategy for minimising adverse environmental effects of the proposals will be through careful OHL routeing. While some environmental effects can be avoided through careful routeing, other effects are best mitigated through local deviations of the route, the refining of tower locations and appropriate construction practices. Additionally, in certain cases, specific additional mitigation measures will be required, and these have been identified through the EIA process.

Consultation has taken place with statutory stakeholders including SEPA and Nature Scot in relation to the proposals. Consultation was also undertaken with all other relevant stakeholders including the wider public and landowners.

6. Deliverability

We have applied SPT project management approach to ensure that this project work is delivered safely, and in line with the agreed time, cost, and quality commitments. We have a proven track record of delivering essential transmission network upgrade projects and will draw upon this knowledge and experience to effectively manage these works. We work closely with our supply chain partners and this relationship is critical to the successful delivery of our plans. Our supply chain provides the support and agility to respond to changes in workload over the course of a price review. Further information is contained within our Workforce & Supply Chain Resilience Annex. We have assigned a dedicated Project Manager to the works at every stage who is responsible for overall delivery of the scope and is the primary point of contact for all stakeholders. The project manager responsibilities, albeit not limited, include:

- Handing over the project from development phase to delivery phase and ensuring minimum requirements of the SPT project handover are met.
- System and customer updates to reflect transfer of ownership.
- Leading tender activities during development phase.
- Provision of a comprehensive resource plan to encompass all contractor and SPT operational activities.
- Booking outages and risks of trip with operational planning.
- Ensure all offline works are completed prior to any outage being taken to reduce system risk.
- Co-ordinate all site commissioning issues.
- Chair commissioning panel meetings.
- Chair progress meetings.
- Maintain the site quality plan.

Some further responsibilities of the project manager are discussed in the following sub-sections.

6.1. Delivery Schedule

A standard approach has been applied to the planning phase of these works and that will continue for the reporting and the application of processes and controls throughout the lifecycle. Table 9 summarises the key milestones within the delivery schedule for Stage 1 of this project.[redacted]

[redacted]

Table 9 – Summary of Key Milestones within the Project Delivery Schedule (Stage 1 only)

Item	Project Milestone	Estimated Completion Date
1	Earthworks ITT	December 2024
2	Conclude Missives on Glenmuckloch 400kV Substation	January 2025
3	Section 37 Submission	April 2025
4	ITT OHL	June 2025
5	Section 37 Award Date	April 2026
6	OHL Contract Award Date	July 2026
7	Substation Site Works Commencement	July 2026
8	Earthworks Contract Award Date	August 2026
9	OHL Works Commencement	November 2026
10	Commissioning	October 2028

SP Energy Networks (SPEN) for its procurement process follows a generic global process (INS 00.08.04) for supplier pre-qualification, product technical assessment, manufacturing factory capability assessment and quality audit. The SPEN's equipment approval procedure is to:

- identify and select candidate equipment.
- ensuring the candidate equipment is assessed to meet the specific requirements of SPEN.
- ensuring a structured and consistent approach is adopted for the approval of candidate equipment prior to energisation.
- Ensuring no equipment is installed on SPEN's network without first having been examined in accordance with the procedure and issued with a formal internal approval.

ASSET-02-002 specifies the SPEN's approval process inclusive of assessment scope and business processes for various equipment.

Regular meetings with the project and construction management teams will be undertaken to assess the ongoing effectiveness of the project management interfaces.

The Project Manager will facilitate internal Project team meetings, in which project progress and deliverables will be reviewed and any arising risks or issues will be discussed and addressed.

6.2. Risk and Mitigation

A Project Risk Register has been developed, collaboratively, during the initial project kick-off meeting to identify any risks to the delivery plan. Mitigation strategies have been developed to manage the risks identified and these will be implemented by the Project Manager. The risk register shall remain a live document and will be updated by the project team on an ongoing basis. The top scheme risks as currently identified are as follows:

Table 10 - Main Scheme Risks and Mitigation Plans

Risk Title	Risk Description	Mitigation Plan
Planning Consent	Delay in submission of Section 37 application and receiving approvals from Scottish Ministers may delay the project delivery plans.	Regular meetings will be held with developers and/or landowners to satisfy the stakeholders requirements, manage an in-time submission of Section 37 application and frequent follow ups with Scottish Ministers to ensure receiving the approvals on time.
Compulsory Purchase Order (CPO)	CPO being sought due to being unable to secure voluntary land rights for 400kV substation platform and parts of the circuit route.	Regular meetings will be held with SPEN's planning and permission team to ensure SPEN's OHL route principles have been met. Continued engagement with relevant landowners.
Network's Growing Needs	Considering the incorporation of this scheme in WCN2 reinforcement project, changes to the scope of WCN2 or any changes in the wider system needs may require changes in Glenmuckloch substation layout and delay potential Geotech and Topology surveys.	Executing the project in a sequence of staged investments to ensure flexibility in responding to future network developments in the region. This approach will ensure a timely project delivery.

6.3. Quality Management

SPT adopts a 'life cycle' approach to Quality Management in major project delivery. Our Management Systems are certified to ISO 9001, ISO 14001 and ISO 45001. The key quality management areas are detailed below:

6.3.1. Quality Requirements During Project Development

Any risk or opportunity that may affect the quality of the product is detailed in the Project Risk Register. The suppliers of main equipment may also receive a Factory Acceptance Test Inspection when the asset is being built.

6.4. Quality Requirements in Tenders

Each contract that SPT issues has a standard format. Specifically in relation to quality, this will include a Contractors' Quality Performance Requirement (CQPR). This CQPR represents a specification that details roles and responsibilities for all parties during the works, frequency, and format of reporting. It will also specify the document management process to be adhered to during the delivery of the project. In addition to the CQPR, each project has a contract specific Quality Management Plan, detailing the inspection and testing regime for works as well as the records to be maintained.

6.4.1. Monitoring and Measuring During Project Delivery

SPT Projects undertake regular inspections on projects to monitor and measure compliance with SPT Environmental, Quality and Health and Safety requirements, as detailed in the contract specifications for the work. This also includes oversight of contractors. All inspections are visual, with the person undertaking the inspection ensuring that evidence of the inspection and any actions raised are documented.

The following inspections are completed:

- Quality Inspections (monthly).
- Environmental Inspections (monthly, with weekly review by third party Environmental Clerk of Works).
- Safety Assessments & Contractor Safety Inspection (daily, with full time Site Manager).
- Project Management Tours (monthly).

The scope of audits and inspections is set to ensure compliance with the following:

- Procedures & Guides.
- Planned arrangements for ISO 9001, 14001 & 18001.
- Legal and other requirements.

6.4.2. Post Energisation

SPT Projects and SPT Operations carry out a Defect Liability Period Inspection within the Contract Defect Liability Period with the aim of identifying any defects and rectifying them with the contractors.

6.5. Environmental Sustainability

IMS-01-001 encompasses all activities undertaken within and in support of SPEN's three Licences. This includes operational and business support functions concerned with management of SP Transmission, SP Distribution and associated regulatory and commercial interfaces, products, services, and their associated environmental, social, and economic impacts. The policy makes the following commitments which shall be respected in any works associated with this scheme.

SP Energy Networks will incorporate environmental, social, and economic issues into our business decision-making processes, ensuring compliance with or improvement upon legislative, industry, regulatory and other compliance obligations. We will deliver this by being innovative and demonstrating leadership on the issues which are important to us and our stakeholders, and will:

- Ensure the reliability and availability of our Transmission and Distribution network whilst creating value and delivering competitiveness by increasing efficiency and minimising losses.
- Reduce greenhouse gas emissions in line with our Net Zero Science Based GHG target, which is a target of 90% reduction in GHG emissions by 2035 (TBC) from a 2018/19 baseline.
- Integrate climate change adaptation requirements into our asset management and operations processes to support business resilience and reduce the length and time of service interruptions.
- Consider whole life cycle impacts to reduce our use of resources to sustainable levels, improve the efficiency of our use of energy and water and aim for zero waste.
- Improve land, air, and watercourse quality by preventing pollution and contamination and protecting and enhancing biodiversity in our network areas.
- Improve our service to local communities, supporting their economic and social development, protecting vulnerable customers, and respecting human rights.

ENV-04-014 gives specific guidance on the management of incidents with environmental consequence, or potential for environmental consequences, over and above the general requirements for the management of incidents.

The proposed design solution is also resilient to future climate change risks, such as substation flooding or potential faults from vegetation along the route.

SPEN policy to eliminate risk of substation flooding entails:

- Substations shall be designed such that there is no loss of supply or damage to strategic equipment during a 0.1% annual exceedance probability (AEP) flood event. Access routes to the substation shall also be considered to ensure access will be available during flood conditions and consideration of staff access to the key plant and buildings during the 0.1% annual flood event.
- In those instances where there is a compelling reason to locate a substation inside this zone and this is accepted by SPEN Network Planning & Regulation the substation design shall eliminate or mitigate against the risk of such a flood impacting the operation of the substation (access requirements, loss of supply, or damage to equipment).
- The 400kV substation platforms shall be constructed at a minimum level of 600mm above the 0.1% designed flood level, the 600mm freeboard allows for uncertainties in data and modelling. The designed flood level shall include an allowance for climate change for a 50-year design life, in accordance with the requirements of the relevant national environment agency. Where climate change guidance is not available then a minimum of 200mm shall be applied. The flood design should consider Pluvial, Fluvial, Coastal and Reservoir flooding, as well as combinations of these.

SUB-01-018 gives detailed specific guidance on SPEN's substation flood resilience policy.

Also, SPEN policy to reduce the number of vegetation related OHL faults entails:

In SPEN to reduce the number of vegetation related OHL faults, the route will be surveyed, consented, and cut on a per kilometre basis. The cutting specification entails:

- Falling distance plus 5m (i.e., Vicinity Zone) to the conductor and maintain 5 years clear from that distance.
- Clearance as 5.3m to be achieved from conductor positioned at 45° blowout and maximum sag condition. Maintain 5 years clear from that distance.

- All vegetation directly below the OHL with the potential to breach the Vicinity Zone before the next cut cycle shall be removed.
- Hedgerows shall be maintained. Species identified with no threat to breach the Vicinity Zone at any point in the future shall continue to be managed as part of the 3-year vegetation management programme.
- Tower bases shall be kept free of all scrub to a distance of 5m from the base.

OHL-03-080 gives detailed specification for OHL vegetation management in SPEN.

Additionally, the preferred OHL route for the project needs to be identified after extensive evaluation of the length of route, biodiversity and geological conservation, landscape, and visual amenity (including recreation and tourism), cultural heritage, land use, forestry, and flood risk.

If routing the OHLs in areas of forestry the guideline is to -

- Avoid areas of landscape sensitivity;

- Not follow the line of sight of important views;
- Be kept in valleys and depressions;
- Not divide a hill in two similar parts where it crosses over a summit;
- Cross skylines or ridges where they dip to a low point;
- Follow alignments diagonal to the contour as far as possible, and;
- Vary in the alignment to reflect the landform by rising in hollows and descending on ridges.

The overall project design objective is to minimise the extent of felling required and woodland areas and individual trees are to be avoided where possible during the routeing phase. Where routeing through woodland has been unavoidable, a 'wayleave' corridor is required for safety reasons to ensure that trees do not fall onto the line and for health and safety of forestry operatives. SPEN has statutory powers to control tree clearance within the wayleave corridor. Where possible the design of the new OHLs and associated infrastructure must be sought to avoid/minimise felling where possible, when balancing with other technical and environmental objectives.

6.6. Stakeholder Engagement

SPT is committed to delivering optimal solutions in all the projects it undertakes. A key part of this is engaging with relevant stakeholders throughout the project-development and delivery process. SPT's stakeholder engagement plan for this reinforcement project will be closely aligned to our wider stakeholder engagement commitments as outlined in our RIIO-T3 business plan. Stakeholders includes customers, regulatory bodies and other statutory consultees, national and local government, landowners, community groups, and local residents and their representatives (e.g., MPs, MSPs and councillors). Community impacts associated with construction activities are considered at project initiation by completion of a Community Communications Plan, which details the stakeholders relevant to the project, the communication channels that will be used to engage with them, the information that will be provided to and sought from them, and the timescales over which this will happen. It considers any sensitivities that may require increased stakeholder consultation and details specific events that will be held with stakeholders during the development of the project.

As part of this project, SPT will engage with statutory consultees associated with the planning application for these works - the Local Authority, SEPA and Nature Scot - and the third-party landowner.

Due to the location and nature of this project, no particular sensitivities or community impact issues have been identified, but a general level of interest from local representatives has been noted and we will continue to engage with them throughout the project. Stakeholder engagement to date has informed the details of the construction and permanent drainage details for the works.

7. Eligibility for Competition

Under the RIIO-T3 Business Plan Guidance, Ofgem has requested that projects that are above £50m and £100.00m should be flagged as being eligible for being suitable for early and late competition respectively. This project is above both thresholds, however, is not suitable due to:

- Being significantly developed, therefore not suitable for early competition.
- A number of new connections projects are dependent on the completion date, therefore delays through any project tender exercise will delay these projects.

- A large portion of the works is integral to existing transmission substations and are therefore not identified as separable. Splitting of the project to remove these elements would result in works less than the late competition threshold (£100.00m).

8. Conclusion

This EJP demonstrates the need to establish the new Glenmuckloch 400kV substation and install a 400kV double circuit OHL between the proposed Glenmuckloch 400kV substation and the planned Redshaw 400kV substation, on ZV route. This reinforcement scheme primarily serves as enabling work required for the connection of 0.9GW of contracted renewable generation in South-West Scotland, providing a new point of interconnection between New Cumnock and the ZV route.

In addition, construction of the proposed Glenmuckloch 400kV substation can facilitate a new 400kV double circuit corridor between Scotland and the North of England (with the project reference WCN2).

The main conclusions of this EJP are:

- It is necessary to invest in transmission infrastructure at the Glenmuckloch 400kV Substation, and between Glenmuckloch 400kV and Redshaw 400kV substations, to enable the connection of 0.9GW of contracted renewable generation, this having been identified as the most economic and efficient option. This need is clear.
- The staging of the construction of the proposed Glenmuckloch 400kV substation has been established to reflect the growing needs in the area and enable the timely and efficient connection of contracted generation as well as future network needs i.e. the expansion of the 400kV system.
- The proposed reinforcement scheme plays a vital role in reaching legislated net zero targets and is aligned with SPT's RIIO-T3 strategic goals.

The expected project delivery year for Stage 1 is 2028. The estimated project cost for this stage is £139.55m.

This EJP is submitted for Ofgem's assessment of the need case for the project and the selection of the preferred option in order to provide sufficient funding for pre-construction and early construction activities. A cost assessment submission for the project will be made to Ofgem under the Load Related Reopener at an appropriate time.

9. Appendices

Appendix A – Maps and Diagrams

[redacted]

Appendix A: Maps and Diagrams

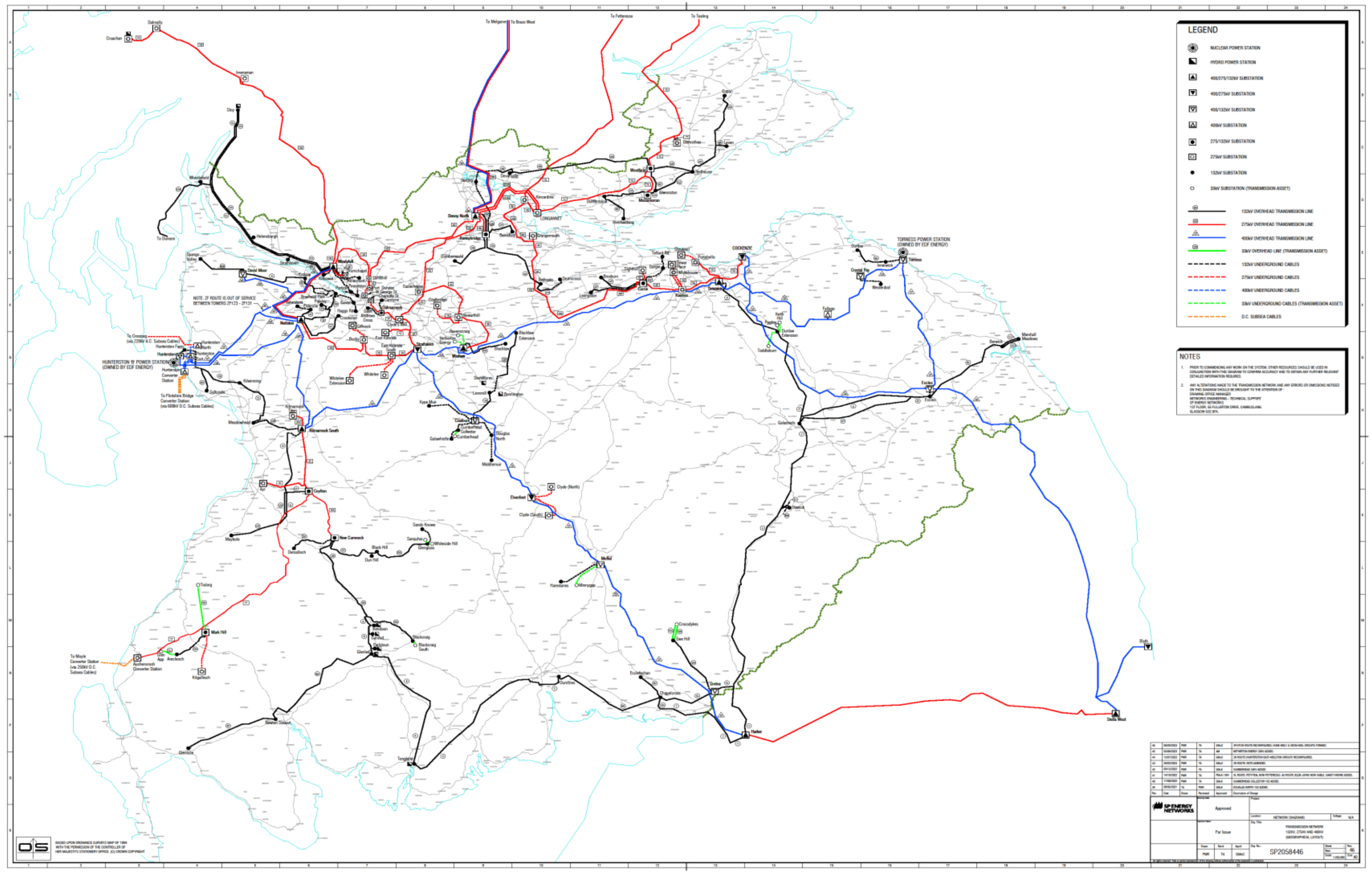

Figure A-1: Networks Diagram of the existing SPT system - Geographical Layout.

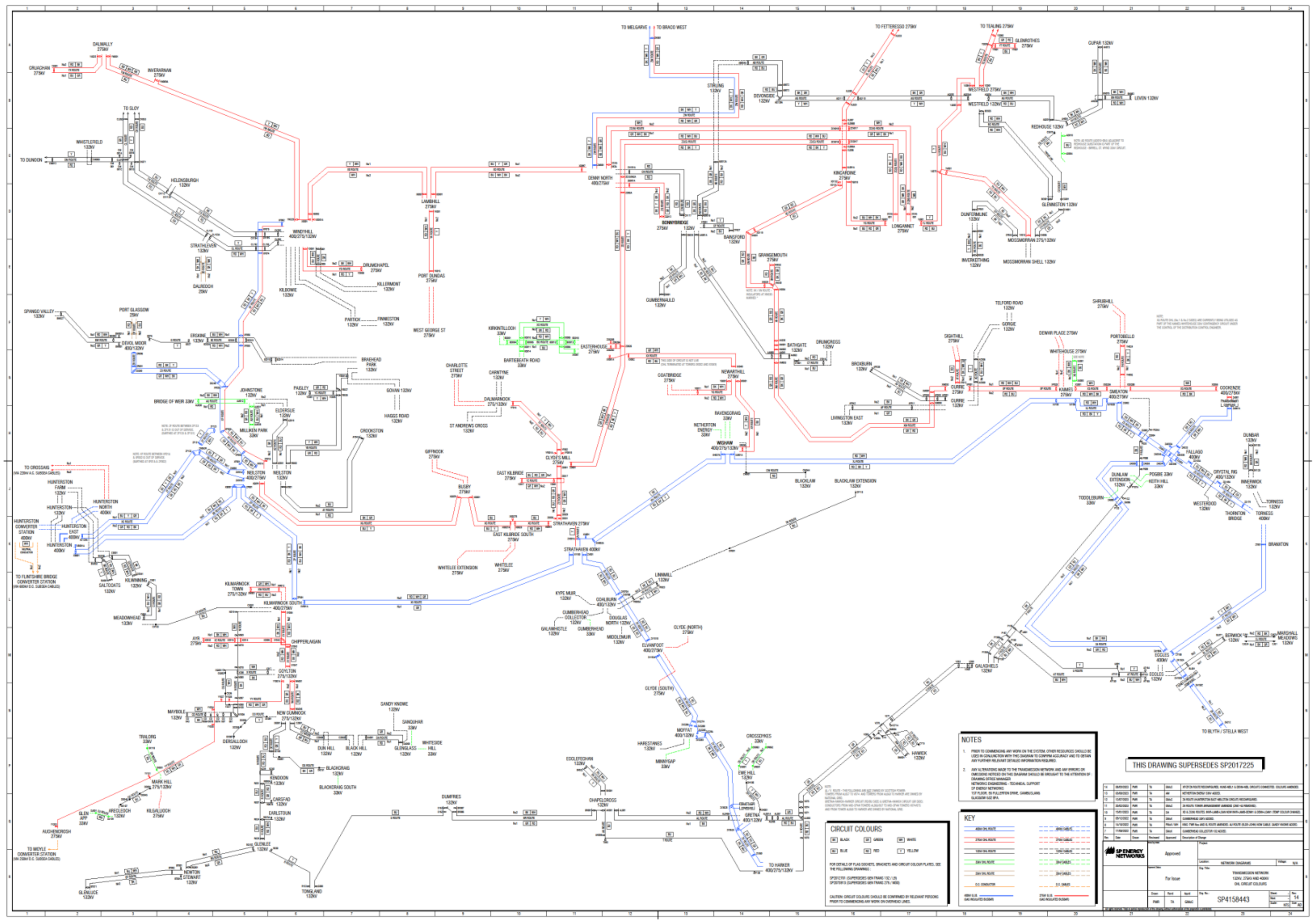

Figure A-2: Networks Diagram of the existing SPT systems – Single Line Diagram.

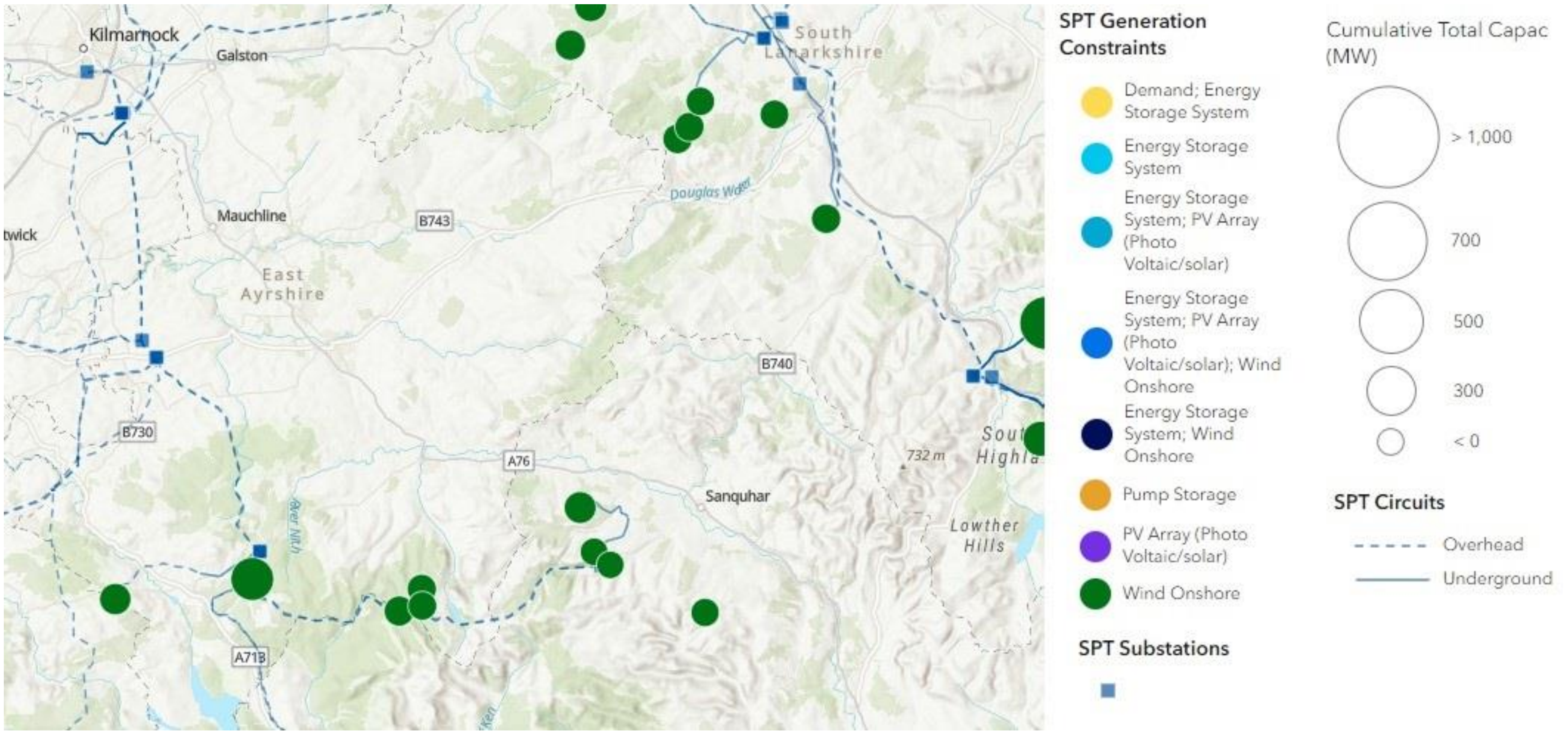

Figure A-3: Currently Connected Generation Extracted from Transmission Generation Heat Map*.

* The Energy Storage Systems represent the Battery Energy Storage Systems technology (commonly known as BESS technology).

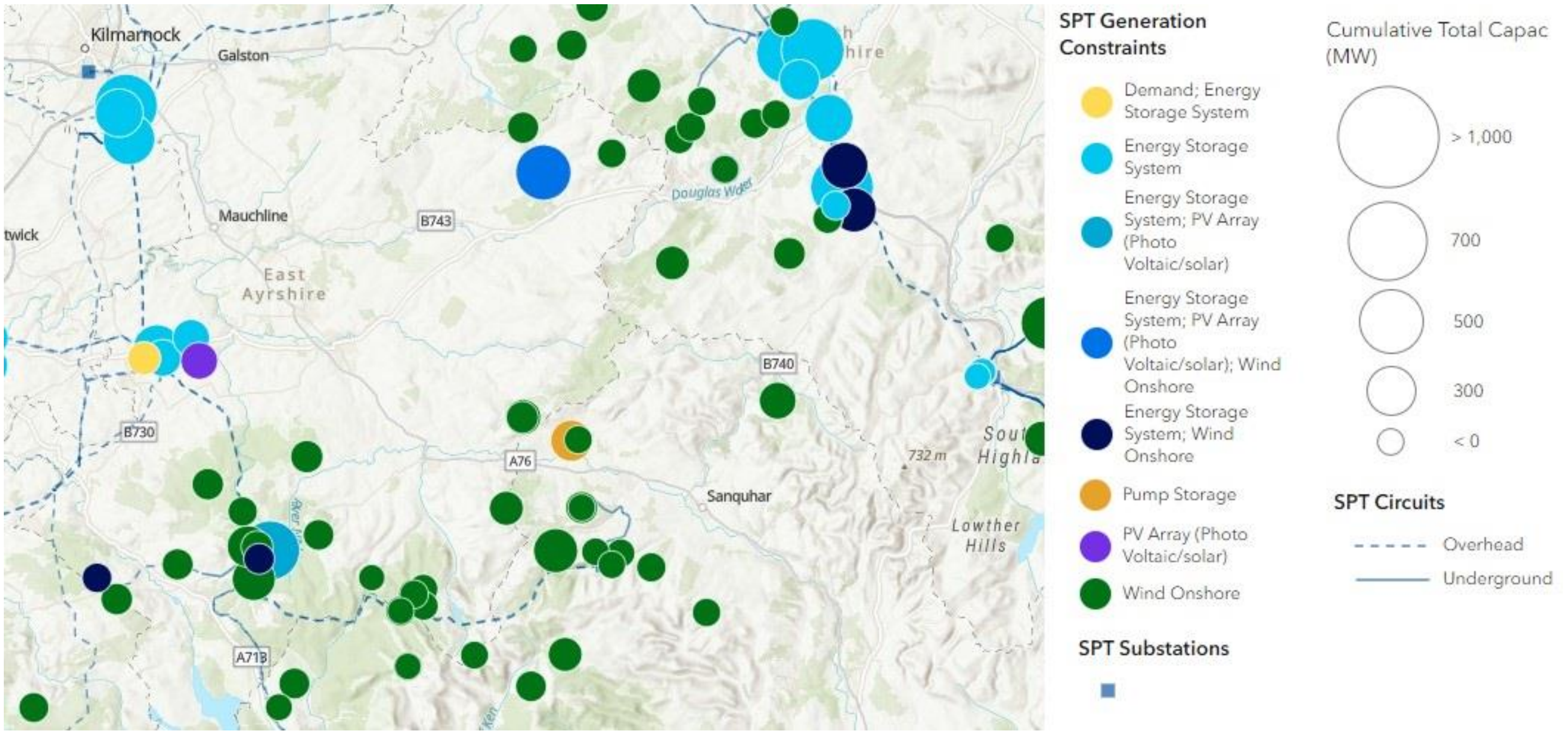

Figure A-4: Contracted and Connected Generation Extracted from Transmission Generation Heat Map.*

* The Energy Storage Systems represent the Battery Energy Storage Systems technology (commonly known as BESS technology).

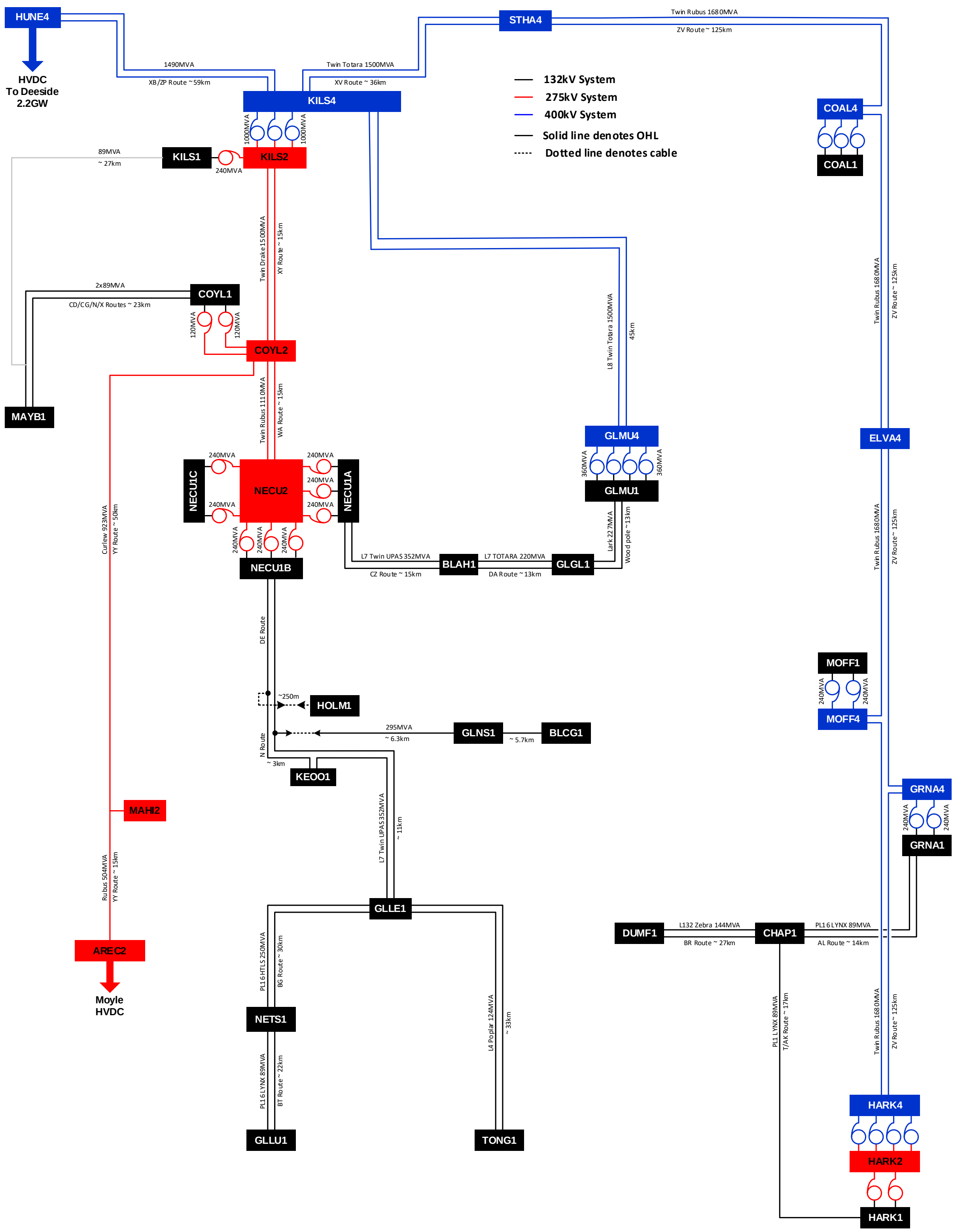

Figure A-5: Network diagram for Option 1.

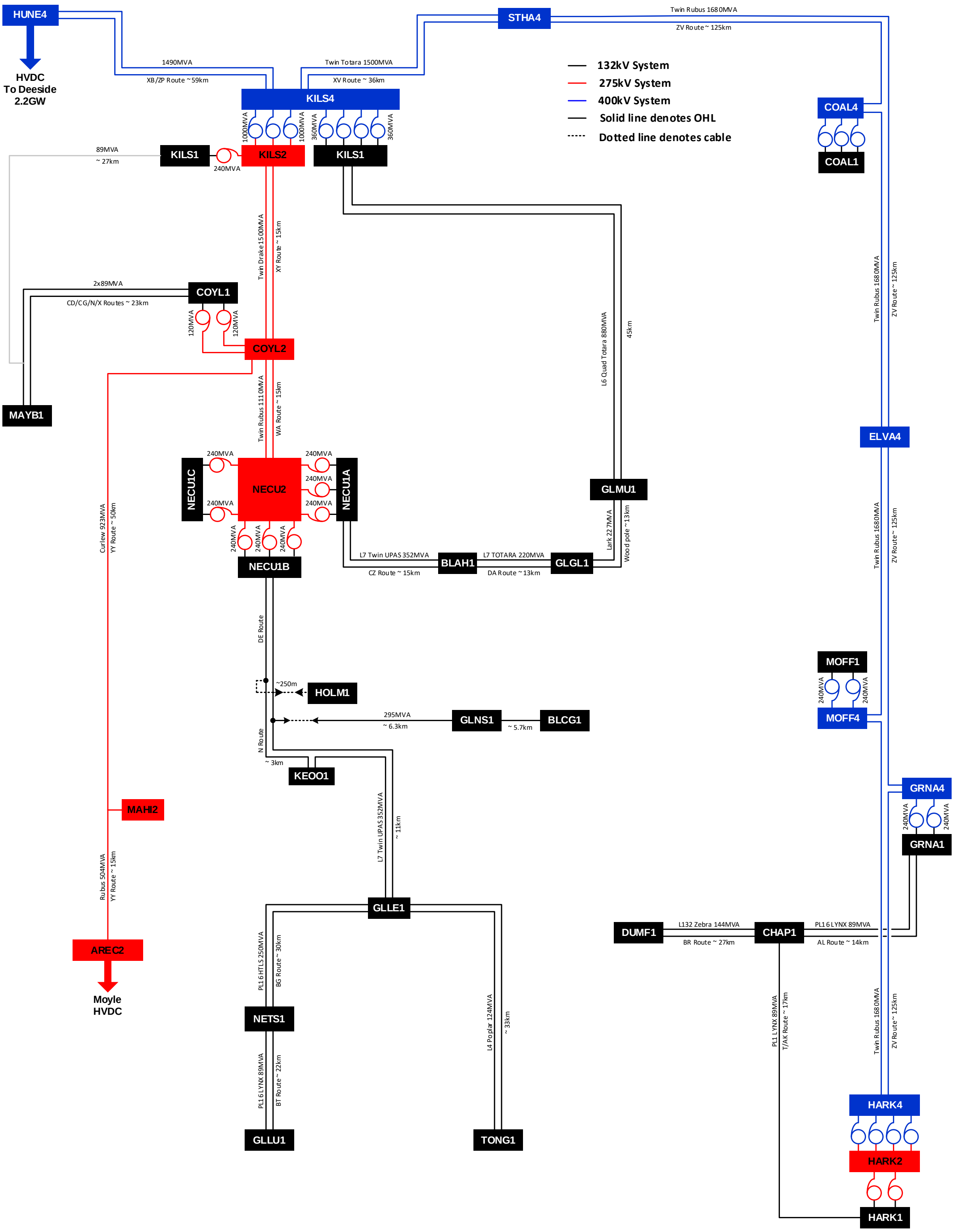

Figure A-6: Network Diagram for Option 2.

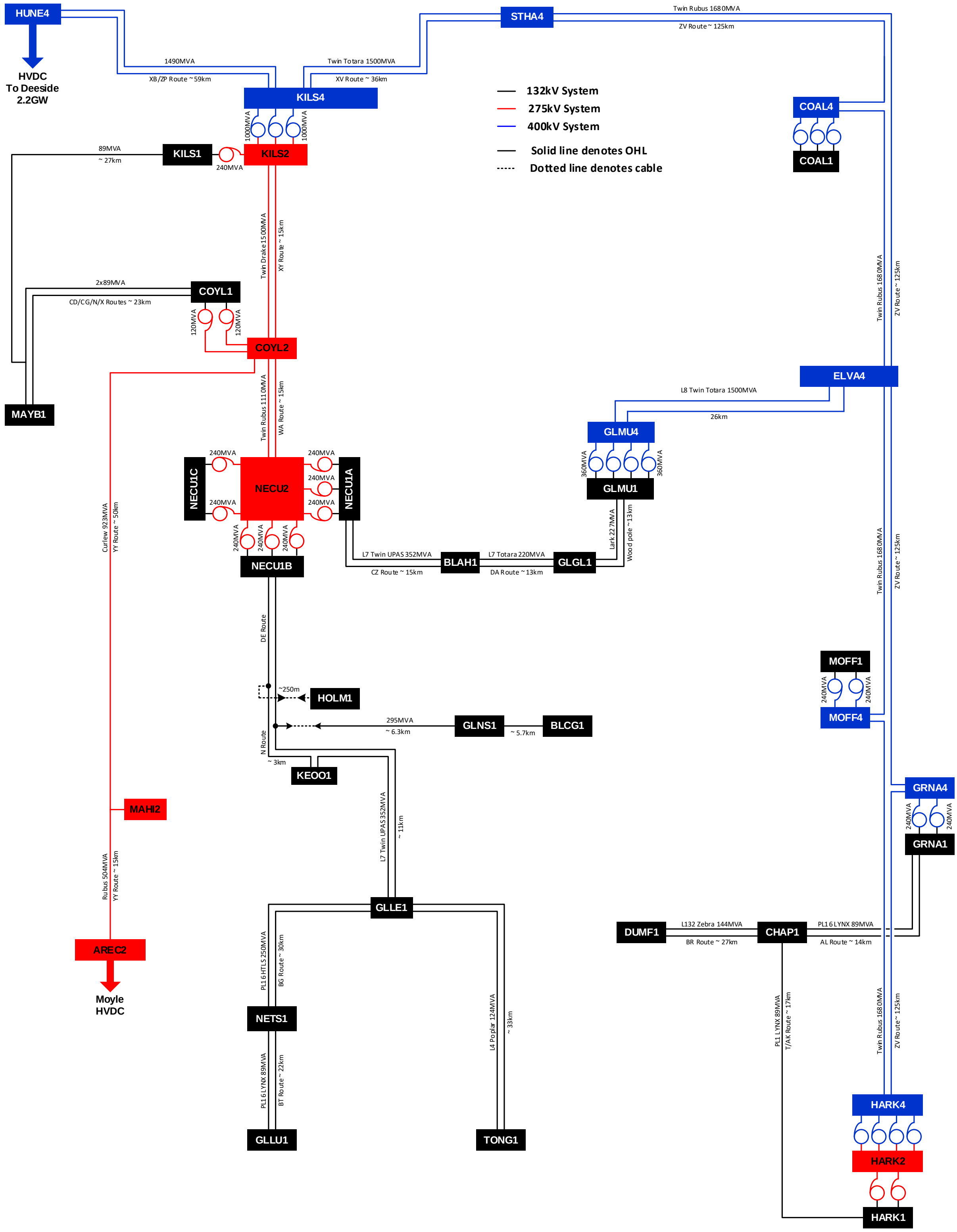

Figure A-7: Network Diagram for Option 3.

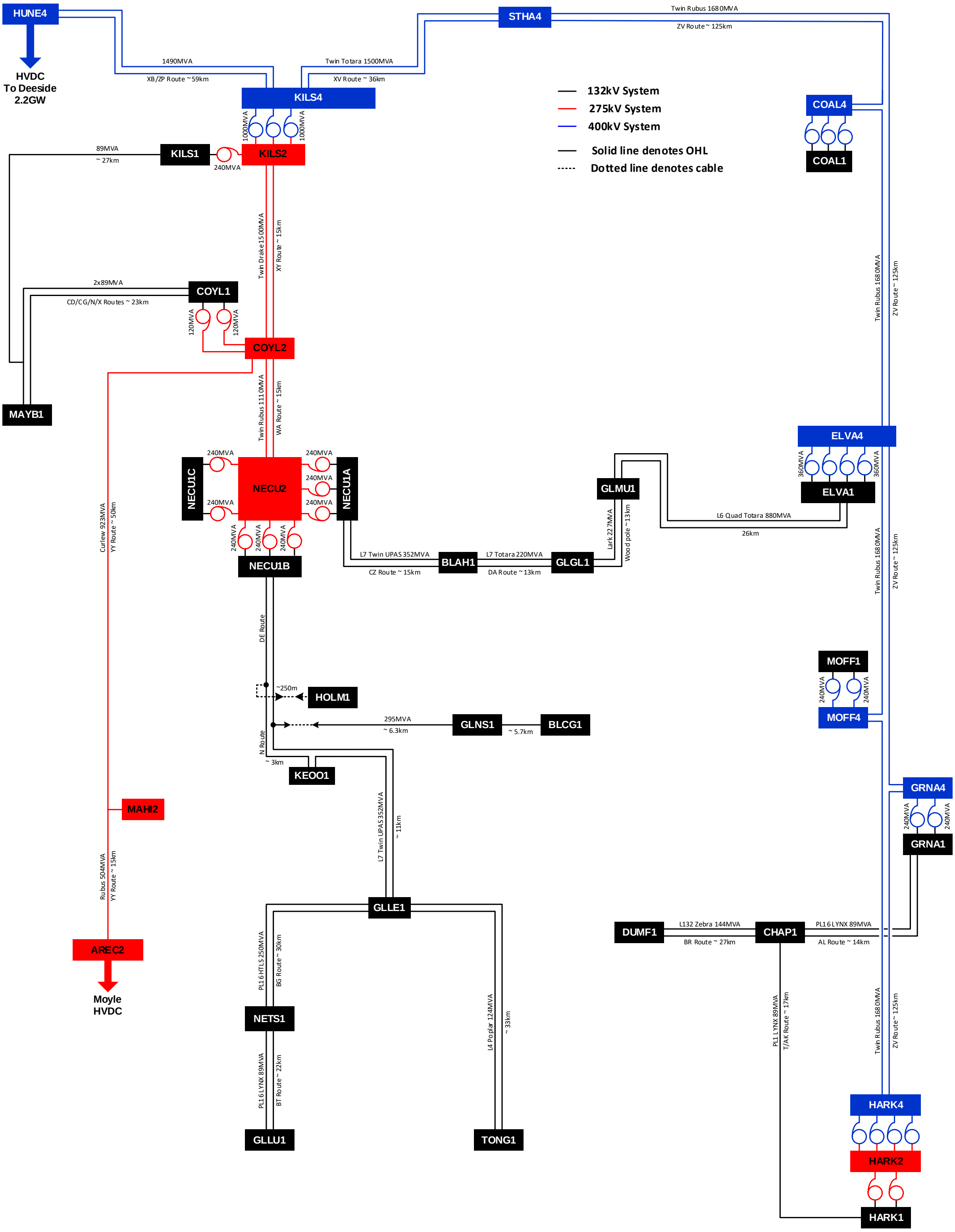

Figure A-8: Network Diagram for Option 4.

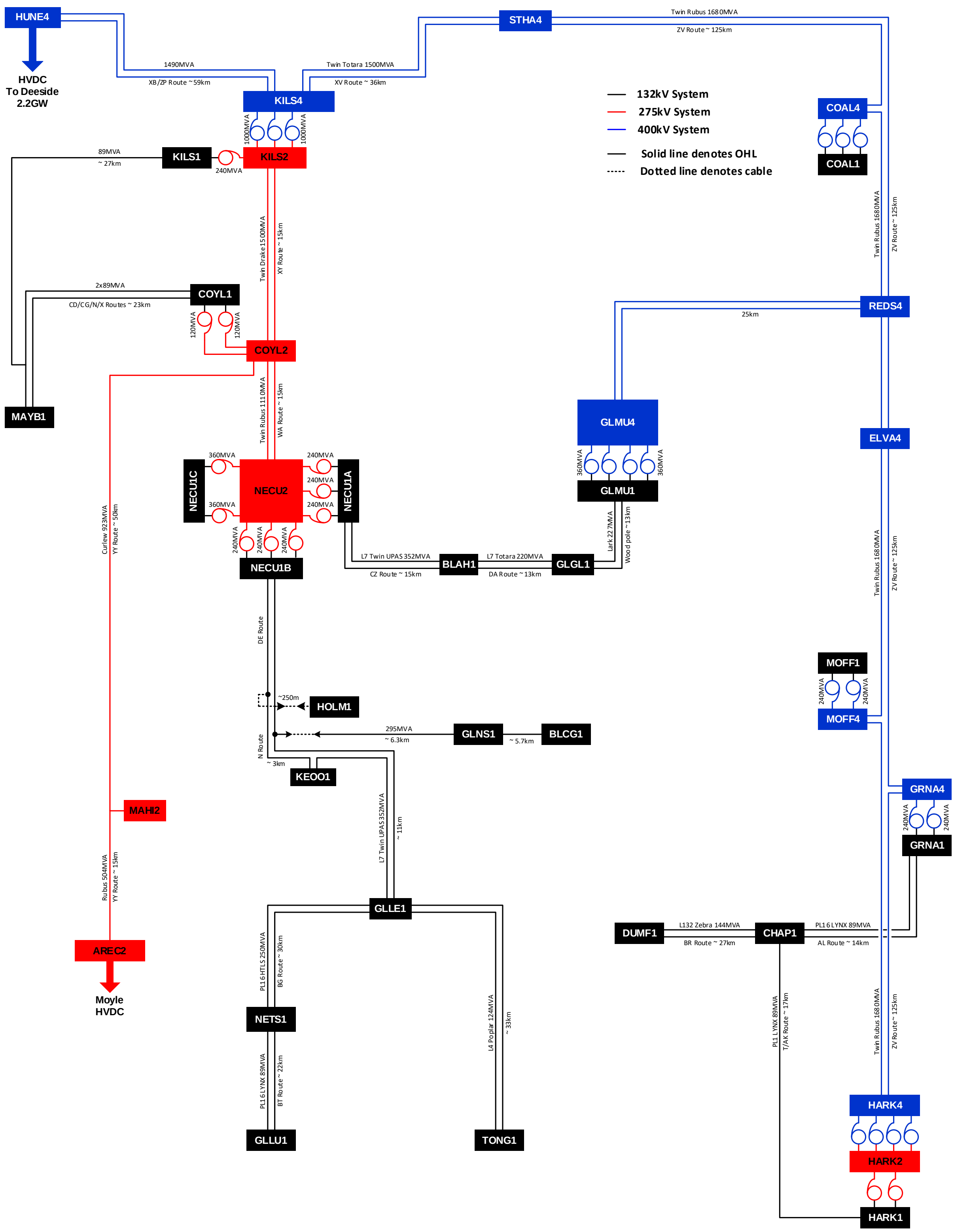

Figure A-9: Network Diagram for Option 5.

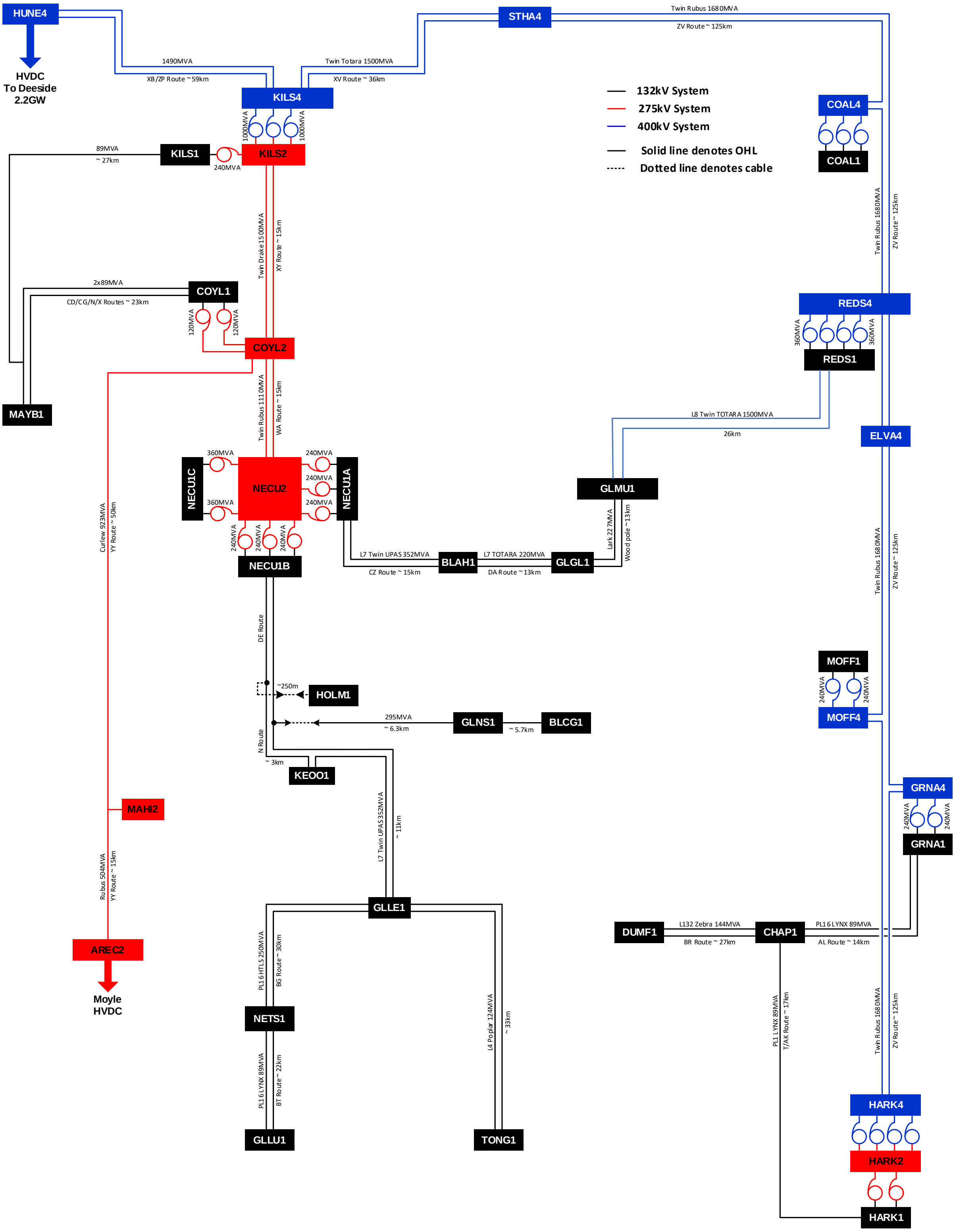

Figure A-10: Network Diagram for Option 6.

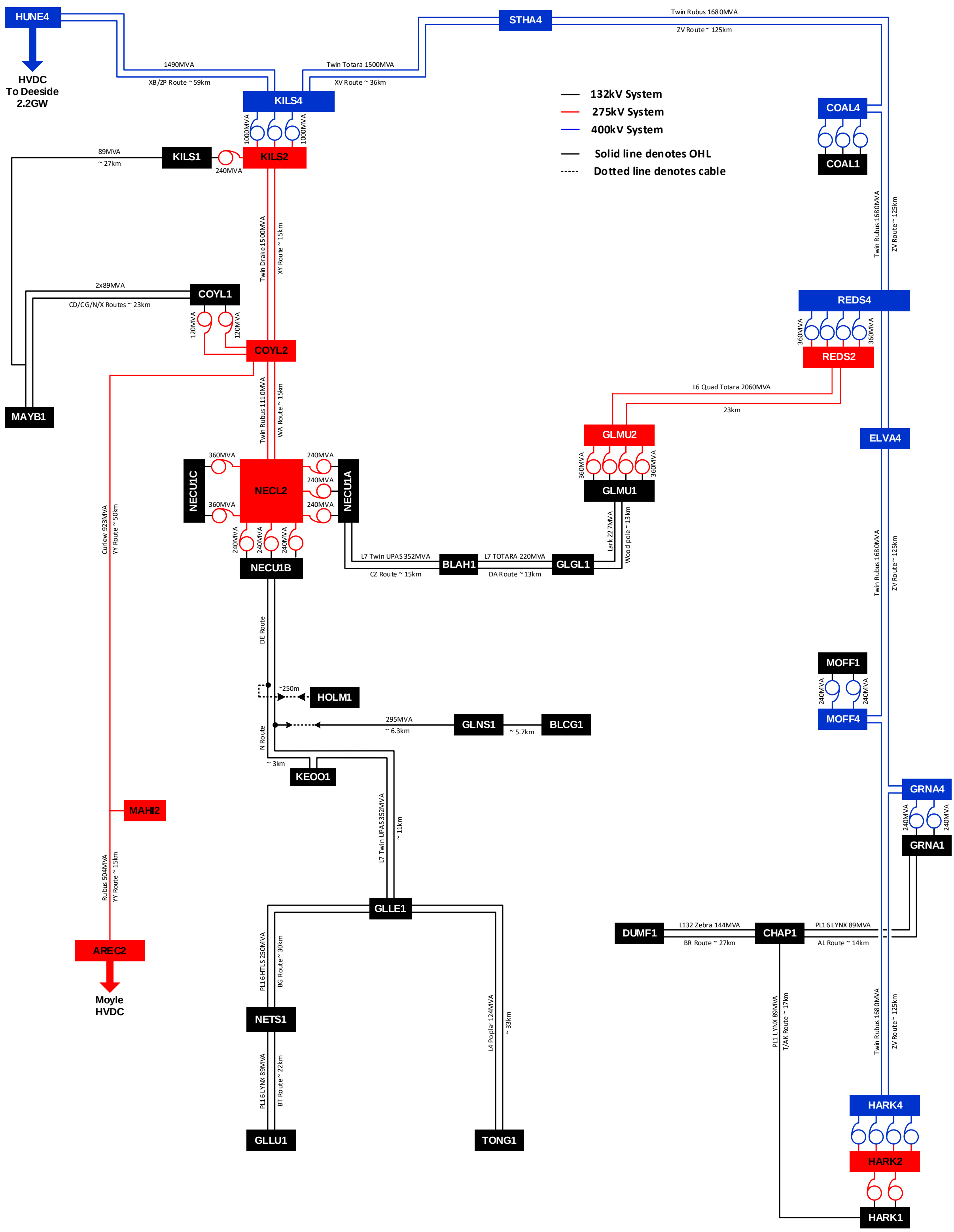

Figure A-11: Network Diagram for Option 7.

[redacted]

Figure A-12: Geographical location of Elvanfoot Substation.

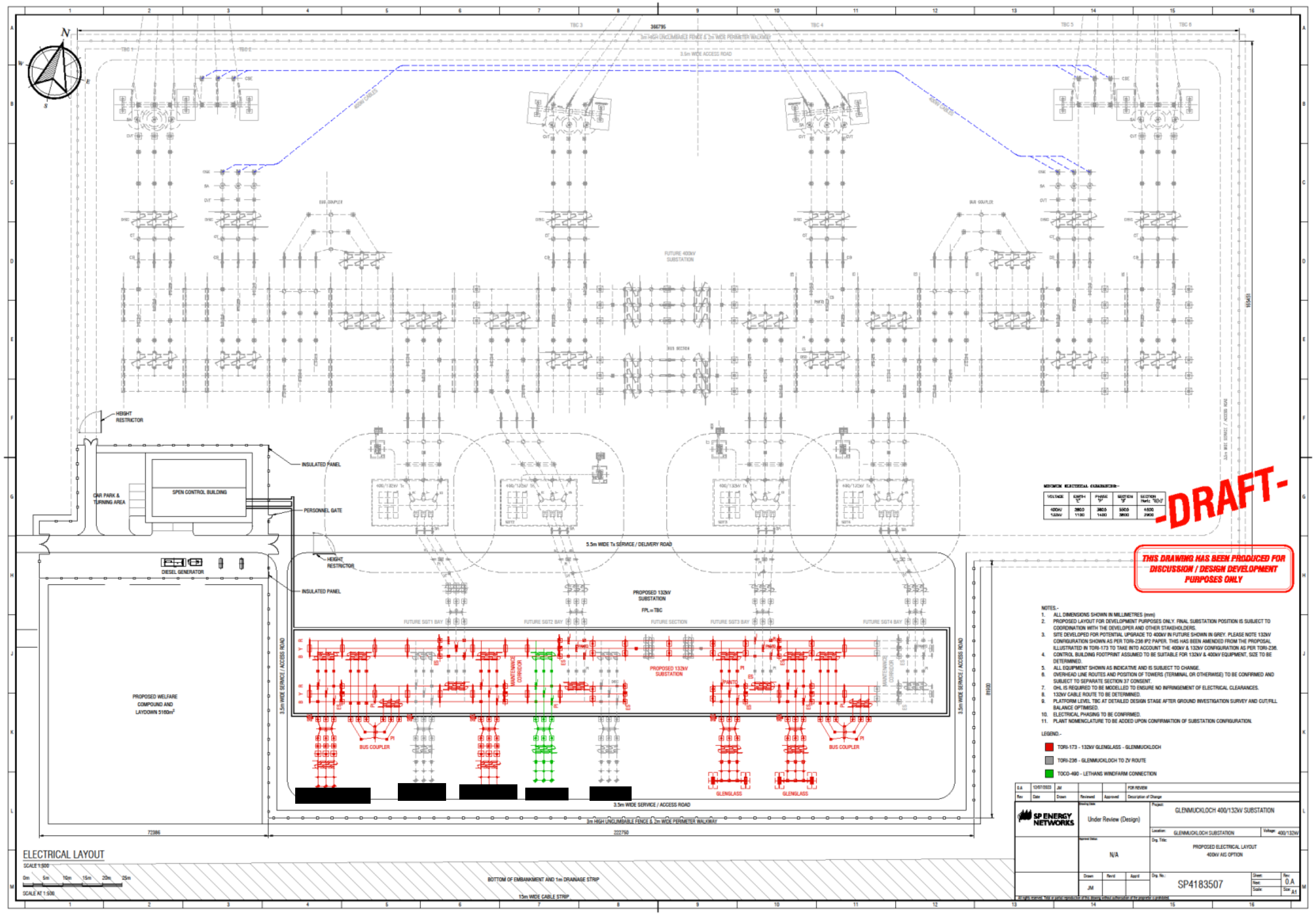

Figure A-13: Electrical layout for Glenmuckloch 400kV Air Insulated Switchgear (AIS).

[redacted]

Figure A-14: Electrical layout for Glenmuckloch 400kV Air Insulated Switchgear (AIS) with respect to the available land boundary – note when considered within land boundary (shown in Figure A-15) cannot be accommodated.

[redacted]

Figure A-15: Geographical location of the available land with respect to the surrounding environment.

[redacted]

Figure A-16: Comparison between the electrical layout for an AIS option and the geographical location of the available land.

[redacted]

Figure A-17: Proposed Electrical layout at Stage 1 of project delivery.

[redacted]

Figure A-18: Proposed Electrical layout at Stage 2 of project delivery.

[redacted]

Figure A-19: Proposed Electrical layout at Stage 3 of project delivery.

[redacted]

Figure A-20: Proposed Glenmuckloch to Redshaw 400kV OHL Route, subject to detailed routing and consultation.

[redacted]