Glenshimmeroch 132kV Collector Substation Reinforcements

Site Strategy EJP
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SP Energy Networks
RIIO-T3 Business Plan

SP Energy Networks

Glenshimmeroch 132kV Collector Substation Reinforcements				
Name of Scheme	SPT-RI-274 Glenshimmeroch 132kV Substation; SPT-RI-2243 Glenshimmeroch 132/33kV 120MVA Transformer; SPT-RI-296 Glenshimmeroch OHL & Cable Route Uprate; and Glenshimmeroch Harmonic Filter;			
Investment Driver	Local Enabling (Entry) / Wider works			
NESO Review	NESO Reviewed: No			
BPDT / Scheme Reference Number	SPT200404; SPT200460; SPT200270;and SPT200874 (part of)			
Outputs	• 132kV Platform creation – 1 unit • Flexible AC Transmission Systems (FACTS) – 1 unit • 132kV CB (Air Insulated Busbar) – 4 units • 33kV CB (Switchgear - Other) – 3 units • 33kV Other Switchgear (Switchgear Other) – 2 units • 132kV>90MVA Wound Plant (Transformer) – 1 unit • 132kV Circuit Cable (1 core per phase) addition • 132kV Circuit Cable (1 core per phase) disposal • 132kV OHL (Pole Line) High Temperature Low Sag (HTLS) Conductor addition • 132kV OHL (Pole Line) High Temperature Low Sag (HTLS) Conductor disposal			
Cost	Glenshimmeroch Harmonic Filter - £6.91m SPT-RI-274 Glenshimmeroch 132kV Substation - £5.46m SPT-RI-2243 Glenshimmeroch 132/33kV 120MVA transformer - £9.48m SPT-RI-296 Glenshimmeroch OHL & Cable Route Uprate - £5.53m			
Delivery Year	Glenshimmeroch Harmonic Filter - 2028 SPT-RI-274 Glenshimmeroch 132kV Substation – 2028 SPT-RI-2243 Glenshimmeroch 132/33kV 120MVA transformer – 2028 SPT-RI-296 Glenshimmeroch OHL & Cable Route Uprate – 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 per TORI	**ET1**	**ET2**	**ET3**	**ET4**
SPT-RI-274	£0.00m	£0.80m	£4.66m	£0.00m
SPT-RI-2243	£0.00m	£2.84m	£6.64m	£0.00m
SPT-RI-296	£0.00m	£1.04m	£3.86m	£0.00m
Harmonic Filter	£0.00m	£0.92m	£5.99m	£0.00m

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1. Executive Summary

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

- development of a new Glenshimmeroch 132kV substation on south west Scotland (SWS) area of SP Transmission (SPT) network (ref. SPT-RI-274);
- installation of a 132/33kV 120MVA transformer in the new Glenshimmeroch substation (ref. SPT-RI-2243);
- uprating a section of the existing overhead line (OHL) and underground cable (UGC) on existing DG route, from the new Glenshimmeroch substation to existing DE route in SWS area (ref. SPT-RI-296); and
- installation of one unit of 20MVAr harmonic filter in the new Glenshimmeroch 132kV substation.

The primary drivers behind this project are to:

(i) accommodate the significant amount of wind farm development application received near the DG route; and
(ii) ensure network compliance with EREC G5/5 in the SWS area.

The expected project delivery year for the proposed scheme is:

- SPT-RI-274 - 2028;
- SPT-RI-2243 - 2028;
- SPT-RI-296 - 2028; and
- Glenshimmeroch Harmonic Filter - 2028.

The estimated project cost breakdown for the proposed scheme is:

- SPT-RI-274 - £5.46m;
- SPT-RI-2243 - £9.48m;
- SPT-RI-296 - £5.53m; and
- Glenshimmeroch Harmonic Filter - £6.91m.

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. It is anticipated that all of the projects detailed within this paper will be funded using the proposed Load Use It Or Lose It (UIOLI) pot as proposed within the RIIO-T3 period, due to total cost being less than £25.00m.

2. Introduction

This EJP sets out SPT's plans to:

(i) establish a new Glenshimmeroch 132kV collector substation on SWS area;
(ii) install a 132/33kV 120MVA transformer (T1) in the new Glenshimmeroch substation;
(iii) uprate a section of the existing OHL and UGC, on existing DG route, from the new Glenshimmeroch substation to the tee off point on DE route (also known as Glenshimmeroch tee) in order to provide a minimum summer pre-fault rating of 285MVA; and
(iv) install one unit of 20MVAr harmonic filter (with a site-specific damping resistor) in the new Glenshimmeroch 132kV substation.

For reference, DE route is a 132kV circuit comprising of approximately 24.5km of twin 'UPAS' OHL conductor built on L7 towers (i.e., 352MVA capacity). The DE route connects New Cumnock 275/132kV substation (board B) to a point (tee off point) approximately 3km north of Kendoon 132/11kV substation, where it splits into two sections, one extended to Kendoon substation (i.e., N route) and the other to Blackcraig 132kV substation (i.e., DG route). The DG route is a 132kV circuit connecting Blackcraig 132kV substation to the tee off point on the DE route, north of Kendoon (i.e., Glenshimmeroch tee). The DG route currently entails:

- Approximately 1km of underground cable with 1600mm^2 Al XLPE conductor. The conductor's continuous summer rating is 1014A (231MVA).
- Approximately 10km of 132kV OHL circuit with 'UPAS' conductor installed on wood poles (from pole number 1 to 125). The conductor's summer pre-fault rating is 176MVA at 75°C.
- Approximately 2km of 132kV OHL circuit with 'POPLAR' conductor installed on wood poles (from pole number 126 to 151). The conductor's summer pre-fault rating is 124MVA at 75°C.

The current schematic configuration of transmission network in the area is shown in Figure 1. The diagram indicating geographical location of the proposed scheme can be found in Figure 2.

The driver behind this project is the renewable generation applications (wind farm developments) received near the DG route in SWS area which necessitate creating a new collector substation and increasing the thermal capability of the existing circuit route with respect to the increased power flow. Additionally, with an increasing number of large wind farm connection applications received into the 132kV network in the SWS area, there is a need to ensure the electricity system is complaint with harmonic level standards (also known as ENA Engineering Recommendation (EREC) G5/5 [1]).

The volume of existing wind farm connections to the DG route is shown in Appendix A, Figure A-3. The Figure A-4 in Appendix A indicates the scale of currently contracted and the existing wind farm developments near the DG route. Currently four wind farm (WF) connections, with total generation capacity of 213MW, have been contracted to connect to the new Glenshimmeroch 132kV substation (ref. SPT-RI-274). These are [redacted]).

As part of the proposed scheme in this EJP a new 132/33kV 120MVA transformer (named as T1) will be installed to collect the wind farms' generation. The need for installation of the new 132/33kV 120MVA T1 has been triggered by connection of [redacted] and [redacted] wind farms, which is captured under SPT-RI-2243.

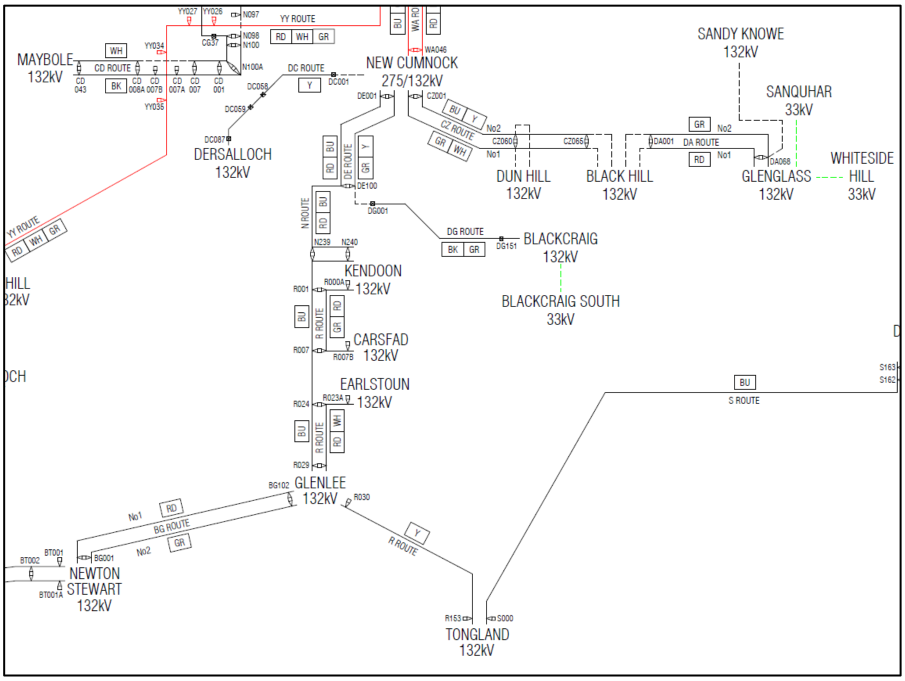

Figure 1: The existing transmission network in the area extracted from Networks Diagram of the Existing SPT Systems shown in Appendix A (Figure A-1).

To accommodate the connection of these two wind farms at the new Glenshimmeroch 132kV substation, SPT-RI-2243 also proposes to install a new 33kV busbar, which will be detailed in the following sections of this EJP. Further, an additional 132/33kV 60MVA transformer (T2) will be installed at Glenshimmeroch to facilitate connection of [redacted].

As depicted in Figure 2, the proposed Glenshimmeroch 132kV substation is located close to the DG route (132kV circuit), between the Blackcraig 132kV substation and the Glenshimmeroch tee on the DE route. The circuit between the proposed Glenshimmeroch substation and the Glenshimmeroch tee currently entails:

- ~6.3km of 132kV OHL circuit with 'UPAS' conductor installed on wood poles (from pole number 1 to 71). The conductor's summer pre-fault rating is 176MVA at 75°C.
- ~1km of underground cable with 1600mm^2 Al XLPE conductor. The conductor's continuous summer rating is 1014A (231MVA).

In order to provide sufficient capacity for connection of the contracted wind farms in addition to the existing renewable (i.e., wind farm) generation load on the DG route, the section of the existing OHL and underground cable from the proposed Glenshimmeroch 132kV substation to the Glenshimmeroch tee point is required to be uprated to provide a minimum summer pre-fault rating of 280MVA, based on currently contracted position. This can be achieved through:

- replacing the existing OHL circuit with 'EAGLE' High Temperature Low Sag (HTLS) conductor on the existing wood poles. This conductor's summer pre-fault rating is 295MVA at 190°C.
- replacing the existing underground cable conductor with 2000mm^2 Cu XLPE conductor. This conductor's continuous summer rating is 1354A (310MVA).

The need case for this scheme is scoped under SPT-RI-296.

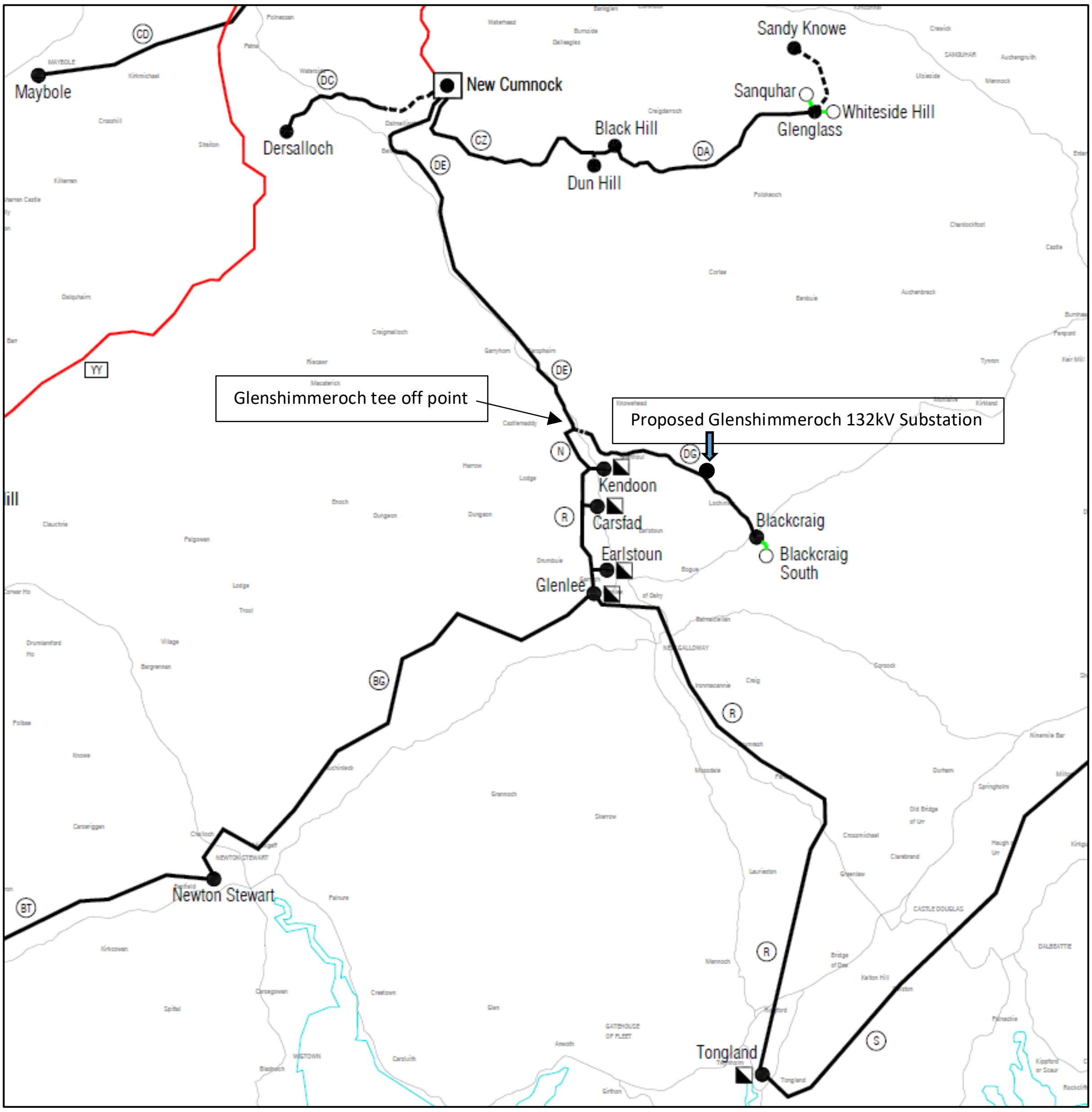

Figure 1:Geographical location of the proposed scheme with respect to the wider network in area - extracted from Networks Diagram Geographical Layout shown in Appendix A (Figure A-2).

In addition to the above-mentioned wind farm developments near the DG route, an increasing number of large wind farm connection applications have been received into the 132kV network in the SWS area. The volume of existing wind farm generators in the SWS area is depicted in Appendix A, Figure A-5. The Figure A-6, in Appendix A, indicates the scale of currently contracted and the existing wind farms. The electricity system in the SWS area already has a relatively high network impedance and is considered a weak system. The wind farm connections are characterised by the extensive use of arrays of underground cable (i.e., effectively large capacitances in the overall electricity network) which impacts the system's resonant frequency. The combination of these large capacitances with high system impedance leads lower resonant frequencies (typically below the 20th harmonic or 1kHz) in the network. There is therefore a high risk that a network resonance coincides with a background harmonic, leading to harmonic voltages above planning and compatibility limits of the EREC G5/5.

Users are normally responsible for harmonic compliance at their connection point. This is based on the premise that harmonic voltages at the connection point are primarily due to harmonic injection from the user's plant (e.g., in the case of a HVDC converter). In such scenarios, the user can install harmonic filters to confine the harmonic injection to acceptable limits. The harmonic injection from most modern wind turbines is very low and high harmonic voltages at the connection point arise primarily due to harmonics that already exist on the network, amplified by a resonant condition. Under such resonant conditions, the harmonic levels at the connection point are a strong function of the network characteristics and hence very difficult for a user to design harmonic filter mitigation. This difficulty is due to:

- The final network design is uncertain. The resonant frequencies of the network will move under outage conditions, or as the network is developed and new connections are made.
- The design of future windfarms and their harmonic emissions are unknown.
- Network outages (due to faults or for maintenance or construction) can have a significant impact on harmonic resonance.
- Mitigation designed by a user to deal with harmonic resonance is unlikely to be efficient from a 'whole system' point of view.
- Harmonic resonances do not only affect windfarm connection points but lead to increased harmonic voltages throughout the network. The best location for a harmonic filter may not be at the connection point, but elsewhere in the transmission network.
- Windfarm array cables contribute to the problem. However, high harmonics are due to the amplification of pre-existing background harmonics and generally not harmonics produced by windfarms.

From a 'whole system' point of view, it is therefore economic and efficient for SPT to design and install harmonic mitigation, consistent with the approach taken in RIIO-T2 and also previously proposed by two SP Energy Networks (SPEN) innovation projects; NIA_SPT_1506 and 1610 [2-4].

At some sites in the SWS area, the risk of exceeding the EREC G5/5 limits is higher or high harmonic levels have already been reported. The most economic and co-ordinated solution is the installation of standardised 20MVAr damped (C-type) harmonic filters. Previously the need for installation of 6 standardised damped (C-type) harmonic filters at different locations in this area has been justified, as a solution for harmonic problem, in our submissions for the RIIO-T2 price control period [5] and has been approved by Ofgem. These locations namely are Moffat, Linnmill, Black Hill, New Cumnock (board 'C'), Newton Stewart and [redacted]. The installation of harmonic filters at five sites; Moffat, Linnmill, Black Hill, New Cumnock (board 'C') and Newton Stewart, is proposed for completion in the RIIO-T2 price control period, before end of 2026. The [redacted] harmonic filter project is withdrawn. This due to the [redacted] substation not being constructed due to customer terminating their connection (i.e., [redacted][1]) and the need for a collector substation at [redacted] is no longer required. Should the [redacted] wind farm have not terminated their connection

1 [redacted]

agreement, the system configuration in the area near [redacted] substation would have been as depicted in Appendix A, Figure A-7. Although the [redacted] harmonic filter project is terminated, the need for installation of further harmonic filtering in the SWS area still exists to ensure system compliance with standard limits, particularly with the continued growth of onshore wind contracted to connect in the area. This EJP therefore proposes installation of a 20MVAr harmonic filter at Glenshimmeroch 132kV collector substation.

A schematic of the proposed new Glenshimmeroch 132kV substation, together with the harmonic filter is depicted in Figure 3, where the work scope of SPT-RI-274, SPT-RI-2243 and SPT-RI-296 have been highlighted.

Enabling the connection of the contracted wind farm developments requires providing additional transmission capacity to the local and wider network. To facilitate which incremental reinforcements are proposed for the electricity system in the area. The proposed scheme in this EJP is contingent with:

- Kendoon to Tongland 132kV Reinforcement (KTR) Project – This project includes SPT-RI-221 Kendoon to Glenlee 132kV Reinforcements, SPT-RI-222 Glenlee to Tongland 132kV modernisation and SPT-RI-213 New Cumnock SGT2B reinforcements. The KTR project will radialise the 132kV network from around 3km north of Kendoon (i.e., Glenshimmeroch tee point) to Glenlee and then to Tongland and hence removing the interconnected 132kV network and providing much needed capacity to Dumfries and Galloway. It is estimated that the KTR project will be completed in 2029; however, it is currently subject to public inquiry and therefore likely to change. The completion date will be updated once the outcome is known.
- New Cumnock 132kV substation extension (SPT-RI-158) – This project focuses on extending the New Cumnock 132kV substation to create a new 132kV board at New Cumnock (board 'C') by adding two new 275/132kV 360MVA SGTs. It is proposed to complete this project in 2025.
- Glenglass extension and Glenmuckloch collector (SPT-RI-173) – In this project the 132kV network is extended from Glenglass substation to Glenmuckloch substation. This will allow the establishment of another collector substation near Glenmuckloch. It is planned to complete this project in 2027.
- Glenmuckloch to ZV route (SPT-RI-236) – This project establishes a new exist route for the generation in SWS area to the ZV route. This project is proposed to be completed in 2029.

Figure A-9, in Appendix A, depicts the single line diagram of the network in the area where these reinforcement projects have been highlighted. It should be noted that the above-mentioned reinforcement projects (i.e., KTR, SPT-RI-158, SPT-RI-173 and SPT-RI-236) have been / will be justified through separate need cases.

A complete description of the need case for development of Glenshimmeroch harmonic filter, TORI 274, TORI 2243 and TORI 296 as well as full justification for the selected reinforcement option are provided in the following sections. At a high level, however, the scheme will comprise the following:

- Establish the substation platform for the new Glenshimmeroch 132kV collector substation and install a 132kV busbar, six 132kV circuit breakers and associated disconnectors/isolators.

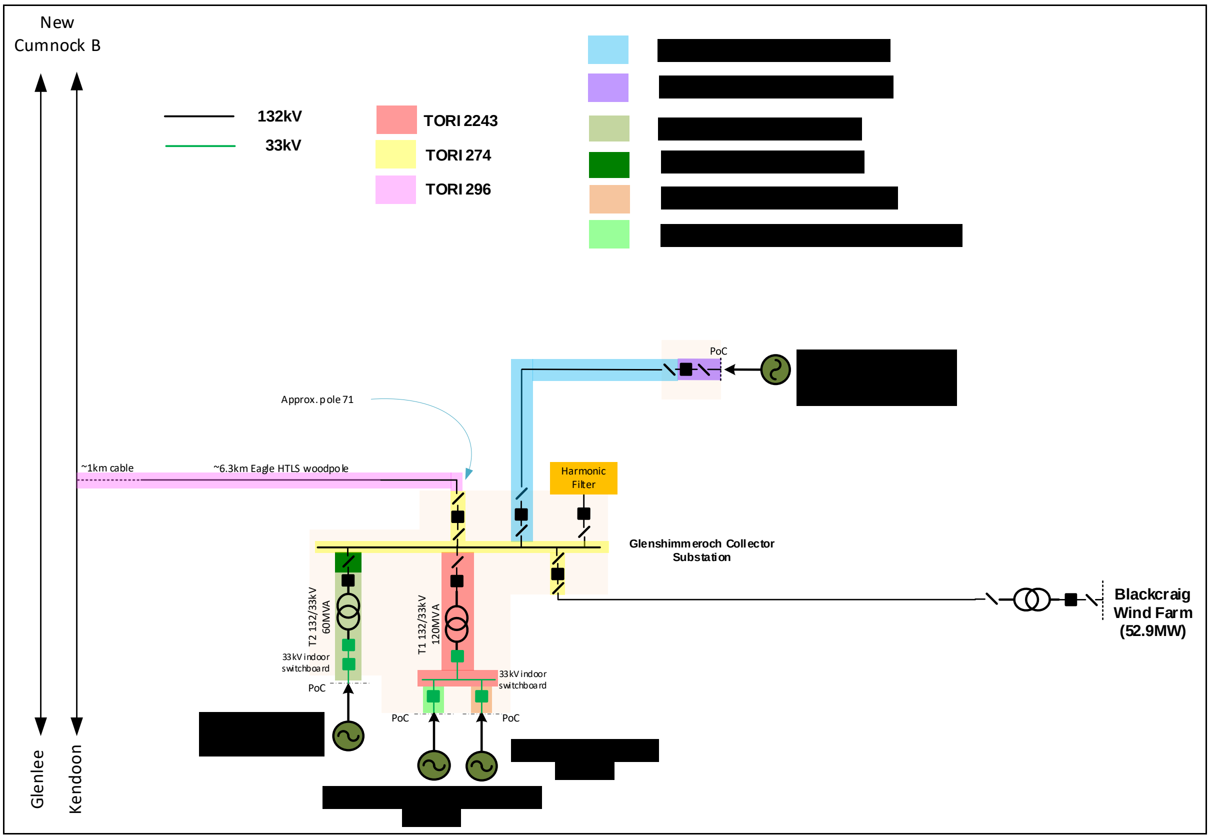

Figure 2: Single Line Diagram of the proposed Glenshimmeroch 132kV collector substation and the Glenshimmeroch harmonic filter. The work scope of SPT-RI-274, SPT-RI-2243 and SPT-RI-296 have been depicted with highlights.

- At Glenshimmeroch 132kV substation install a new 132/33kV 60MVA transformer, a new 132/33kV 120MVA transformer and two new 33kV indoor switchboards.
- At the new Glenshimmeroch 132kV substation install a new 20MVAr harmonic filter (with a site-specific damping resistor).
- Uprate the existing OHL and cable circuit between Glenshimmeroch 132kV substation and Glenmuckloch tee point with a new 'EAGLE' HTLS 132kV OHL conductor, approximately 6.3km, and a new cable suitably rated to match the OHL rating, approximately 1km.

The expected project delivery date for this reinforcement scheme is October 2027. The estimated project cost breakdown is:

- Development of Glenshimmeroch substation (SPT-RI-274) - £5.46m;
- Uprating of a section of the existing OHL and UGC on the existing DG route (SPT-RI-296) - £5.53m;
- Installation of 132/33kV 120MVA transformer in the new Glenshimmeroch substation (SPT-RI-2243) - £9.48m;
- Installation of 132kV harmonic filter at Glenshimmeroch 132kV substation - £6.91m.

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, with all projects using the proposed Load UIOLI pot for full funding within the RIIO-T3 period.

3. Background Information

The south west Scotland area is sparsely populated but rich in natural wind resources. It has therefore attracted an increasing interest from developers wishing to connect significant wind farm generators to the transmission system. The volume of existing wind farm generators in the SWS area is presented in Appendix A, Figure A-5. The Figure A-6 in Appendix A indicates the scale of currently contracted and the existing wind farm developments.

As part of a regulated business, SPEN evaluates compliance of the connection applications with respect to industry standards including compliance with ENA Engineering Recommendation (EREC) G5/5 for harmonic voltage levels. As outlined in the previous section, users are normally responsible for harmonic mitigation at their point of connection. However, it is expected that the harmonic injection from recent wind farm contracts to be very low due to the modern structural design of their wind turbines. With respect to this and also acknowledging the transmission network in SWS area is relatively weak (i.e., has high network impedance), the high harmonic voltages at the connection point arise primarily due to harmonics that already exist on the network. In this case, analyses have shown the most economic and coordinated solution is the installation of standardised damped (C-type) harmonic filters by SPT, consistent with the approach adopted in RIIO-T2 period. A similar approach has been also considered by other transmission owners such as NGET in relation to the connection of large offshore wind farms to a relatively weak 132kV network (i.e., a network with high network impedance) [6]. Employing this approach can also assist with the following problems:

- Harmonic headroom in the network can be managed better and apportioned more fairly.
- Mitigation costs are distributed more equitably between users. For example, a situation where a windfarm (windfarm 'b') avoids filter installation costs because a nearby windfarm (windfarm 'a') has already installed filters, becomes much less likely.
- The risk of late detection of harmonic problems will be reduced.
- The filter redundancy will be improved. A coordinated approach would avoid extensive harmonic problems arising from the failure or unavailability of a single harmonic filter bank. Note that disconnecting the associated windfarm would not necessarily solve the problem.

In our previous submissions for the RIIO-T2 price control period [5] a set of multiple analyses had been carried out in order to mitigate harmonics in the 132kV network connected to New Cumnock 132kV substation in the SWS area. Part of the solution to deal with this challenge was to install a harmonic filter in the future [redacted] 132 kV collector substation before the end of 2026.

Considering the cancellation of [redacted] wind farm, in depth analyses have been carried out using power system simulations indicting the need to install a 132kV 20MVAr damped filter, similar to an MSCDN[2] or also known as a C-type filter, at Glenshimmeroch 132kV collector substation. The results of these simulations have been included in Appendix C.

3.1. Proposed damped harmonic filter

The layout and parameters of the harmonic filter derived from the power system simulations are shown in Figure 4. These parameters are chosen according to maintain a homogenous criteria with

[2] Mechanically Switched Capacitor (bank with) Damping Network. Equipment primarily designed as shunt capacitor for reactive compensation, but with an additional damping network to mitigate potential harmonic resonance.

other filters that are going to be installed in the network. To achieve that a 600Ω tunning resistance has been determined resulting in a 250Hz resonance frequency that corresponds to the 5^{th} harmonic of the network.

One of the main advantages of the proposed filter design is that it provides damping to a wide range of harmonic frequencies, rather than being sharply tuned to a specific harmonic. This characteristic is important for this project but comes at the expense of increased losses. In such standardised harmonic filters although the devices are similar, note that a discharge VT as installed on MSCDNs is not required for the harmonic filters. After de-energising a harmonic filter, it is sufficient to enforce a time-delay to allow the capacitors to discharge before the filter can be switched in again.

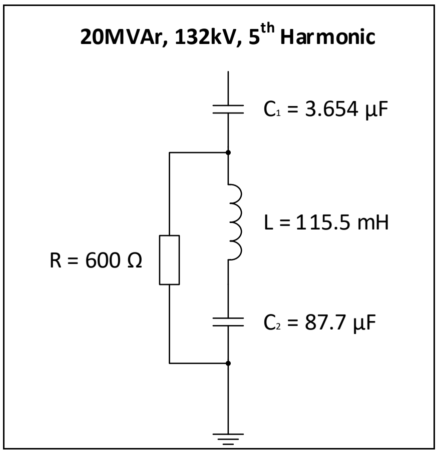

Figure 4: Schematic of the proposed harmonic filter – Filter Layout and Parameters.

Additionally, insulation coordination must be considered in further detail but note that a high-energy surge arrester is likely to be required across the resistor. The switching duty for the associated circuit breaker is not unusually onerous and a standard 132kV circuit breaker rated for capacitive switching duty can be employed.

3.1.1. Losses of the proposed damped harmonic filter

In an ideal scenario, there won't be any current passing through the filter resistor (i.e., R in *Figure 4*)[3] at 50Hz frequency, therefore the 50Hz losses are normally very low. In practice, some losses result due to component tolerances or deviation of the system frequency from 50Hz. The filter losses due to harmonic currents depend on the levels of harmonic distortion on the network. If it is assumed that all harmonic voltages are at the maximum compatibility limit allowed by EREC G5/5, the losses could be in excess of 500kW. However, such a condition is extremely unlikely to arise and would not persist for very long. Losses are normally not expected to exceed 60kW – 70kW.

Generally, lower harmonic voltage levels across the network will reduce losses at harmonic frequencies and therefore contribute to a reduction in total network losses. However, extensive network simulations are required to estimate these losses. As harmonic losses are low compared to 50Hz losses, this has not been attempted.

3.2. Installation of the harmonic Filter at Glenshimmeroch 132kV substation

The volume of existing wind farm connections to the DG route is shown in Appendix A, Figure A-3. The Figure A-4 in Appendix A indicates the scale of currently contracted and the existing wind farm

[3] L and C_2 are tuned to 50 Hz to bypass the resistor.

developments near the DG route. Considering the volume of contracted wind farm generators in the SWS area, a new Glenshimmeroch 132kV substation is proposed for connection to the New Cumnock B – Kendoon 132kV circuit. The new Glenshimmeroch 132kV substation is a collector substation with the main purpose of collecting the generation of multiple wind farms to connect to the transmission network.

Bilateral Connection Agreements are in place between NESO, and the developers of the wind farm generator projects detailed in Table 1 for connection to the new Glenshimmeroch 132kV substation.

Table 1: Contracted Generation for Connection to Glenshimmeroch Substation

Connecting Substation	Contracted Development	Consent Status	TECA Score[4]	Contracted Energisation Date	SPT-RI-2243 & SPT-RI-296	SPT-RI-274
[redacted]						
Total Capacity (MW)		-	-	-		213MW

*NB – The KTR project is an Enabling Work required for energisation of these contracted renewable generations. It is estimated that the KTR project will be completed in 2029; however, it is currently subject to a public inquiry and therefore likely to change. The completion dates will be updated once the outcome is known.

TECA Legend

TECA Probability	Designated Colour
High	
Medium	
Low	

The connection of the last two wind farm developments within Table 1 (i.e., [redacted]) will require installation of a new 132/33kV 120MVA transformer, together with a new 33kV busbar in the new Glenshimmeroch 132kV substation (ref. SPT-RI-2243 Glenshimmeroch 132/33kV 120MVA transformer).

The circuit connecting the proposed Glenshimmeroch 132kV substation to the DE route currently consists of ~6.3km of ‘UPAS’ OHL conductor with summer pre-fault rating of 176MVA, and ~1km of 1600mm^2 Al XLPE underground cable conductor with continuous summer rating of 231MVA. The

[4] 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.

existing summer pre-fault rating of the connecting conductor system is clearly not sufficient for the required export. In order to facilitate connection of the wind farm developments detailed in Table 1 as well as the existing Blackcraig wind farm – 52.9MW (connection via Blackcraig South 33kV and Blackcraig 132/33kV substations), it is proposed to uprate the existing conductor system between the new Glenshimmeroch 132kV substation and the Glenshimmeroch tee point by replacing conductor of the existing OHL section with 'EAGLE' High Temperature Low Sag (HTLS) conductor and of the existing underground cable section with 2000mm^2 Cu XLPE conductor (ref. SPT-RI-296 Glenshimmeroch OHL & Cable Route Uprate). The summer pre-fault rating of 'EAGLE' HTLS OHL conductor is 295MVA at 190°C. It is proposed to install this OHL circuit on the existing wood poles. The continuous summer rating of the 2000mm^2 Cu XLPE conductor is 1354A (310MVA).

As depicted in Figure 3, the new Glenshimmeroch 132kV substation consists of one feeder for connection to the wider network (i.e., connection to DE route through OHL and cable), and multiple bays to facilitate connection of the Glenshimmeroch harmonic filter and connected wind farm developments. Some connections will be at 132kV level, such as connection to the Blackcraig 132kV substation, the Glenshimmeroch harmonic filter and [redacted] wind farm. The other connections (i.e., [redacted], [redacted] and [redacted] wind farms) will be, as per customers' request, at 33kV level through the local transformers (i.e., T1 & T2) installed in the new Glenshimmeroch 132kV substation. It should be noted that a 132/33kV 60MVA transformer (i.e., T2) and an associated 33kV indoor switchboard will be installed as part of A1 connection assets works for [redacted] wind farm.

The Glenshimmeroch 132kV substation (SPT-RI-274) project, in combination with SPT-RI-2243 Glenshimmeroch 132/33kV 120MVA transformer, and SPT-RI-296 Glenshimmeroch OHL & Cable Route Uprate are Enabling Works for connection of 213MW of wind farm generators (i.e., renewable generation) to the transmission network, corresponding to Transmission Owner Construction Agreements that are in place between NESO and SPT.

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

3.3. Asset Condition

The '132-400kV Transmission Overhead Line Asset Investment Policy' document[5] covers the model describing how overhead line component's condition is expected to change over time and its calculated technical asset life based upon a condition data approach. It also defines a common way on how condition data is interpreted, removing subjectivity, and providing a clear view on how condition ratings have been concluded. These values are subsequently input into NARM to obtain a rating for the health of the asset. These NARM ratings can be found in Table 2 and Table 3.

SPT conducts planned inspections to ensure assets are in condition that are safe and reliable for ongoing operation. The OHL section of the DG route has been subject to annual inspections to ensure public safety and a detailed condition assessment carried out every 10 years from a helicopter to check the condition of all components that can be visually assessed. In addition to

[5] OHL-01-014 '132-400kV Transmission Overhead Line Asset Investment Policy'.

regular visual inspections, more detailed 'hands on' assessments have been carried out on the wood poles on the OHL section of the DG route.

3.3.1. NARM Summary

The NARM methodology models the risk associated with the failure of certain lead assets in the network by identifying the asset condition, its probability of material failure and the consequences of the asset failure such as system, environment, safety and financial. The methodology enables the calculation of health and risk bands generated from the assets specific data (age, duty, location, function), the data collected through inspections and any other measured condition (such as cormon testing or conductor sampling for OHL).

The NARM metrics are used to provide logical links between asset data held in SPT's Asset Management Systems and the proposed interventions and are a key element of justification to the regulator. Table 2 and Table 3 show the NARM data for the part of the DG route which is between the Glenshimmeroch 132kV substation and the Glenshimmeroch tee off point. In Table 2, the Health bands (P bands) represent the health of the asset and give an indication of the likelihood of asset failure. The P bands can range from 1-10, being 1 very good health (i.e., lowest probability of failure) and 10 poor health-end of the operational life (i.e., highest probability of failure). Also, in Table 3 the Risk bands (R bands) represent a measure of the criticality of the asset relative to the rest of the assets of the same type and voltage. There are 10 R bands ranging from 1 to 10, being R1 lowest criticality and 10 highest criticality. This metric is useful to prioritise asset interventions within the same asset category (i.e., 132kV OHL conductor) as required.

From Table 2 and Table 3 it can be seen that the surveyed assets are in a very good health condition. As discussed earlier, the OHL conductor and underground cable are subject to uprate. It should be noted that the fittings of the OHL towers will be used for the proposed scheme in this EJP.

Table 2: NARM Data for the circuit under uprate - P Band

Asset Type	P Band								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
OHL Conductor	11.982	0	0	0	0	0	0	0	0
Underground Cable Conductor	757	0	0	0	0	0	0	0	0
Fittings	71	0	0	0	0	0	0	0	0

Table 3: NARM Data for the circuit under uprate - R Band

Asset Type	R Band								
	R1	R2	R3	R4	R5	R6	R7	R8	R9
OHL Conductor	0	11.982	0	0	0	0	0	0	0
Underground Cable Conductor	0	757	0	0	0	0	0	0	0
Fittings	0	71	0	0	0	0	0	0	0

The system requirements and design parameters of the proposed scheme are summarised in Table 4.

Table 4: System Requirements and Design Parameters

System Design Table	**Circuit/Project**	**Glenshimmeroch 132kV Substation; Glenshimmeroch 132/33kV 120MVA Transformer; Glenshimmeroch Cable & OHL Route; and Glenshimmeroch Harmonic Filter**
Thermal and Fault Design	Existing Voltage (if applicable)	132kV
	New Voltage	132kV
	Existing Continuous Rating (if applicable)	770A (OHL- Summer Rating) 1014A (Cable - Summer Rating)
	New Continuous Rating	1290A (OHL- Summer Rating) 1354A (Cable - Summer Rating)
	Existing Fault Rating (if applicable)	N/A
	New Fault Rating	20/25kA
ESO Dispatchable Services	Existing MVAr Rating (if applicable)	N/A
	New MVAr Rating (if applicable)	20
	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	4
	Future Generation Capacity	213MW
Initial Design Considerations	Limiting Factor	N/A
	AIS / GIS	AIS
	Busbar Design	Single Busbar
	Cable / OHL / Mixed	Mixed
	SI	The proposed standardised harmonic filter mitigates the harmonic levels in the 132kV network connected to New Cumnock substation.

4. Optioneering

This section provides a description of the options that have been considered to ensure network compliance with EREC G5/5 limits as well as accommodating connection of wind farm developments in the area. A summary of each option is described, at the end of this section, in Table 6 and Table 7, while the system requirements and design parameters for the considered options are outlined in Table 8 and Table 9.

4.1. Baseline: Do Nothing / Deferral

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. This option would also not provide the necessary capacity uplift required to accommodate the contracted wind farm developments to connect in the area. The proposed works are identified as Enabling Works in the connection agreements relating to the projects in Table 1.

With respect to harmonic filter installation, a 'Do Nothing' or 'Delay' option would lead to increasing harmonic levels on the transmission network, causing a disturbance to users and transmission equipment. Due to resonant conditions, harmonic levels are likely to exceed the EREC G5/5 compatibility levels.

4.2. Option 1: Installation of harmonic filters only in wind farms

This option was the employed approach prior to the RIIO-T2 price control period. As discussed in section 2, this option is neither economic nor efficient from a 'whole system' point of view. Also, it will not eliminate excessive harmonic voltages in all areas of the network. Considering these reasons, this option was discounted in advance of detailed cost estimating exercise.

4.3. Option 2: Installation of 33kV standard harmonic filters

This is a variation of the Option 1 (i.e., installing a standardised filter at wind farms' 33kV connection points). This would lead to the installation of a high number of filters (between 15 and 20 installations), but these would not be effective in controlling harmonic voltages in all areas of the network. Further detail on this option has been provided in the SPEN NIA project; NIA_SPT_1506 [2-3]. Considering this reason, this option was discounted in advance of detailed cost estimating exercise.

4.4. Option 3: Installation of active harmonic filters

This option is to use power electronic converters and a suitable control system to provide harmonic filtering. This technology is often deployed as part of an equipment such as STATCOM (i.e., a system that provides reactive compensation and harmonic filtering). The capital and operational costs for this option are high, and the technology is effective only at low harmonic orders. The availability of the active harmonic filters is significantly lower than that of a passive filter. Also, their losses and noise emissions are high. Considering these reasons, this option was discounted in advance of detailed cost estimating exercise.

4.5. Option 4: Installation of bespoke harmonic filter for each site

It could be possible to design bespoke filters for each site in the SWS area. This would provide more efficient filtering at specific harmonics with a reduced filter rating. However, such filters could themselves become part of an unintended resonant condition. They would be very sensitive to network changes and may require re-tuning or extension in future. Also, these filters will not be very efficient to procure as each site requires a different type of filter. Considering these reasons, this option was discounted in advance of detailed cost estimating exercise.

4.6. Option 5: Installation of 132kV standard harmonic filters

This approach was shown to provide the best technical solution, able to mitigate harmonic levels in the 132kV network in an economic and efficient manner by NIA projects; NIA_SPT_1506 and 1610 [2-4]. The proposed standardised 132kV filter design provides damping across the full range of harmonic frequencies. This ensures a high level of immunity to network outages or changes. The use of a standard design should also assist in achieving efficiencies in procurement, delivery, spares holding, etc.

A proposed single line diagram for the considered harmonic filter installation is shown in Figure 4 and fully described in Section 3.1. A large number of power system simulation studies have been carried out, with considering connected and contracted wind farms in the SWS area, under intact and under different system outage scenarios to investigate the mitigation effect of installing 132kV harmonic filters in the network connected to New Cumnock 132kV substation in the SWS area. These in-depth studies can be found in Appendix C. In these studies, ETYS 2022 networks for Year 5 (2025-26) and Year 15 (2036-37) are assessed.

Table 5 expresses the background harmonic on the 132kV and 33kV network area, for a number of network conditions, prior to installing any harmonic filter. Large 7th harmonic over-voltages are observed on the 132kV and 33kV networks indicting that harmonic filters are required to surpass 3 times of the limit in a 2025/26 scenario. It can be concluded that the main problems arise because of resonances between wind farms and the main network when the wind farms are under low or no load.

[redacted]

The installation of 132kV standard harmonic filters was also proposed in our submission for the RIIO-T2 price control period [5]. The need for installation of 6 standardised harmonic filters at different locations in the SWS area was justified and approved by Ofgem. As discussed in Section 2, [redacted] harmonic filter was one of the sites identified to mitigate the harmonic problem in the 132kV network connected to New Cumnock substation. Following termination of the [redacted] 43MW wind farm by the customer, the need for construction of a collector substation at [redacted] is no longer a requirement and hence the [redacted] harmonic filter project is withdrawn. The below three options have been investigated as an alternative for the [redacted] harmonic filter project to ensure the network's compliance with EREC G5/5.

4.6.1. Option 5a – Installation of 132kV standard harmonic filter in Glenshimmeroch 132kV substation

This option covers the proposition to install the filter at Glenshimmeroch 132kV collector substation which is schematically indicated in Figure 3. As can be seen in the figure, the filter bank will be connected through a new circuit breaker and a disconnector to the single busbar arrangement. The electrical layout for installation of the harmonic filter in the Glenshimmeroch 132kV substation has been provided in Appendix A, Figure A-5.

For this option, as shown in Appendix C, the power system simulations for both 2025/26 and 2036/37 studies indicate all network harmonics remain well within G5/5 planning limits except for a few individual wind farms and at certain network outage scenarios.

The estimated total cost for this option (only cost of installation of harmonic filter in the new Glenshimmeroch 132kV substation) is approximately £6.91m, as indicated in Table 17.

4.6.2. Option 5b – Installation of 132kV standard harmonic filter in New Cumnock 'B' 132kV substation

This option proposes to install the 132kV harmonic filter in New Cumnock 'B' 132kV substation. The power system simulations for this option (as shown in Appendix C) indicate an improvement in the harmonic levels for the 2025/26 studies in comparison with the Glenshimmeroch harmonic filter, but with a less clear result in the 2035/36 studies. The studies shown how the solution gets better results than Option 5a (i.e., harmonic filter installation in the new Glenshimmeroch 132kV substation) when Kendoon 132kV circuit (i.e., N route in Figure 2) is disconnected but can compromise the network limits in other network scenario outages.

To connect the harmonic filter to the New Cumnock 'B' substation, the board 'B' will need to be extended for one new circuit breaker. The substation can only be extended from north of the board, to ensure satisfying the required safety distances with the other equipment installed in the substation. Creating the required space for this circuit breaker necessitates expanding the substation fence line beyond its current location, which will impose extra cost to the project. The electrical layout for installation of the harmonic filter in the New Cumnock 'B' 132kV substation has been provided in Appendix A, Figure A-6.

The estimated total cost for this option (only cost of installation of harmonic filter in the New Cumnock 'B' 132kV substation) is approximately £8.11m. Additionally, this option would not enable connection of the contracted wind farm developments detailed in Table 1, due to an extensive distance between the location of the New Cumnock 'B' substation and the wind farms. Considering the discussed reasons, this option was discounted.

4.6.3. Option 5c – Installation of 132kV standard harmonic filters in New Cumnock 'B' and Glenshimmeroch 132kV substations

This option proposes to install one 132kV harmonic filter in New Cumnock 'B' 132kV substation and a second one in the new Glenshimmeroch 132kV substation. Based on the power system simulation studies shown in Appendix C, employing this option can improve harmonic performance in both areas of concern (i.e., New Cumnock B and Glenshimmeroch substations). However, the harmonic voltage levels remain high for the problematic individual wind farms and at certain network outage scenarios.

Additionally, this solution will have a higher cost. Considering these reasons, this option was discounted in advance of detailed cost estimating exercise.

4.6.4. Discussion – Harmonic Filter

Comparing the power system studies and cost for options 5a, 5b and 5c, shown in Appendix C, the most optimum solution to mitigate the harmonic problem in the SWS 132kV network connected to the New Cumnock 132kV substation is to install the harmonic filter in the Glenshimmeroch location.

In addition to the abovementioned advantages, installation of harmonic filter in the new Glenshimmeroch 132kV substation has been selected as the preferred option compared to the existing New Cumnock 132kV substation as installation of the harmonic filter in the new Glenshimmeroch 132kV substation at this early development stage of the substation will eliminate the need to return to the site for additional works in the near future. This is with considering high volume of connected/contracted wind farm developments near the Glenshimmeroch area which makes the need to mitigate harmonic problems in this part of the electricity network inevitable. Should the exiting New Cumnock 132kV substation be selected to instal the harmonic filter now, there will be a need to install a new harmonic filter in the Glenshimmeroch 132kV substation in the near future.

4.7. Option 6: Establishment of the new Glenshimmeroch 132kV substation, reconductoring the circuits between the Glenshimmeroch substation and DE route, installation of 132/33kV 120MVA Glenshimmeroch transformer and 132kV harmonic filter

As shown in Figure 3, this option mainly entails the following:

- Establishing a new Glenshimmeroch 132kV collector substation, on the DG route.
- Install a 132kV single busbar with six 132kV circuit breakers to accommodate connection of the harmonic filter, termination of the 132kV wind farm connections, termination of the 132/33kV 120MVA and 60MVA transformers (at the HV side), as well as termination of the 132kV DG OHL circuit.
- Install a new 132/33kV 120MVA transformer, a new 132/33kV 60MVA transformer and two new 33kV busbars at the new Glenshimmeroch 132kV collector substation. Each transformer (at the LV side) will be connected to a new 33kV busbar to facilitate the wind farm developments that require connection at 33kV voltage level.
- Reconductoring a section of the OHL circuit between the new Glenshimmeroch 132kV collector substation and the cable end on the DE circuit (i.e., Glenshimmeroch tee point), approximately 6.3km, by replacing the existing ‘UPAS’ conductor with an ‘EAGLE’ HTLS conductor on the existing wood pole system.
- Replace the existing cable, approximately 1km, on the Glenshimmeroch / DE circuit with 132kV cable suitable rated to match the OHL rating.
- Installing a 20MVAr damped (C-type) harmonic filter in the new Glenshimmeroch 132kV substation.

The overall cost associated with this option is approximately £27.38m. Complete detail on the project’s delivery, requirements and cost have been provided in Section 5.

4.8. Option 7: Reprofiling the existing OHL route between the Glenshimmeroch 132kV substation and the DE route

This option entails reprofiling of the existing conductor (i.e., ‘UPAS’ conductor with summer pre-fault rating of 176MVA at 75°C) on the 132kV OHL section of the circuit between the new Glenshimmeroch 132kV substation and the Glenshimmeroch tee point to operate at a higher temperature and as the result with higher rating. The highest operational rating for this type of conductor is 85°C, which provides pre-fault summer rating of 192MVA (840A).

The operation at this temperature would not provide sufficient capacity for connection of the wind farm developments discussed in Table 1. Additionally, following a complete conductor system study for this option, it has been identified that the existing 'UPAS' conductor in this part of the network is not suitable to be reprofiled.

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

4.9. Option 8: Separate connection of each wind farms to the DG route

This option proposes to install isolated connection circuits between each contracted wind farm developments (detailed in Table 1) and the wider 132kV network in the area. In this option, the wind farm developments need to be separately connected to the DG route, as their nearest 132kV route in the area. Employing this option, each connection requires an individual assessment and planning for the suitable connection to corridor route, which makes the connections costly and time consuming. In this option the isolated circuit ends connected to the network is also increased. Based on the design policy for the complexity of transmission circuits [SPEN Policy ESDT-01-002] which is consistent with Appendix B of the NETS SQSS, for a good design practice, no 132kV circuit shall have isolating facilities on more than four different sites. Following this policy the number of wind farms connected directly to the DG route can't be higher than two. Hence the contracted wind farm developments shown in Table 1 can't be separately connected to the network.

This also increases the land intake as a separate new site needs to be established only for installation of the required 132kV harmonic filter in this part of SWS area. Additionally, considering that some of the contracted wind farm developments (i.e., [redacted] wind farms) require a 33kV connection, installation of local 132/33kV transformers will be required in multiple locations, which increases the connections' overall footprint. It should be noted that employing this option still involves uprating the section of OHL and cable circuits on the DG route however for a different length depending on the location of each connection.

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

4.10. Selected Option – Establishment of the new Glenshimmeroch 132kV substation, reconductoring the circuits between the Glenshimmeroch substation and DE route, installation of 132/33kV 120MVA Glenshimmeroch transformer and 132kV harmonic filter (Option 6)

As discussed above, the most appropriate option to enable the economic, technically feasible and co-ordinated connection of the wind farm developments near the DG route as well as ensuring the network compliance with EREC G5/5 limits in SWS area is to establish the new Glenshimmeroch 132kV collector substation, install the new 132/33kV 120MVA and 60MVA transformers together with a new 132kV 20MVAr damped harmonic filter in this substation as well as uprate the existing cable and OHL circuits between the new Glenshimmeroch collector substation and Glenshimmeroch tee point on the DE route (i.e., Option 6).

The Glenshimmeroch 132kV collector substation will be established on the existing DG route, approximately 7.3km away from the New Cumnock 132kV circuit (i.e., DE route). The substation platform size is [redacted] with an approximate OS coordinate of [redacted] as shown in Figure 2. To accommodate sufficient capacity for connection of the Glenshimmeroch 132kV collector substation to the DE route (i.e., Glenshimmeroch tee point), the existing OHL circuit between the Glenshimmeroch substation and the Glenshimmeroch tee point will be replaced with 'EAGLE' HTLS conductor (summer pre-fault rating - 295MVA at 190°C). The length of the OHL circuit is approximately 6.3km and it will be installed on the existing wood poles (71 poles). Also, the route's existing underground cable will be replaced with 2000mm^2 Cu XLPE conductor (continuous summer rating 310MVA, 1354A). Accommodating collection of the wind farm generations that are at 33kV voltage level requires installation of one 132/33kV 120MVA transformer and one 132/33kV 60MVA transformer as well as one 33kV busbar for each transformer.

To mitigate the harmonic problem in the SWS area, a 132kV 20MVAr damped (C-type) harmonic filter as shown in Figure will be installed in the Glenshimmeroch 132kV collector substation following in-depth power system studies.

It should be noted that all the assets (i.e., underground cable, OHL conductor, 33kV indoor busbars, harmonic filter, etc.) in the preferred option in this EJP have been designed according to the connected and contracted wind farm applications in the area. The considered connected and contracted wind farm connections are shown in Appendix A, Figure A-4 (for substation, transformer and cable uprate design purpose) and Figure A-6 (for harmonic filter design purpose). Ensuring the optimal size for the required equipment necessitates installing the assets described in Section 5 and as can be found in Appendix A, Figure A-9.

4.11. 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. This is with consideration that it is not expected that there is any future requirement for SP Distribution (SPD) connections at this location, as the DNO in the area.

Our optioneering approach has additionally considered the appropriate 'Whole System' outcome by proposing a technology solution which manages network characteristics (i.e., harmonic issues), which prevents individual harmonic filters being installed at each wind farm connection site.

Table 6: Summary of considered options to respond to the harmonic problem

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
Rejected – Option 5a: Installation of 132kV standard harmonic filter in Glenshimmeroch 132kV substation	Refer to Figure 3	Refer to Appendix A, Figure A-9	N/A	N/A	N/A	Eight options are reviewed to deal with network harmonic problem in terms of scope feasibility, cost, delivery timescales, land requirements, system limitations and restoring SQSS compliant limit, with option 5a demonstrating a better performance under different system outage scenarios. This option is included as part of the preferred option for the wider proposed scheme (i.e., option 6 in Table 7).	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. It makes the network incompliant with harmonic standard (EREC G5/5).
Rejected – Option 1: Installation of harmonic filters only in wind farms	N/A	N/A	N/A	N/A	N/A	N/A	It is neither economic nor efficient from a 'whole system' perspective. It also will not eliminate excessive harmonic voltages in all areas of the network.
Rejected – Option 2: Installation of 33kV standard harmonic filters	N/A	N/A	N/A	N/A	N/A	N/A	This option would lead to the installation of high number of filters but would not be effective in controlling harmonic voltages in all areas of the network.

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
Rejected – Option 3: Installation of active harmonic filters	N/A	N/A	N/A	N/A	N/A	N/A	The active harmonic filters technology is effective only at low harmonic orders. Their availability is significantly lower than that of a passive filter. Also, their losses and noise emissions are high.
Rejected – Option 4: Installation of bespoke harmonic filter for each site	N/A	N/A	N/A	N/A	N/A	N/A	Having bespoke filters for each site can itself become part of an unintended resonant condition. These filters would be very sensitive to network changes and may require re-tuning or extension in future. Additionally, these filters will not be very efficient to procure as each site requires a different type of filter.
Rejected – Option 5b: Installation of 132kV standard harmonic filter in New Cumnock 'B' 132kV substation	N/A	Refer to Appendix A, Figure A-10	N/A	N/A	N/A	N/A	This option does not provide the least background harmonic levels under all network scenario outages. It additionally will require expanding the New Cumnock 'B' substation fence line beyond its current location. The estimated cost of this option is £8.11m. Additionally, it would not enable connection of the contracted wind farm developments.
Rejected – Option 5c: Installation of 132kV standard harmonic filters in New Cumnock 'B' and Glenshimmeroch 132kV substations	N/A	N/A	N/A	N/A	N/A	N/A	This option does not provide the least background harmonic levels for all wind farms and under all network scenario outages. It will be more expensive than options 5a. This option was discounted in advance of detailed cost estimating exercise.

Table 7: Summary of considered options with respect to the wider scheme proposed in this EJP

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
Preferred – Option 6: Establishment of the new Glenshimmeroch 132kV substation, reconductoring the circuits between the Glenshimmeroch substation and DE route, installation of 132/33kV 120MVA Glenshimmeroch transformer and 132kV harmonic filter	Refer to Figure 3	Refer to Appendix A, Figure A-9	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	Considering option 5a, in Table 6 as the most optimum solution for the network's harmonic problem, four additional options have been considered with respect to the wider scheme proposed in this EJP. These four options have been reviewed in terms of scope feasibility, cost, delivery timescales, land requirements, system limitations and restoring SQSS compliant limit with option 6 demonstrating a wider network capacity reinforcement whilst affording the least project deliverability risk.	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. It would not provide the necessary capacity uplift required to accommodate the contracted wind farm developments to connect in the area.
Rejected – Option 7: Reprofiling the existing OHL route between the Glenshimmeroch 132kV substation and the DE route	N/A	N/A	N/A	N/A	N/A	N/A	The highest operational rating for the existing OHL conductor (i.e., UPAS) is at 85°C, which provides pre-fault summer rating of 192MVA (840A), which does not provide sufficient capacity for connection of the contracted wind farms.

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
							Additionally, the existing UPAS conductor in this part of the network is not suitable to be reprofiled.
Rejected – Option 8: Separate connection of each wind farms to the DG route	N/A	N/A	N/A	N/A	Increased consenting risks developing individual connection sites.	N/A	It requires an individual assessment and planning to find the suitable connection corridor route for each wind farms hence will be costly and time-consuming. Considering the number of contracted wind farms in the area, this option will not be compliant with the SPEN design policy ESDT-01-002. This option will result in an increased land intake and footprint for the connections.

Table 8: System Requirements and Design Parameters for the considered Options to respond to the harmonic problem

System Design Table	Circuit/Project	**Preferred – Option 5a:** Installation of 132kV standard harmonic filter in Glenshimmeroch 132kV substation	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 1:** Installation of harmonic filters only in wind farms	**Rejected – Option 2:** Installation of 33kV standard harmonic filters	**Rejected – Option 3:** Installation of active harmonic filters	**Rejected – Option 4:** Installation of bespoke harmonic filter for each site	**Rejected – Option 5b:** Installation of 132kV standard harmonic filter in New Cumnock 'B' 132kV substation	**Rejected – Option 5c:** Installation of 132kV standard harmonic filters in New Cumnock 'B' and Glenshimmeroch 132kV substation
Thermal and Fault Design	Existing Voltage (if applicable)	132kV	132kV	132kV	132kV	132kV	132kV	132kV	132kV
	New Voltage	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Existing Continuous Rating (if applicable)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)
	New Continuous Rating	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Existing Fault Rating (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	New Fault Rating	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESO Dispatchable Services	Existing MVAr Rating (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	New MVAr Rating (if applicable)	20MVAr	N/A	N/A	N/A	N/A	N/A	20MVAr	20MVAr (2 units)
	Existing GVA Rating (if applicable)	N/A	N/A	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	N/A	N/A
	Present Demand (if applicable)	N/A	N/A	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	N/A	N/A

System Design Table	Circuit/Project	**Preferred – Option 5a:** Installation of 132kV standard harmonic filter in Glenshimmeroch 132kV substation	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 1:** Installation of harmonic filters only in wind farms	**Rejected – Option 2:** Installation of 33kV standard harmonic filters	**Rejected – Option 3:** Installation of active harmonic filters	**Rejected – Option 4:** Installation of bespoke harmonic filter for each site	**Rejected – Option 5b:** Installation of 132kV standard harmonic filter in New Cumnock 'B' 132kV substation	**Rejected – Option 5c:** Installation of 132kV standard harmonic filters in New Cumnock 'B' and Glenshimmeroch 132kV substation
System Requirements	Present Generation (if applicable)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Future Generation Count	4	4	4	4	4	4	4	4
	Future Generation Capacity	213MW	213MW	213MW	213MW	213MW	213MW	213MW	213MW
Initial Design Considerations	Limiting Factor	N/A	Inconsistent with SPT's various statutory duties and licence obligations. It makes the network incompliant with harmonic standard (EREC G5/5).	It's neither economic nor efficient from a whole system perspective. It also does not eliminate excessive harmonic voltages in all areas of the network.	It is not effective in controlling harmonic voltages in all areas of the network.	They are effective only at low harmonic orders. They have high losses and noise emission.	Having bespoke filters for each site can itself become part of an unintended resonant condition. They would be very sensitive to network changes and may require re-tuning or extension in future. Also, they will not be very efficient to procure as each site requires a different type of filter.	It does not provide the least background harmonic levels under all network scenario outages. It will require expanding the New Cumnock 'B' substation fence line beyond its current location. It would not enable connection of the contracted	It does not provide the least background harmonic levels for all wind farms and under all network scenario outages. It will be more expensive than options 5a.

System Design Table	**Circuit/Project**	**Preferred – Option 5a:** Installation of 132kV standard harmonic filter in Glenshimmeroch 132kV substation	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 1:** Installation of harmonic filters only in wind farms	**Rejected – Option 2:** Installation of 33kV standard harmonic filters	**Rejected – Option 3:** Installation of active harmonic filters	**Rejected – Option 4:** Installation of bespoke harmonic filter for each site	**Rejected – Option 5b:** Installation of 132kV standard harmonic filter in New Cumnock 'B' 132kV substation	**Rejected – Option 5c:** Installation of 132kV standard harmonic filters in New Cumnock 'B' and Glenshimmeroch 132kV substation
								wind farm developments. It is more expensive in comparison with the option 5a.	
	AIS / GIS	AIS	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Busbar Design	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Cable / OHL / Mixed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	SI	The proposed standardised harmonic filter mitigates the harmonic levels in the 132kV network connected to New Cumnock substation.	N/A	N/A	N/A	N/A	N/A	The proposed standardised harmonic filter mitigates the harmonic levels in the 132kV network connected to New Cumnock substation.	The proposed standardised harmonic filter mitigates the harmonic levels in the 132kV network connected to New Cumnock substation.

Table 9: System Design Parameters for the considered options with respect to the wider scheme proposed in this EJP

System Design Table	Circuit/Project	**Preferred – Option 6:** Establishment of the new Glenshimmeroch 132kV substation, reconductoring the circuits between the Glenshimmeroch substation and DE route, installation of 132/33kV 120MVA Glenshimmeroch transformer and 132kV harmonic filter	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 7:** Reprofiling the existing OHL route between the Glenshimmeroch 132kV substation and the DE route	**Rejected – Option 8:** Separate connection of each wind farms to the DG route
Thermal and Fault Design	Existing Voltage (if applicable)	132kV	132kV	132kV	132kV
	New Voltage	132kV	N/A	132kV	132kV
	Existing Continuous Rating (if applicable)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)	770A (OHL-Summer Rating) 1014A (Cable-Summer Rating)
	New Continuous Rating	1290A (OHL-Summer Rating) 1354A (Cable-Summer Rating)	N/A	840A (OHL-Summer Rating) 1354A (Cable-Summer Rating)	1290A (OHL-Summer Rating) 1354A (Cable-Summer Rating)
	Existing Fault Rating (if applicable)	N/A	N/A	N/A	N/A
	New Fault Rating	20/25kA	N/A	20/25kA	N/A
ESO Dispatchable Services	Existing MVAr Rating (if applicable)	N/A	N/A	N/A	N/A
	New MVAr Rating (if applicable)	20MVAr	N/A	20MVAr	N/A
	Existing GVA Rating (if applicable)	N/A	N/A	N/A	N/A

System Design Table	**Circuit/Project**	**Preferred – Option 6:** Establishment of the new Glenshimmeroch 132kV substation, reconductoring the circuits between the Glenshimmeroch substation and DE route, installation of 132/33kV 120MVA Glenshimmeroch transformer and 132kV harmonic filter	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 7:** Reprofiling the existing OHL route between the Glenshimmeroch 132kV substation and the DE route	**Rejected – Option 8:** Separate connection of each wind farms to the DG route
	New GVA Rating	N/A	N/A	N/A	N/A
System Requirements	Present Demand (if applicable)	N/A	N/A	N/A	N/A
	2050 Future Demand	N/A	N/A	N/A	N/A
	Present Generation (if applicable)	N/A	N/A	N/A	N/A
	Future Generation Count	4	4	4	4
	Future Generation Capacity	213MW	213MW	213MW	213MW
Initial Design Considerations	Limiting Factor	N/A	Inconsistent with SPT's various statutory duties and licence obligations. It would not provide the necessary capacity uplift required to accommodate the contracted	It does not provide sufficient capacity for connection of the contracted wind farms. Also, the existing UPAS conductor is not suitable to be reprofiled.	It will be more expensive and time-consuming than the preferred option. Considering the number of contracted wind farms in the area, this option will not be compliant with the SPEN design policy ESDT-01-002. This option will result in an increased land intake and footprint for the connections.

System Design Table	Circuit/Project	**Preferred – Option 6:** Establishment of the new Glenshimmeroch 132kV substation, reconductoring the circuits between the Glenshimmeroch substation and DE route, installation of 132/33kV 120MVA Glenshimmeroch transformer and 132kV harmonic filter	**Rejected – Baseline:** Do Nothing / Delay	**Rejected – Option 7:** Reprofiling the existing OHL route between the Glenshimmeroch 132kV substation and the DE route	**Rejected – Option 8:** Separate connection of each wind farms to the DG route
			wind farm developments to connect in the area.		
	AIS / GIS	AIS	N/A	AIS	N/A
	Busbar Design	Single Busbar	N/A	Single Busbar	N/A
	Cable / OHL / Mixed	Mixed	N/A	Mixed	Mixed
	SI	The proposed standardised harmonic filter mitigates the harmonic levels in the 132kV network connected to New Cumnock substation.	N/A	-	-

5. Proposed Works & Associated Cost

5.1. Project Summary

As discussed above, the proposed scheme in this scheme entails establishment of the new Glenshimmeroch 132kV collector substation, installation of the new 132/33kV 120MVA and 60MVA transformers together with a new 132kV 20MVAr damped harmonic filter in the Glenshimmeroch substation as well as uprating the existing cable and OHL circuits between the new Glenshimmeroch 132kV collector substation and Glenshimmeroch tee point on the DE route.

The proposed electrical layout of Glenshimmeroch collector substation can be found in Appendix A, Figure A-5. The associated Works in this stage are summarised in the following –

Pre-Engineering Works

The following list is indicative based on previous experience of such sites and as such should not be read as definitive. The following surveys will be carried out:

- Topological survey of the site.
- GPR survey of areas to be re-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.
- Transport Survey to assess the access of the new Equipment.
- Environmental Study.

Glenshimmeroch 132kV Collector Substation

Considering the connections to the new Glenshimmeroch 132kV collector substation, there will be a requirement to establish a 132kV single busbar with six bays for installation of six 132kV SF_6-free Live Tank Circuit Breakers (CBs) and associated disconnectors. Based on the order from top to down, and right to left side of the Glenshimmeroch 132kV busbar shown in Appendix A, Figure A-5, these 132kV SF_6-free Live Tank CBs accommodate the following connections:

- 132/33kV 120MVA T1.
- 132kV cables from [redacted] wind farm.
- 132kV OHL circuit from Blackcraig wind farm.
- 132kV OHL circuit to the Glenshimmeroch tee point (i.e., New Cumnock/Kendoon tee off).
- 132/33kV 60MVA T2.
- 132kV 20MVAr damped harmonic filter.

There will also be a requirement to establish 2 x 33kV indoor switchgear[6] for connection of [redacted] wind farm, [redacted] Wind farm and [redacted] wind farm. The 33kV indoor switchboard required for connection of [redacted] wind farm is part of A1 Connections Assets works for [redacted] wind farm and the 33kV indoor switchboard required for connection of [redacted] and [redacted] wind farms is part of SPT-RI-2243.

The works at the new Glenshimmeroch 132kV substation shall include:

[6] Ensuring the optimal size of the transformers and connections necessities installing two separate 33kV switchgears.

- Establishing the 132kV single busbar and installing the SF_6-free Live Tank CBs and associated disconnectors based on the requirements discussed in the previous paragraph.
- Installing the 132kV 20MVAr damped harmonic filter.
- Installing one 132/33kV 120MVA transformer (part of SPT-RI-2243) and one 132/33kV 60MVA transformer (part of A1 Connections Assets works for [redacted] wind farm) and connecting their HV sides to their associated SF_6-free Live Tank CBs.
- Installing appropriate lengths of OHL gantries for connection to the 132kV SF_6-free Live Tank CB.
- Establishing a switchgear housing to accommodate two 33kV switchgears; switchgears 1 & 2. Establishment of switchgear-panel 1A is part of A1 Connections Assets works for [redacted] wind farm, switchgear-panel 1B is part of A1 Connections Assets works for [redacted] and switchgear-panel 2 is part of A1 Connections Assets works for [redacted] wind farm.
- Terminating the 132kV 'EAGLE' HTLS OHL circuit into the Glenshimmeroch 132kV busbar to facilitate the connection to the Glenshimmeroch tee point (i.e., New Cumnock/Kendoon tee off point).
- Terminating the 132kV 'UPAS' OHL circuit into the Glenshimmeroch 132kV busbar to facilitate the existing connection from the Blackcraig wind farm.
- Terminating the 132kV cable circuit into the Glenshimmeroch 132kV busbar to facilitate the connection from the [redacted] wind farm.
- Facilitating the termination of the 33kV circuits from the wind farms into the 33kV indoor switchgear; [redacted] wind farm to panel 1A, [redacted] wind farm to panel 1B and [redacted] wind farm to panel 2.
- Facilitating the connections between the 132/33kV 120MVA T1 and switchgear panel 1A, and also between the 132/33kV 120MVA T1 and switchgear panel 1B.
- Facilitating the connection between the 132/33kV 60MVA T2 and switchgear panel.
- All control and protection works.
- All environmental and civil works.

The civil engineering works associated with this element of the project entail:

- The design and construction of foundations and structures necessary to construct the site civil platform in the new Glenshimmeroch substation area.
- The design and construction of foundations and structures necessary to construct the harmonic filter's site civil platform.
- The design and construction of foundations and structures necessary to construct the 33kV indoor switchgear's site civil platform.
- 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.

Uprating Glenshimmeroch 132kV substation to Glenshimmeroch tee 132kV OHL and Cable Circuits

As discussed in Section 3 (Table 2 and Table 3), the assets under uprate (i.e., ~6.3km of OHL circuit and ~1km of underground cable) are in a very good health condition and relatively new. These assets have been installed in 2017 and are relatively new. The main reason for the proposed replacement of these circuits is the significant volume of connection applications. The scale of existing wind farm connections to the DG route, based on which the circuits were designed and installed in 2017, is shown in Appendix A, Figure A-3. The Figure A-4 in Appendix A indicates the scale of currently contracted plus the existing wind farm developments near the DG route. The proposed scheme in this EJP now would look to size these circuits according to the level demonstrated in the Figure A-4 in Appendix A to avoid such uprating requirements in near future.

Glenshimmeroch 132kV substation to Glenshimmeroch tee 132kV OHL

The work associated with this element of the project entail:

- Reconductoring of a section of the OHL between the new Glenshimmeroch 132kV collector substation and the cable end (at pole 1) on the DG route 132kV circuit, approximately 6.3km, by replacing the existing 'UPAS' conductor (summer pre-fault rating is 176MVA at 75°C) with an 'EAGLE' HTLS conductor, operating at 190°C, on the existing wood pole system.
- All associated environmental and civil works.
- Update all records to reflect the works carried out.
- Confirm that all ESQCR requirements have been met.

The rating of 'EAGLE' HTLS conductor operating at 190°C is as follows:

Table 10: Rating of EAGLE HTLS Conductor at 132kV and Operating at 190°C

Season / State	Amps	MVA
Winter Pre Fault	1340	305
Winter Post Fault	1600	365
Spring/Autumn Pre Fault	1320	300
Spring/Autumn Post Fault	1570	360
Summer Pre Fault	1290	295
Summer Post Fault	1530	350

Glenshimmeroch 132kV substation to Glenshimmeroch tee 132kV Cable

The work associated with this element of the project entail:

- Replace the existing underground cable, approximately 1km, on the Glenshimmeroch 132kV substation / Glenshimmeroch tee point circuit with 2000mm^2 Cu 132kV cable including cable ends if required. The continuous summer rating of this conductor is 310MVA (1354A).
- All associated environmental and civil works.
- Update all records to reflect the works carried out.
- Confirm that all ESQCR requirements have been met.

5.2. Project Cost

5.2.1. Allocation of Harmonic Filter Costs

As outlined in the previous sections, users are normally responsible for harmonic mitigation and therefore the full cost of mitigation. For users that are significant sources of harmonic emissions, this is consistent with a 'polluter pays' approach. However, most windfarms are not a significant source of harmonics (i.e., they are not by themselves polluters). In some parts of the SPT's 132kV network, they simply form part of a wider resonant system that amplifies background harmonics caused by a range of sources, including consumer devices and equipment. This suggests that part of the cost of harmonic mitigation should be socialised, rather than penalising individual Users for resonant conditions that are largely out of their control.

It is anticipated that the harmonic filter installation proposed in this paper will be funded fully via the RIIO-T3 price review. However:

1. The responsibility for harmonic compliance should not be removed from users to ensure that they remain liable if they connect polluting equipment to the network.
2. User choice could have a significant impact on harmonic resonance (e.g., the use of cable instead of an overhead line connection). In such cases, where there is deemed to be an increased risk of harmonic resonance, a harmonic filter should be included in the offer as a one-off cost.

This approach is consistent with the 'polluter pays' principle while ensuring that harmonic compliance is managed in an economic and efficient manner across the transmission system.

5.2.2. Estimated Total Project Cost

Glenshimmeroch 132kV Substation (SPT-RI-274)

A Business Plan provision and estimated cost of the Glenshimmeroch 132kV substation project is indicated in the following table. Costs provided below include direct, indirect, and contingency costs.

Project costs for Glenshimmeroch 132kV substation are summarised in the cost breakdown in Table 11:

Table 11: Project Cost Breakdown – SPT-RI-274

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

Expenditure incidence is summarised in Table 12:

Table 12: Summary of Expenditure Incidence – SPT-RI-274

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	RIIO-T2 Total: CAPEX	RIIO-T3 Total: CAPEX	Total: CAPEX
2027	£0.0m	£0.01m	£0.01m	£0.07m	£0.11m	£0.60m	£3.27m	£1.39m	£0.80m	£4.66m	£5.46m

Glenshimmeroch 132/33kV 120MVA Transformer (SPT-RI-2243)

A Business Plan provision and estimated cost of the Glenshimmeroch 132/33kV 120MVA transformer project is indicated in the following table. Costs provided below include direct, indirect, and contingency costs.

Project costs for Glenshimmeroch 132/33kV 120MVA transformer are summarised in the cost breakdown in Table 13:

Table 13: Project Cost Breakdown – SPT-RI-2243

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

Expenditure incidence is summarised in Table 14:

Table 14: Summary of Expenditure Incidence – SPT-RI-2243

Energisation Year	Yr. 2024: CAPEX	Yr. 2025: CAPEX	Yr. 2026: CAPEX	Yr. 2027: CAPEX	Yr. 2028: CAPEX	RIIO-T2 Total: CAPEX	RIIO-T3 Total: CAPEX	Total: CAPEX
2027	£0.00m	£0.26m	£2.57m	£4.85m	£1.79m	£2.84m	£6.64m	£9.48m

Glenshimmeroch OHL & Cable Route Uprate (SPT-RI-296)

A Business Plan provision and estimated cost of the Glenshimmeroch OHL & cable route uprate project is indicated in the following table. Costs provided below include direct, indirect, and contingency costs.

Project cost for Glenshimmeroch OHL & cable route uprate is summarised in the cost breakdown in Table 15:

Table 15: Project Cost Breakdown – SPT-RI-296

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

Expenditure incidence is summarised in Table 16:

Table 16: Summary of Expenditure Incidence – SPT-RI-296

Energisation Year	Yr. 2022: CAPEX	Yr. 2023: CAPEX	Yr. 2024: CAPEX	Yr. 2025: CAPEX	Yr. 2026: CAPEX	Yr. 2027: CAPEX	Yr. 2028: CAPEX	RIIO-T2 Total: CAPEX	RIIO-T3 Total: CAPEX	Total: CAPEX
2027	£0.00m	£0.00m	£0.01m	£0.01m	£1.15m	£3.03m	£1.33m	£1.17m	£4.36m	£5.53m

Glenshimmeroch Harmonic Filter

A Business Plan provision and estimated cost of the Glenshimmeroch harmonic filter project is indicated in the following table. Costs provided below include direct, indirect, and contingency costs.

Project costs for Glenshimmeroch harmonic filter installation are summarised in the cost breakdown in Table 17:

Table 17: Project Cost Breakdown – Harmonic Filter Installation

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

Expenditure incidence is summarised in Table 18:

Table 18: Summary of Expenditure Incidence – Harmonic Filter Installation

Energisation Year	**Yr. 2025: CAPEX**	**Yr. 2026: CAPEX**	**Yr. 2027: CAPEX**	**Yr. 2028: CAPEX**	**RIIO-T2 Total: CAPEX**	**RIIO-T3 Total: CAPEX**	**Total: CAPEX**
2027	£0.00m	£0.92m	£4.28m	£1.71m	£0.92m	£5.99m	£6.91m

5.3. Regulatory Outputs

Glenshimmeroch 132kV Substation (SPT-RI-274)

The indicative primary asset outputs for the Glenshimmeroch 132kV substation project are identified in Table 19:

Table 19: Indicative Primary Asset Outputs – SPT-RI-274

Asset Category	Asset Sub-Category Primary	Voltage	Intervention	Forecast Addition[7]	Forecast Disposal[8]
Circuit Breaker	CB (Air Insulated Busbar)	132kV	Addition	2 units	-
Substation Platform	Platform Creation	132kV	Addition	1 unit	-

Glenshimmeroch 132/33kV 120MVA Transformer (SPT-RI-2243)

The indicative primary asset outputs for the Glenshimmeroch 132/33kV 120MVA transformer project are identified in Table 20:

7 Forecast Additions are indicative pending further detail design.
8 Forecast Disposals are indicative pending further detail design.

Table 20: Indicative Primary Asset Outputs – SPT-RI-2243

Asset Category	Asset Sub-Category Primary	Voltage	Intervention	Forecast Addition[9]	Forecast Disposal[10]
Circuit Breaker	CB (Air Insulated Busbar)	132kV	Addition	1 unit	-
Circuit Breaker	Switchgear - Other	33kV	Addition	3 units	-
Other Switchgear	Switchgear Other	33kV	Addition	2 units	-
Wound Plant	Transformer	132kV>90MVA	Addition	1 unit	-

Glenshimmeroch OHL & Cable Route Uprate (SPT-RI-296)

The indicative primary asset outputs for the Glenshimmeroch 132kV substation project are identified in Table 21:

Table 21: Indicative Primary Asset Outputs – SPT-RI-296

Asset Category	Asset Sub-Category Primary	Voltage	Intervention	Forecast Addition[11]	Forecast Disposal[12]
Cable	Circuit Cable – 1 core per phase	132kV	Addition	1 km	-
Cable	Circuit Cable – 1 core per phase	132kV	Disposal	-	1 km
Overhead Pole Line	OHL (Pole Line) High Temperature Low Sag (HTLS) Conductor	132kV	Addition	6.3 Km	-
Overhead Pole Line	OHL (Pole Line) High Temperature Low Sag (HTLS) Conductor	132kV	Disposal	-	6.3 Km

Glenshimmeroch Harmonic Filter

The indicative primary asset outputs for the Glenshimmeroch harmonic filter project are identified in Table 22:

Table 22: Indicative Primary Asset Outputs – Glenshimmeroch Harmonic Filter

Asset Category	Asset Sub-Category Primary	Voltage	Intervention	Forecast Addition[13]	Forecast Disposal[14]
Circuit Breaker	CB (Air Insulated Busbar)	132kV	Addition	1 unit	-
Flexible AC Transmission Systems (FACTS)	FACTS Equipment	132kV	Addition	1 unit	-

9 Forecast Additions are indicative pending further detail design.
10 Forecast Disposals are indicative pending further detail design.
11 Forecast Additions are indicative pending further detail design.
12 Forecast Disposals are indicative pending further detail design.
13 Forecast Additions are indicative pending further detail design.
14 Forecast Disposals are indicative pending further detail design.

5.4. Environmental and Consents Works

Section 37 consent is not required for this project as the OHL circuit will be installed on the existing wood poles. Deemed planning permission is being sought for the 132kV OHL, underground cable and the proposed Glenshimmeroch substation, as well as the ancillary development. Relevant landowner agreements will also need to be put in place where required.

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 23 summarises the key milestones within the delivery schedule of this project. [redacted]

Table 23: Summary of Key Milestones within the Project Delivery Schedule

Item	Project Milestone	Estimated Completion Date
1	SCA (Design) Approval	April 2025
2	Power Transformer Contract Award	August 2025
3	Planning Application Submission for Glenshimmeroch Substation	January 2026
4	Town & Country Planning Consents	April 2024
5	Gaining Site Access	July 2026
6	OHL Access Contract Award Date	December 2026
7	Commissioning	October 2027

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 shall 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 24 - Main Scheme Risks and Mitigation Plans

Risk Title	Risk Description	Mitigation Plan
Planning consents for new substation	Land rights and consents required for new substation, delays to approvals would delay programme.	Regular engagement with local authority and other relevant stakeholders.
Compulsory Purchase Order (CPO)	CPO being sought due to being unable to secure voluntary land rights for 132kV substation platform.	Regular meetings will be held with SPEN's planning and permission team to ensure SPEN's principles have been met.
Procurement of Harmonic Filter	Learning from RIIO-T2 experience on harmonic filter installations, there is a limited market availability for harmonic filter procurement.	Regular meetings will be held with SPEN's Mega Scheme team to ensure SPEN's principles have been met.

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: Various areas applicable to these standards ensure a quality product is delivered. The significant areas 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.

6.3.2. 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.

6.3.3. 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.

6.3.4. Post Energisation

SPT Projects and SPT Operations within SPEN 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.

6.4. Environmental and Wayleave Considerations

6.4.1. Environmental Planning

The following environmental surveys will require to be carried out prior to any work commencing on site:

- Ecology: Phase 1 habitat survey
- Ecology: Protected species survey
- Archaeology: Desktop based survey
- Archaeology: Field evaluation
- Archaeology: Watching brief for any ground-breaking works within identified areas[15]

The intention should be to use low bearing pressure vehicles where possible. Access routes and formation may be supplementary to existing roads and tracks and should use sustainable materials which can be reutilised where possible. Any compaction of ground should be rectified.

Based on previous surveys on the DG route, the surveys have not identified any sites of historical interest and environmental value that require dialogue with the relevant statutory organisations before work will commence.

6.4.2. Wayleave Issues

The section of the DG route that is under-uprate requires Section 37 consent to operate at 132kV. Any clearance infringement mitigation works, temporary access and working areas required to facilitate physical OHL works will require planning permission from the local planning authority. Landowner agreements will be required to deliver these works. SPT will take a co-ordinated approach to all aspects of these works in view of the need to deliver an overall and integrated solution which recognises potential interaction and cumulative impacts.

6.4.3. 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.

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15 May only be required if any proposed ground-breaking works encroach on areas of interest.

SPEN 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.

6.5. 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. Conclusion

This EJP demonstrates the need to establish the new Glenshimmeroch 132kV collector substation in the SWS area, install one unit of 20MVAr damped (C-type) harmonic filter in this substation, install Glenshimmeroch 132/33kV 120MVA transformer and uprate a section of the existing overhead line (OHL) and underground cable, on DG route, from the new Glenshimmeroch substation to the Glenshimmeroch tee off point, on the DE route, in order to provide a minimum summer pre-fault rating of 280MVA.
This reinforcement scheme primarily serves as enabling work required for collection of 213MW of contracted renewable generation (wind farm development) in the SWS area, providing a new point of connection on the DG route. The existing circuit between the proposed Glenshimmeroch 132kV substation and the Glenshimmeroch tee entails:

- ~6.3km of 132kV OHL circuit with UPAS conductor installed on wood poles. The conductor's summer pre-fault rating is 176MVA at 75°C.
- ~1km of underground cable with 1600mm^2 Al XLPE conductor. The conductor's continuous summer rating is 1014A (231MVA).

In order to provide the required capacity, the section of the existing OHL and underground cable from the new Glenshimmeroch 132kV collector substation to the Glenshimmeroch tee point will be updated by:

- replacing the existing OHL circuit with 'EAGLE' HTLS conductor on the existing wood poles. This conductor's summer pre-fault rating is 295MVA at 190°C.
- replacing the existing underground cable conductor with 2000mm^2 Cu XLPE conductor. This conductor's continuous summer rating is 1354A (310MVA).

To enable connection of the contracted wind farm generation to the new Glenshimmeroch 132kV collector substation, a new 132/33kV 60MVA transformer and a new 132/33kV 120MVA transformer will be installed at the Glenshimmeroch 132kV substation.
The increasing number of large wind farm connections into the SWS area is leading to amplification of background harmonics to levels above the EREC G5/5 planning levels. This issue can be mitigated by the installation of standardised harmonic filters to provide a coordinated and efficient solution. In the SWS area, there are five harmonic filters for completion by the end of December 2026. The

Glenshimmeroch 132kV 20MVAr damped (C-type) harmonic filter proposed in this EJP is proven to ensure our network compliance with harmonic standards, EREC G5/5, in the SWS area.

The main conclusions of this EJP are:

- It is necessary to invest in transmission infrastructure at Glenshimmeroch 132kV Substation, and between the new substation and Glenshimmeroch tee off point on the DE route, to enable the connection of 213MW of contracted wind farm developments, this having been identified as the most economic and efficient option.
- To ensure network compliance with EREC G5/5 it's necessary to install a 132kV 20MVAr damped (C-type) harmonic filter in the new Glenshimmeroch 132kV collector substation.
- The proposed reinforcement scheme plays a vital role in reaching legislated net zero targets and is aligned with SPT's RIIO-T3 strategic goals.

We ask that Ofgem approves the need for this group of projects, with the intention that these shall all be funded through the proposed UIOLI pot within the RIIO-T3 period.

8. Appendices

Appendix A – Maps and Diagrams

Appendix B – Reference to Supporting Documents

[redacted]

Appendix A: Maps and Diagrams

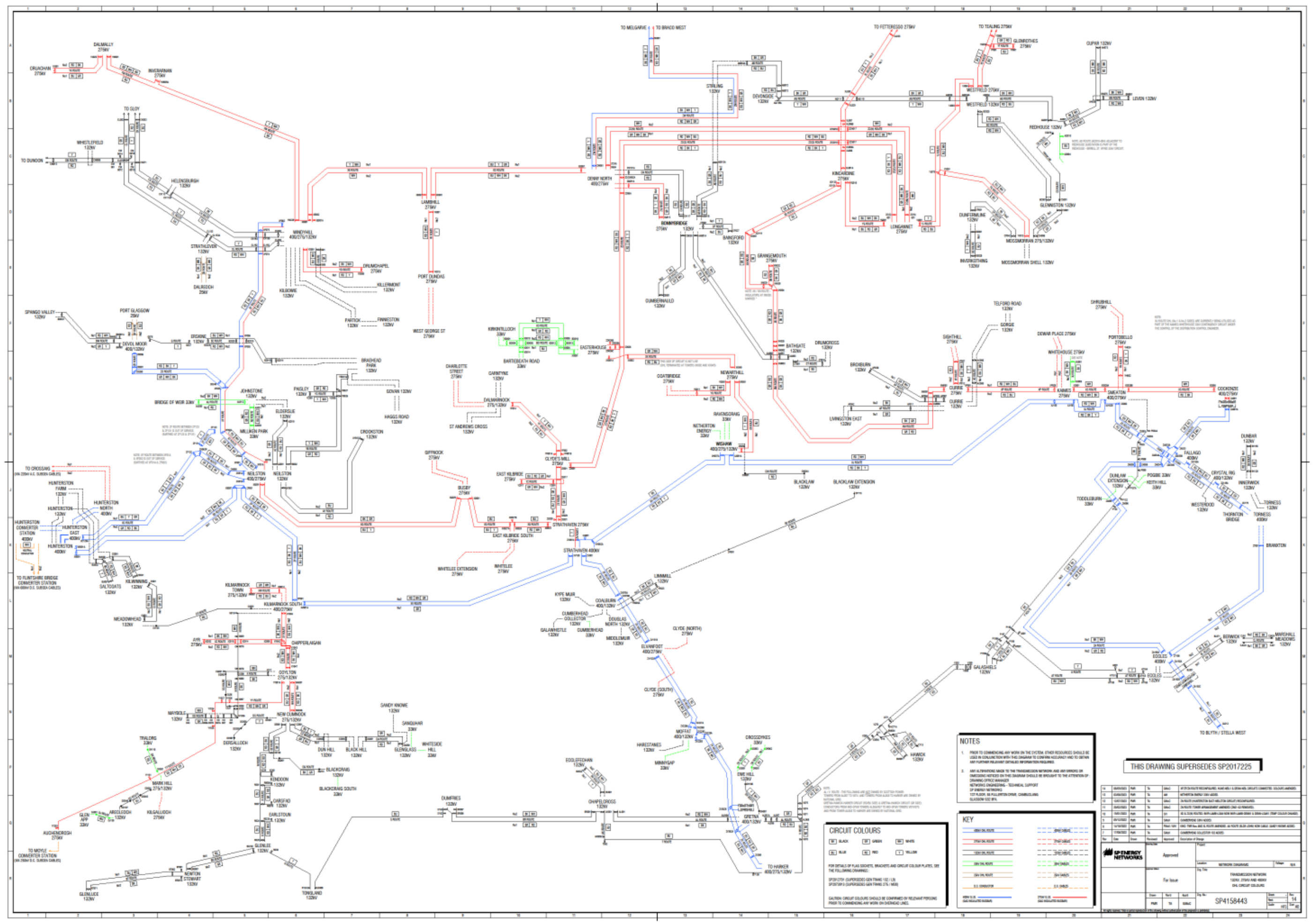

Figure A-1: Networks Diagram of the existing SPT systems – Single Line Diagram

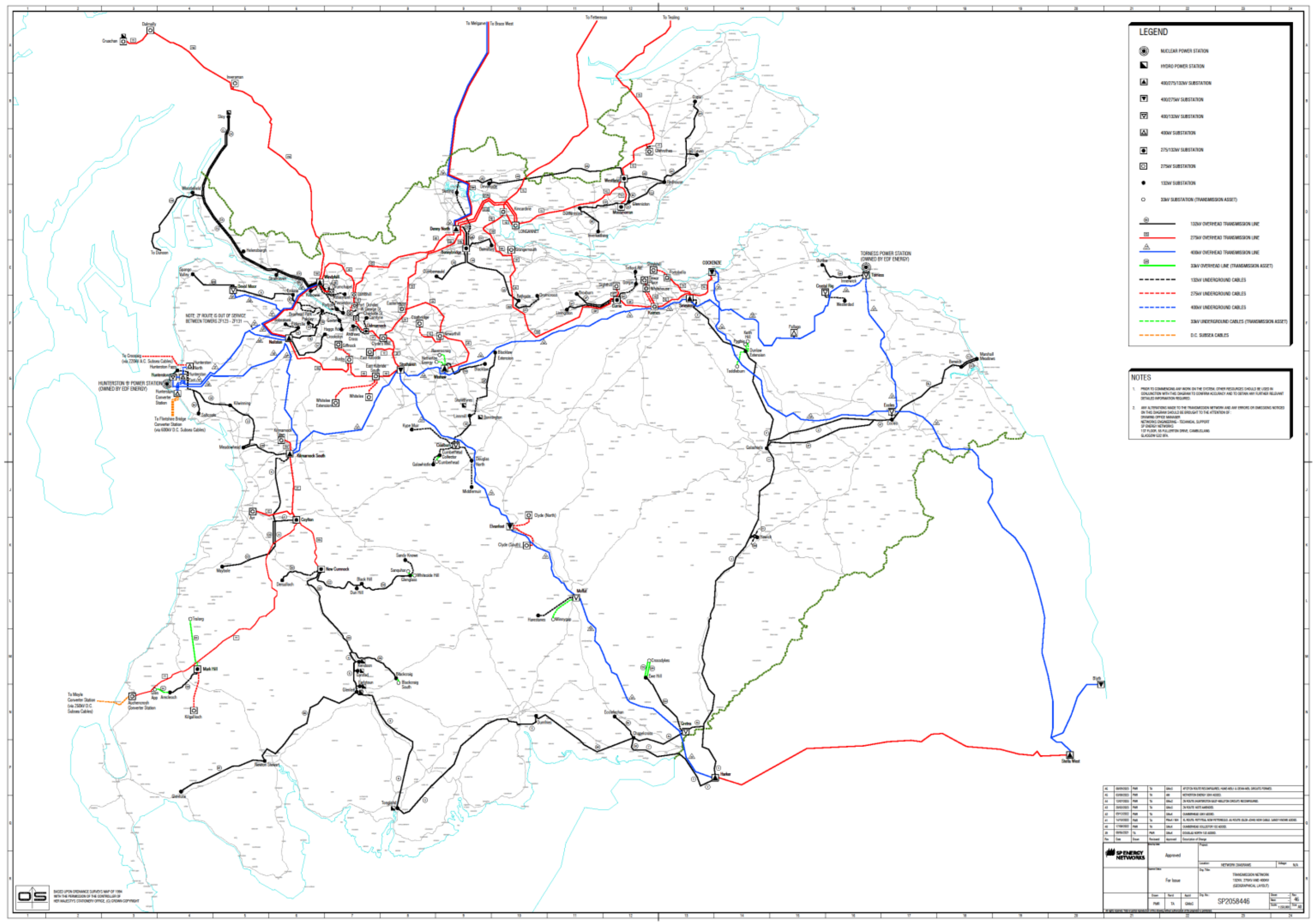

Figure A-2: Networks Diagram of the existing SPT system - Geographical Layout

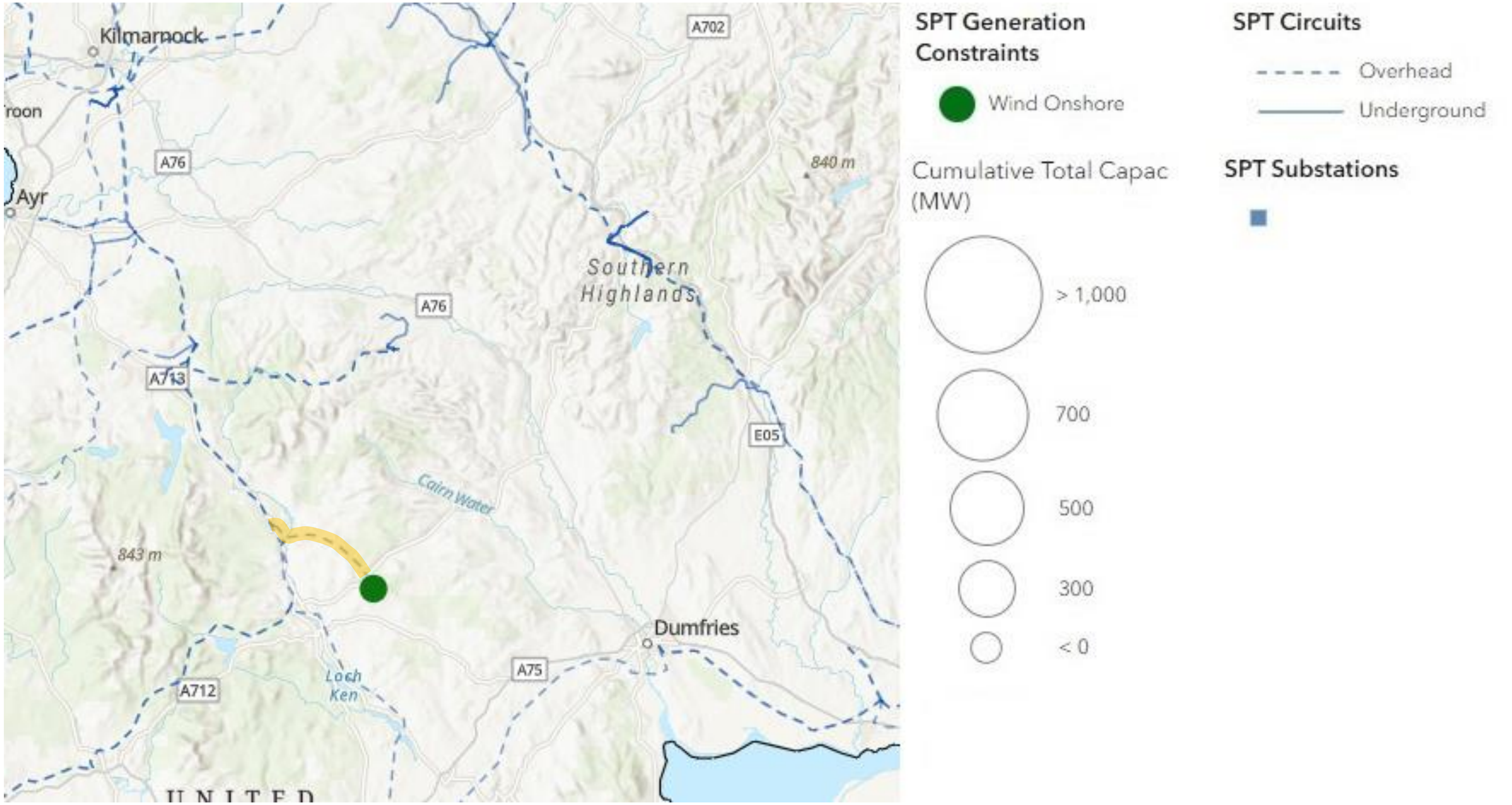

*Figure A-3: Wind Farm Generator Developments currently connected to the DG route, Extracted from Transmission Generation Heat Map**

* NB – The DG route has been highlighted in yellow.

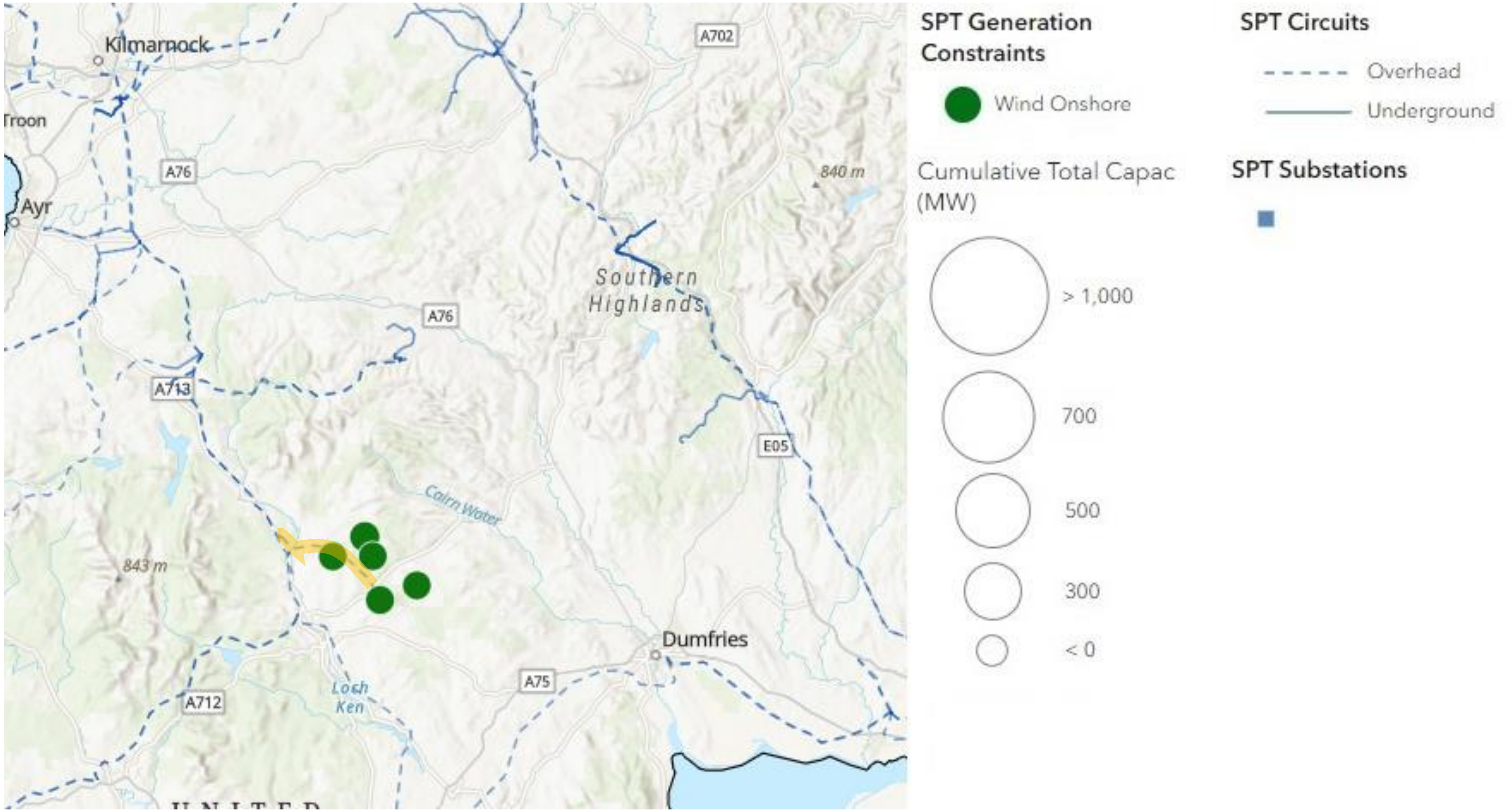

*Figure A-4: Contracted and Connected Wind Farm Developments proposed for connection to the new Glenshimmeroch 132kV collector substation, Extracted from Transmission Generation Heat Map**

* NB – The DG route has been highlighted in yellow.

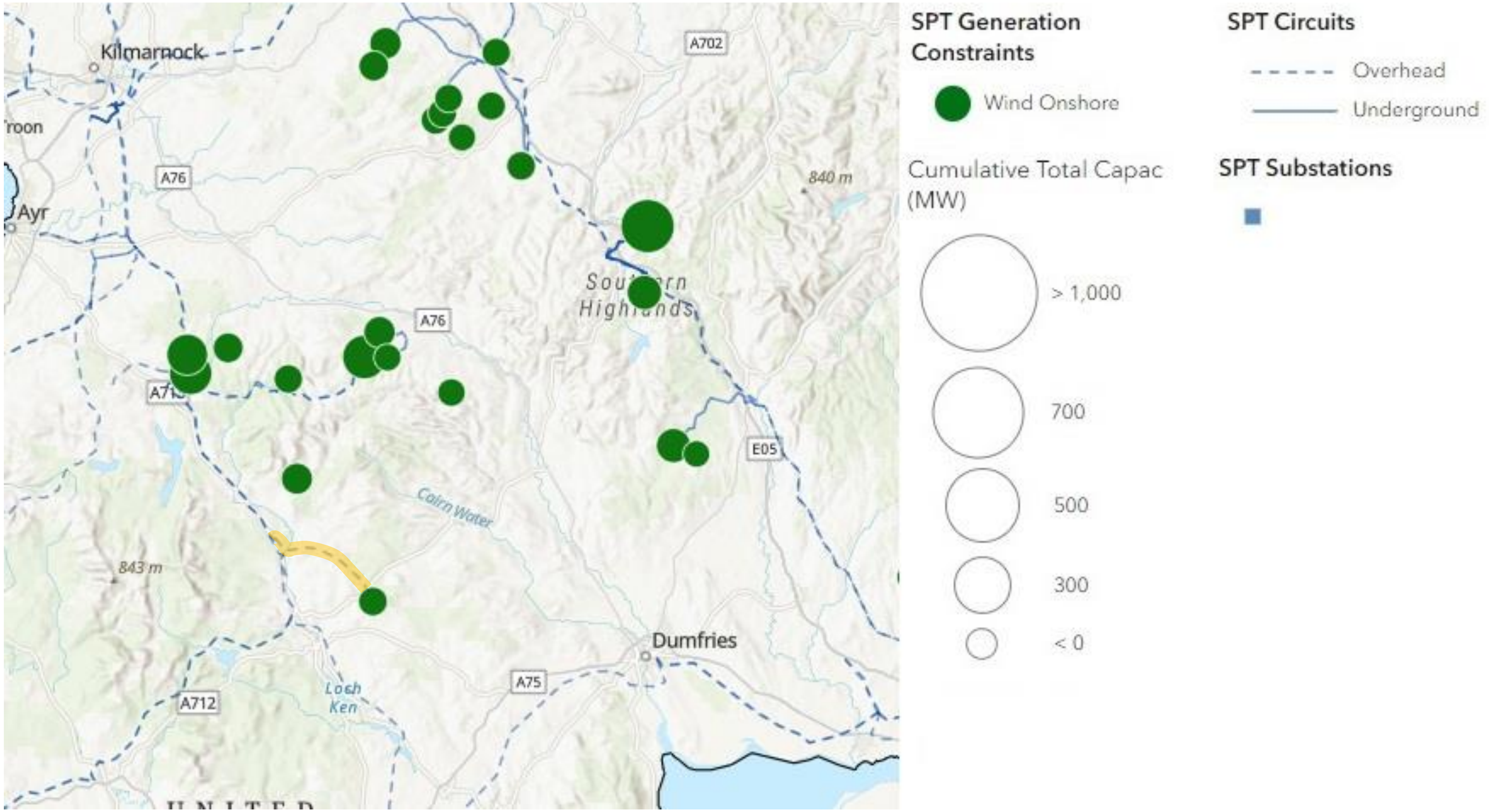

*Figure A-5: Currently Connected Wind Farm Developments in the SWS area as a scale to indicate the network's background harmonic level – Extracted from Transmission Generation Heat Map**

* NB – The DG route, where the Glenshimmeroch 132kV harmonic filter (via connection to the Glenshimmeroch 132kV collector substation) will be connected to, has been highlighted in yellow.

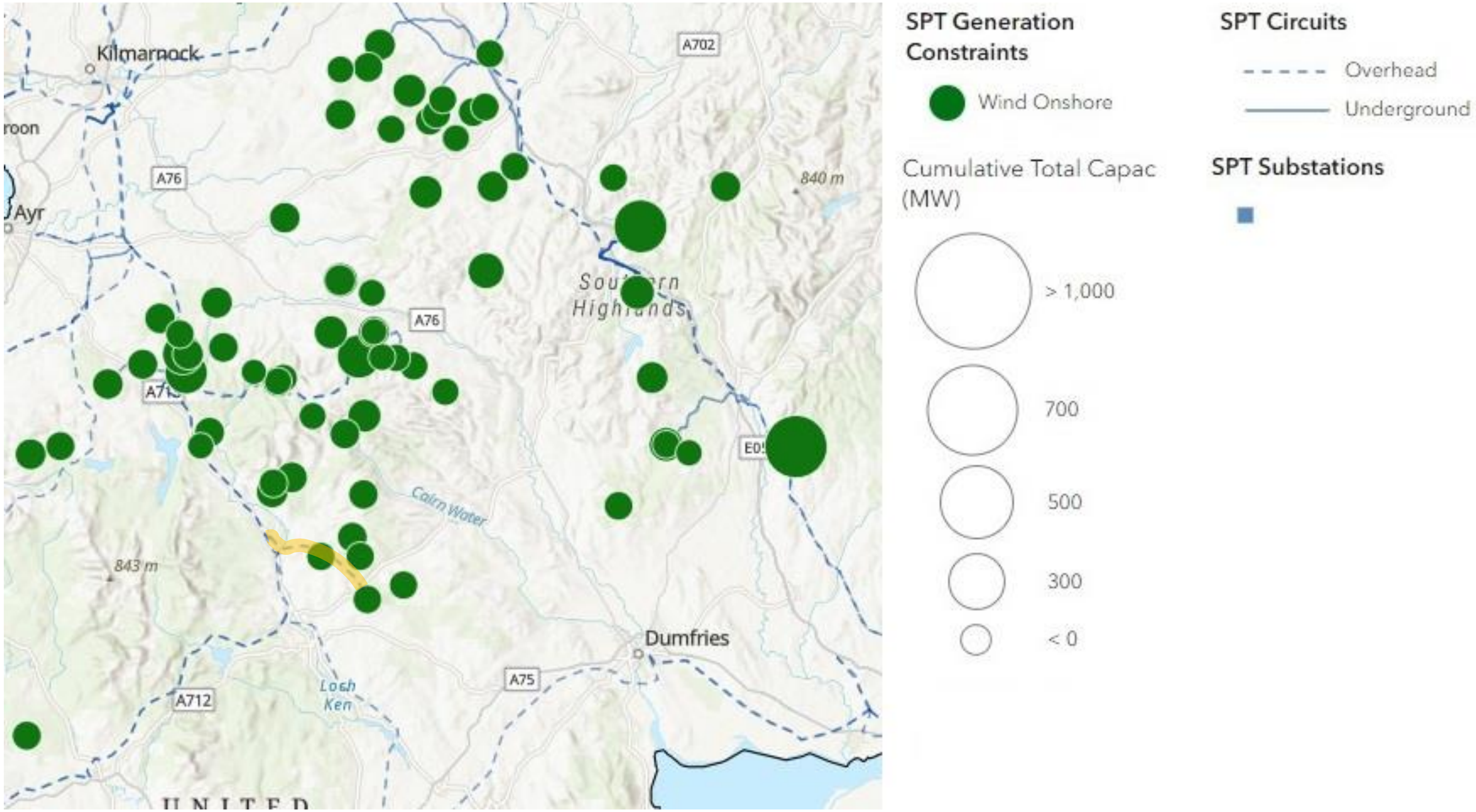

*Figure A-6: Contracted and Connected Wind Farm Developments in the SWS area as a scale to indicate the network's background harmonic level – Extracted from Transmission Generation Heat Map**

*NB – The DG route, where the Glenshimmeroch 132kV harmonic filter (via connection to Glenshimmeroch 132kV collector substation) will be connected to, has been highlighted in yellow.

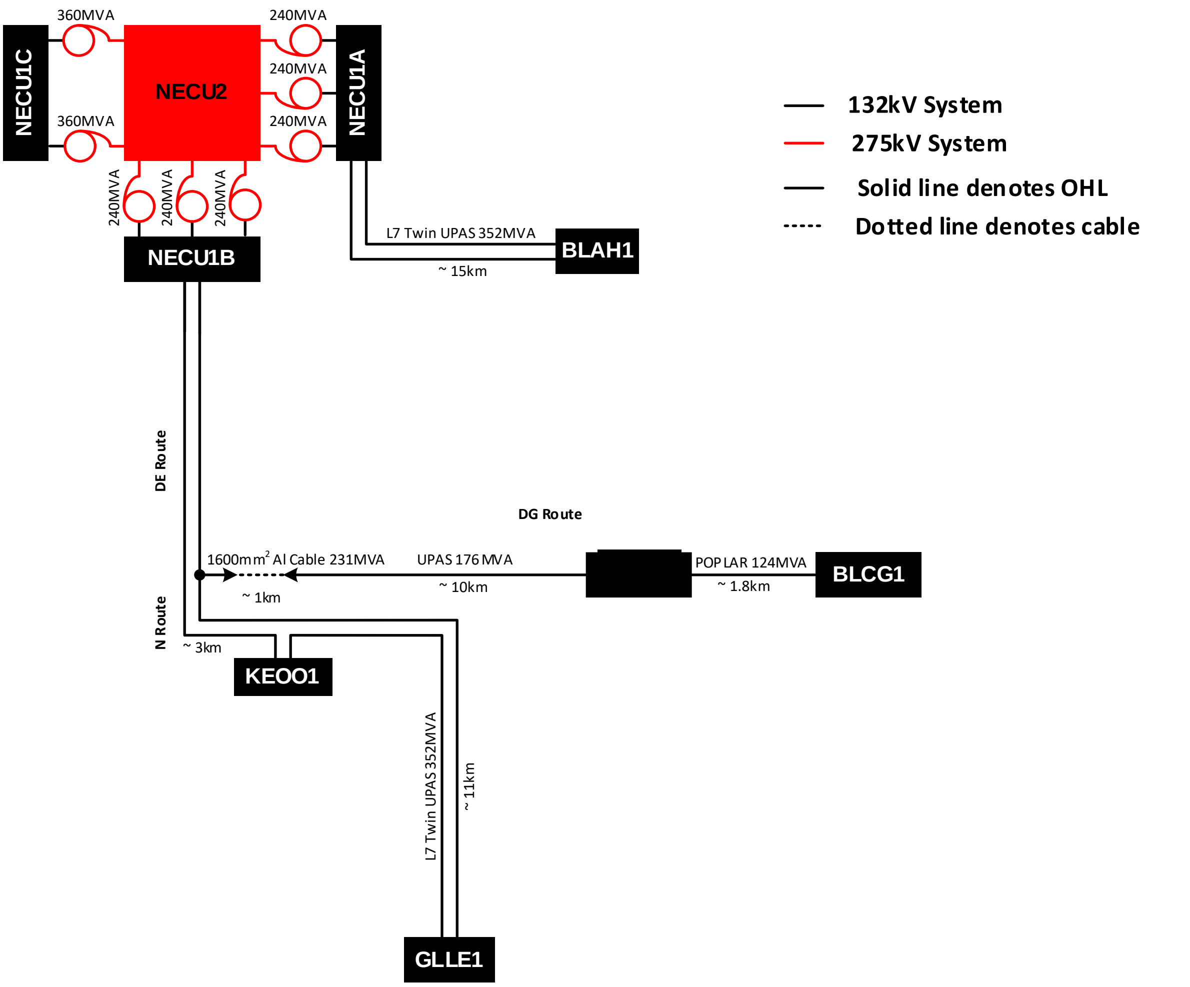

*Figure A-7: System configuration should [redacted] Harmonic Filter project had not been withdrawn**

*NB – The [redacted] harmonic filter project is to be withdrawn as it is not justifiable with considering the cancellation of [redacted] wind farm 43MW connection. [redacted] Wind Farm has withdrawn their 43MW connection contract and with considering the geographical location of the other contracted wind farms in the area, establishment of [redacted] substation and [redacted] harmonic filter is not viable.

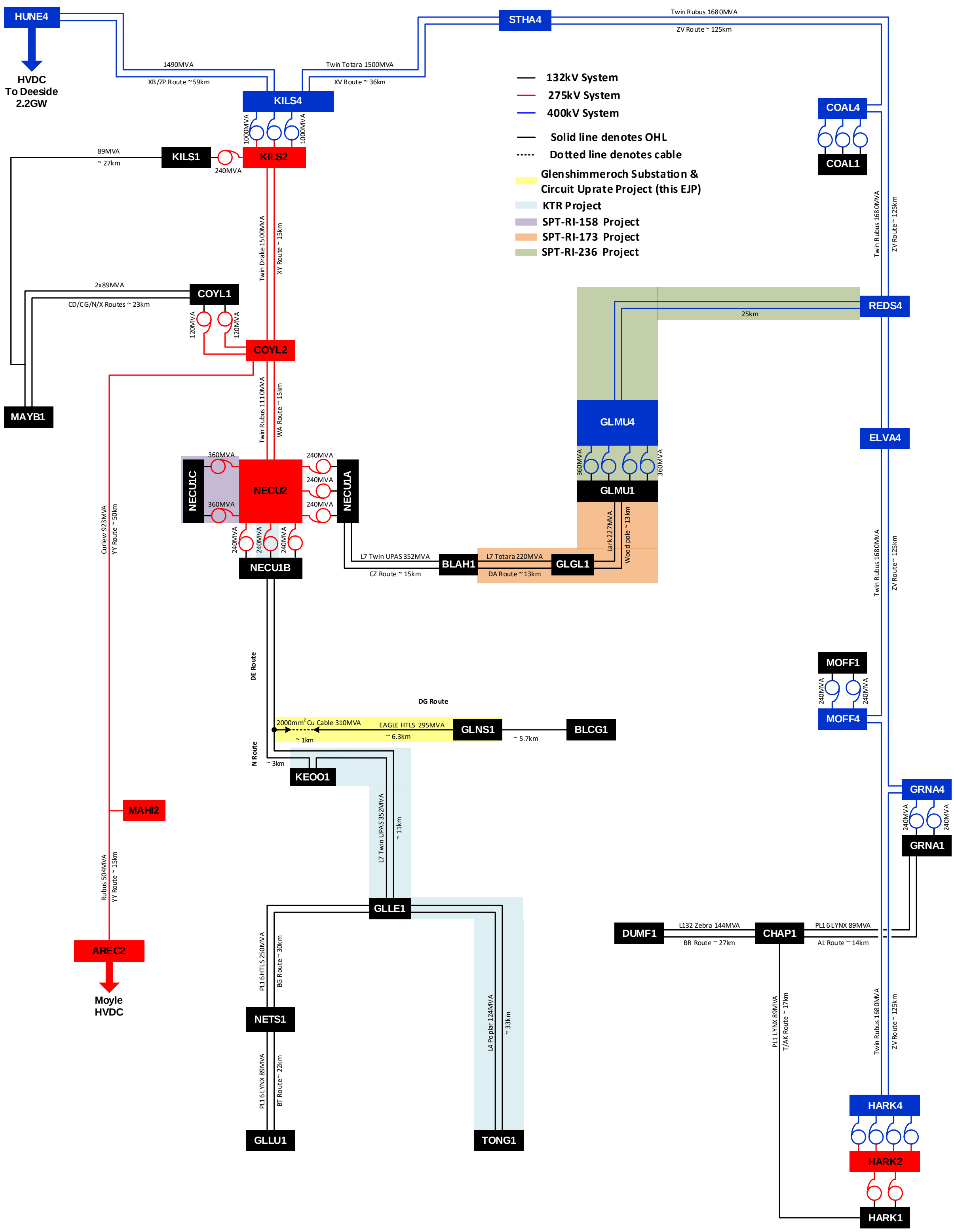

Figure A-8: Single Line Diagram of the transmission network in the area.*

*NB – The focus of this diagram is the Glenshimmeroch substation & circuit uprate project (i.e., Glenshimmeroch substation, 120MVA T1, circuit uprate, and harmonic filter as proposed in this EJP). The rest of the network shown is subject to change as driven by other network needs. The reinforcement projects: KTR, SPT-RI-158, SPT-RI-173 and SPT-RI-236 have been / will be justified through separate need cases.

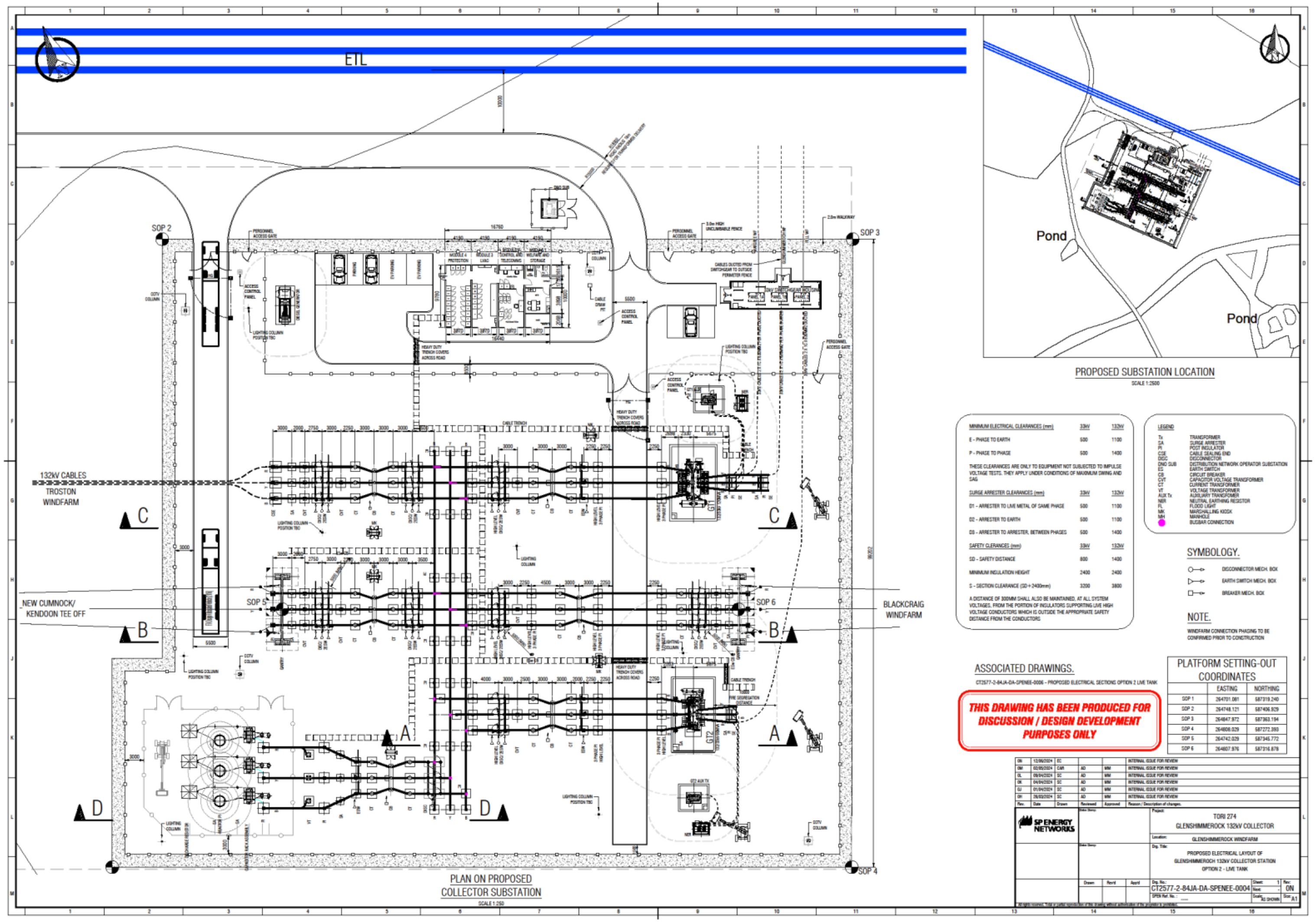

Figure A-9: Electrical layout for option 5a (i.e., installing the 132kV harmonic filter in the new Glenshimmeroch substation)

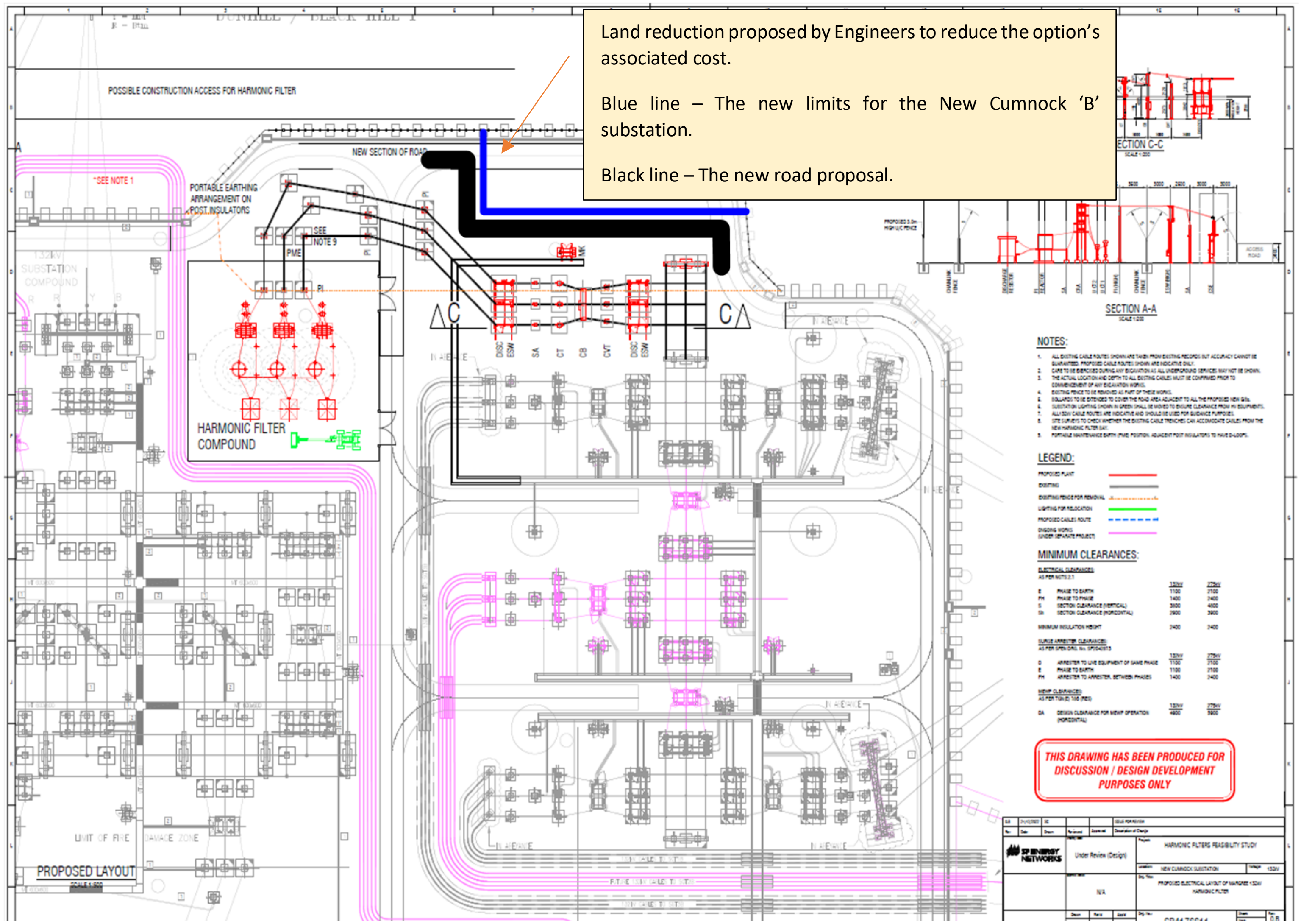

Figure A-10: Electrical layout for option 5b (i.e., installing the 132kV harmonic filter in the New Cumnock 'B' substation)

Appendix B: Reference to Supporting Documents

1. ENA Engineering Recommendation G5 “Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom”, Issue 5, 2020.
2. WSP Parsons Brinckerhoff, “Development of a Standard 33kV Harmonic Filter – Stage 1”, June 2016 (NIA project NIA_SPT_1506, Development of a Standard 33kV Damped Harmonic Filter Design).
3. WSP Parsons Brinckerhoff, “Development of a Standard 33kV Harmonic Filter – Stage II”, February 2017 (NIA project NIA_SPT_1506, Development of a Standard 33kV Damped Harmonic Filter Design).
4. Electric Power Research Institute (EPRI), “South West Scotland Harmonics Study – Filter Design and Analysis Results”, July 2017 (NIA project NIA_SPT_1610, Innovative Approach for Transmission Harmonics Issues).
5. Dr Brozio C.C, IP1 “Harmonic Filters for 132kV Network”, RIIO-T2 Works, January 2020.
6. NIA_NGTO018 (Harmonic compliance management), https://www.smarternetworks.org/project/nia_ngto018