Coalburn Harmonic Filter

NESO Driven Works EJP
Version: 1.0
11/12/2024

SP Energy Networks
RIIO-T3 Business Plan

SP Energy Networks

Coalburn Harmonic Filter			
Name of Scheme	Coalburn Harmonic Filter		
Investment Driver	Wider works		
NESO Review	NESO Reviewed: No		
BPDT / Scheme Reference Number	SPT200874 (part of)		
Outputs	• Flexible AC Transmission Systems (FACTS) – 1 unit • 1 X 132kV CB (Air Insulated Busbar) • 132 cable (substation cable – 1 core per phase) – 250m		
Cost	£11.10m		
Delivery Year	2030		
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	**ET2**	**ET3**	**ET4**
Harmonic Filter	£0.97m	£10.13m	£0.00m

Table of Contents

Table of Contents 2
1. Executive Summary 4
2. Introduction 5
3. Background Information 8
3.1. Existing System 8
3.2. Proposed damped harmonic filter 11
3.2.1. Losses of the proposed damped harmonic filter 12
4. Optioneering 13
4.1. Baseline: Do Nothing / Delay 13
4.2. Option 1: Installation of harmonic filters only in wind farms 13
4.3. Option 2: Installation of 33kV standard harmonic filters 13
4.4. Option 3: Installation of active harmonic filters 13
4.5. Option 4: Installation of bespoke harmonic filter for each site 13
4.6. Option 5: Installation of 132kV standard harmonic filters 13
4.6.1. Option 5a – Installation of 132kV standard harmonic filter adjacent to Coalburn 400kV substation 14
4.6.2. Option 5b – Installation of 132kV standard harmonic filter at Coalburn North 400kV substation 14
4.6.3. Option 5c – Installation of 132kV standard harmonic filter at Cumberhead 132kV collector substation 15
4.6.4. Option 5d – Installation of 132kV standard harmonic filter at Douglas North 132kV collector substation 15
4.6.5. Option 5e – Installation of 132kV standard harmonic filter at Kype Muir 132kV substation 15
4.6.6. Option 5f – Installation of 132kV standard harmonic filter at [redacted] 132kV substation 16
4.6.7. Option 5g – Installation of 132kV standard harmonic filter at [redacted] 132kV substation 16
4.7. Selected Option – Installation of a 132kV harmonic filter adjacent to Coalburn 400kV substation (Option 5a) 16
4.8. Whole System Outcomes 16
5. Proposed Works & Associated Cost 24
5.1. Project Summary 24
5.2. Project Cost 25

5.2.1. Allocation of Harmonic Filter Costs 25

5.2.2. Estimated Total Project Cost 25

5.3. Regulatory Outputs 26

5.4. Environmental and Consents Works 26

6. Deliverability 26

6.1. Delivery Schedule 27

6.2. Risk and Mitigation 28

6.3. Quality Management 28

6.3.1. Quality Requirements During Project Development 28

6.3.2. Quality Requirements in Tenders 28

6.3.3. Monitoring and Measuring During Project Delivery 29

6.3.4. Post Energisation 29

6.4. Environmental Sustainability 29

6.5. Stakeholder Engagement 30

7. Conclusion 31

8. Appendices 31

Appendix A: Maps and Diagrams 32

Appendix B: Reference to Supporting Documents 42

[redacted]

1. Executive Summary

This engineering justification paper (EJP) sets out the need case for installation of one 20MVAr harmonic filter at Coalburn 132kV substation on 'B' busbar. Coalburn substation is in South Lanarkshire area of SP Transmission (SPT) network.

The primary driver behind this project is to ensure network compliance with harmonic level standards set by ENA Engineering Recommendation (EREC) G5/5 in South Lanarkshire area, and the connected electricity system.

The expected project delivery year for the proposed scheme is 2030. The estimated project cost for the proposed scheme is £11.10m.

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 this project will be funded under the proposed Load Use It Or Use It (UIOLI) pot within the RIIO-T3 period, given the total project cost estimate is less than £25m.

2. Introduction

This EJP sets out SPT's plans to install one 20MVAr harmonic filter (with a site-specific damping resistor) in Coalburn 132kV substation, 'B' busbar.

For reference, Coalburn 400/132kV substation is situated to the south of Lesmahagow in South Lanarkshire. This substation forms part of the existing West Coast onshore interconnection between Scotland and England and serves Linnmill 132/33kV GSP. Coalburn 132kV substation has two switchboards, 'A' and 'B' boards. Each of the boards utilise Air Insulated Switchgear (AIS) in a double busbar configuration. Coalburn substation serves as a collector site for onshore wind energy developments. 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.

Network harmonic analysis has identified issues in the South Lanarkshire, near Coalburn area, caused by an increasing number of large wind farm connections into the 132kV network in this area. The driver behind this project is the 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 generators near Coalburn area is depicted in Appendix A, Figure A-3. The Figure A-4, in Appendix A, indicates the scale of currently contracted and the existing wind farms.

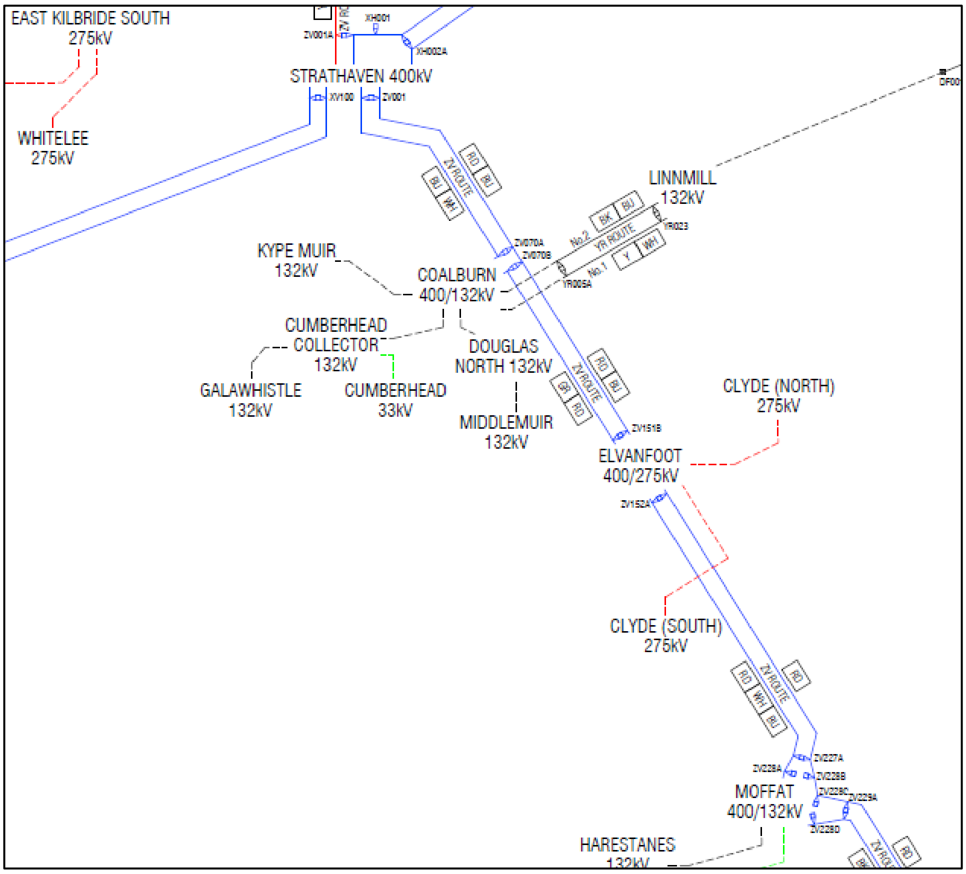

Figure 1: The exiting transmission network in the area – extracted from Networks Diagram of the Existing SPT Systems shown in Appendix A (Figure A-1).

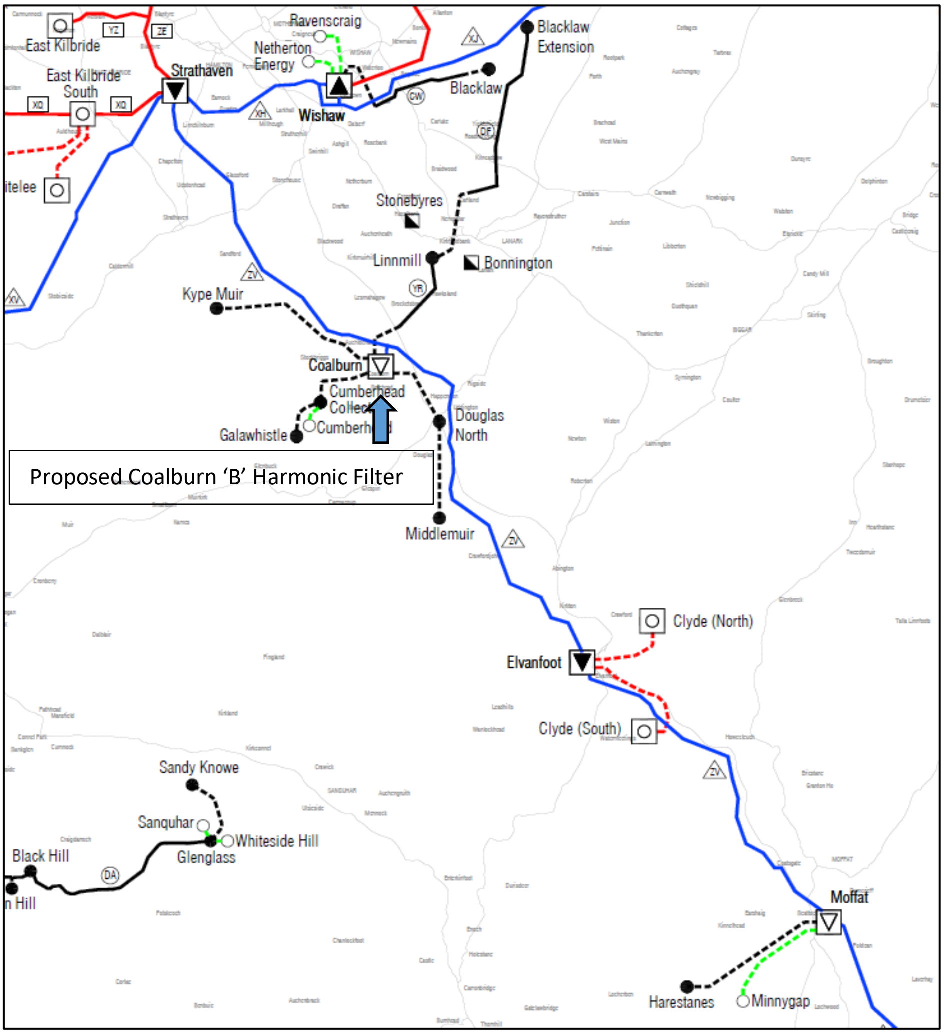

Figure 2: Geographical location of the proposed scheme with respect to the wider network in the area - extracted from Networks Diagram Geographical Layout shown in Appendix A (Figure A-2).

The 132kV electricity transmission system in this 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 resonance frequency. The combination of these large capacitances with high system impedance leads to 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 following:

- 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 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 standardised damped (C-type) harmonic filters at different locations in this area has been justified, as a solution for harmonic issues, in SPT's submissions for the RIIO-T2 price control period [5] and has been approved by Ofgem. These locations namely are Moffat and Linnmill. With the continued growth of onshore wind contracted to connect in South Lanarkshire, the need for installation of further harmonic filtering in the area still exists to ensure system compliance with standard limits. This EJP therefore proposes installation of one 20MVAr harmonic filters at Coalburn 'B' 132kV substation.

A complete description of the need case for development of Coalburn 'B' 132kV harmonic filter, 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:

- At the existing Coalburn 'B' 132kV substation install a new 20MVAr harmonic filter (with a site-specific damping resistor).
- At the 'spare' double busbar feeder bay of the Coalburn 132kV 'B' board install an extended busbar system, busbar disconnectors and circuit breaker to enable connection of the harmonic filter.

The expected project delivery date for this reinforcement scheme is July 2029. The estimated project cost for the proposed scheme is £11.10m.

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 overall funding anticipated via the UIOLI pot proposed within the RIIO-T3 period.

3. Background Information

South Lanarkshire is an area rich in wind energy resource. An increasing number of large wind farms are being connected to relatively weak 132kV network in South Lanarkshire, fed from Coalburn and Moffat 132kV substations. 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 132kV transmission network in the 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 depth analyses have been carried out using power system simulations indicting the need to install a 132kV 20MVAr damped filter, similar to an MSCDN[1] or also known as a C-type filter, at Coalburn 'B' 132kV collector substation. The results of these simulations have been included in Appendix C.

3.1. Existing System

The existing configuration of Coalburn 132kV Substation is illustrated in Figure A-5, in Appendix A. Figure A-6, in Appendix A, also shows the single line diagram of the existing Coalburn substation and the connected and contracted generation developments to this substation. In addition to the connected developments, 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 existing Coalburn substation.

[1] 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.

Table 1: Contracted Generation into Coalburn 400/132kV Substation

Connecting Substation	Contracted Development	Consent Status	TECA Score[2]	Contracted Energisation Date	Capacity (MW)
[redacted]					

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

Connecting Substation	Contracted Development	Consent Status	TECA Score[2]	Contracted Energisation Date	Capacity (MW)
[redacted]					
Total Capacity (GW)		-	-	-	1.4GW

TECA Legend

TECA Probability	Designated Colour
High	
Medium	
Low	

As part of the RIIO-T2 price control, a harmonic filter will be installed at Linnmill 132kV Substation to aid the control of harmonics in the network served from the Coalburn 132kV 'A' busbar system. The existing Coalburn-Broken Cross-Linnmill No.1 and Coalburn-Linnmill No.2 132kV circuits will be connected at Linnmill 132kV Substation, such that the harmonic filter can remain in service with one of the two feeder circuits out of service.

Initial power system analysis indicates that without the further installation of a harmonic filter connected to the network served from the Coalburn 132kV 'B' busbar system, 7^{th} harmonic voltages may exceed planning standards at the majority of 132kV and 33kV busbars (ref. Table 2). The 7^{th} harmonic voltages may reach up to 259% on the 33kV and 211% on the 132kV busbars served from the Coalburn 132kV 'B' busbar system.

Table 2: Maximum harmonics without Coalburn 'B' Harmonic Filter. Wind turbine generators off.

[redacted]

Acceptable harmonic performance is achieved however with deployment of a standard 132kV harmonic filter for intact and outage conditions, especially with wind turbines running and contributing to damping (ref. Table 3 and Table 4).

Table 3: Maximum harmonics with Coalburn 'B' Harmonic Filter in service. wind turbine generators off.

[redacted]

Table 4: Maximum harmonics with Coalburn 'B' Harmonic Filter in service. Wind turbine generators off.

[redacted]

The power system analysis studies referenced above are in the process of being finalised to reflect the final authorised system configuration and account for the following:

- Lesmahagow GSP will no longer be connected to Coalburn 'A', but will instead become Redshaw GSP, connected to new Redshaw 132kV 'B' substation. This is planned under SPT-RI-3060 and is outside the scope of this EJP;
- [redacted]; and
- [redacted].

A link to the current power system analysis report is included in Appendix C. The final power system analysis studies will verify the harmonic filter parameters and therefore tuning frequency but are not expected to change the requirement for the installation of a harmonic filter connected to the Coalburn 'B' busbar system.

3.2. Proposed damped harmonic filter

The layout and parameters of the harmonic filter derived from the power system simulations are shown in Figure 3. These parameters are chosen to maintain similar parameters with other filters that are going to be installed in the network. To achieve that a 200Ω 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. 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.

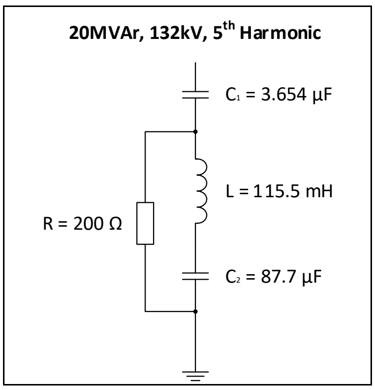

Figure 3: Schematic of the proposed harmonic filter – Filter Layout and Parameters.

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.

3.2.1. 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 3)[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.

Table 5: System Requirements and Design Parameters

System Design Table	Circuit/Project	Coalburn 'B' 132kV Harmonic Filter
Thermal and Fault Design	Existing Voltage (if applicable)	132kV
	New Voltage	N/A
	Existing Continuous Rating (if applicable)	N/A
	New Continuous Rating	N/A
	Existing Fault Rating (if applicable)	20/25kA
	New Fault Rating	N/A
ESO Dispatchable Services	Existing MVAr Rating (if applicable)	N/A
	New MVAr Rating (if applicable)	20MVAr
	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	N/A
	Future Generation Capacity	N/A
Initial Design Considerations	Limiting Factor	Land Availability
	AIS / GIS	AIS
	Busbar Design	Double Busbar
	Cable / OHL / Mixed	Cable
	SI	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.

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

4. Optioneering

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

4.1. Baseline: Do Nothing / Delay

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 very 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 South Lanarkshire 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 3 and fully described in Section 3. A large number of power system simulation studies have been carried out, with considering connected and contracted wind farms in South Lanarkshire, near Coalburn area, under intact and under different system outage scenarios to investigate the mitigation effect of installing 132kV harmonic filters in the area. These consider the RIIO-T2 harmonic filters are connected. These in-depth studies can be found in Appendix C.

The below seven options have been investigated to ensure the networks' compliance with EREC G5/5.

4.6.1. Option 5a – Installation of 132kV standard harmonic filter adjacent to Coalburn 400kV substation

This option involves the direct connection of a 132kV 20MVAr standard damped (C-type) harmonic filter, to the Coalburn 132kV 'B' busbar system.

The filter will be connected to the existing Coalburn 132kV 'B' busbar system via the population of the remaining 'spare' double busbar feeder bay (adjacent to the future [redacted] feeder bay) indicated in Figure 4, including the installation of an extended busbar system, busbar disconnectors and circuit breaker.

[redacted]

Figure 4: Indication of spare bay to be utilised by Harmonic Filter – Extracted from Figure A-7 in Appendix A

A short section of 132kV underground cable will connect the filter to the busbar system. Figure A-8, in Appendix A, provides a feasibility drawing with indicative location for the proposed harmonic filter, adjacent to the existing Coalburn 400kV Substation compound.

Figure A-9, in Appendix A, illustrates the area intended for installation of the harmonic filter. The indicated area has been selected with respect to the challenges associated with civil platform development at/near the existing substation. Initially the ability to locate the harmonic filter within the existing Coalburn 400kV Substation compound and avoid the need to extend the substation platform has been considered. However, this is not feasible, as the only potentially suitable areas are committed for: (i) the 400kV feeder bay serving a contracted customer connection (i.e., Coalburn 500MW BESS development which is in construction phase); and (ii) the future Coalburn – Coalburn North 400kV circuit.

4.6.2. Option 5b – Installation of 132kV standard harmonic filter at Coalburn North 400kV substation

This option involves the direct connection of a 132kV 20MVAr standard damped (C-type) harmonic filter to the Coalburn 132kV 'B' busbar system, similar to Option 5a. However, in this option the harmonic filter is located within or adjacent to Coalburn North 400kV substation.

Following the approach in Option 5a, the harmonic filter will be connected to the existing Coalburn 132kV 'B' Busbar system via the population of the remaining 'spare' double busbar feeder bay (adjacent to the future [redacted] feeder bay) indicated in Figure 4, including the installation of an extended busbar system, busbar disconnectors and circuit breaker.

A longer section of 132kV underground cable, relative to the Option 5a, would connect the filter, which is located within or adjacent to Coalburn North 400kV substation, to the Coalburn 132kV 'B' busbar system.

Figure A-10, in Appendix A, details the feasibility drawing for Coalburn North 400kV Substation, which will be located to the north/ east of the ZV 400kV overhead line route (equipment shown in green indicates assets for currently contracted connection projects).

Considering that compared with Option 5a, a longer underground cable is required to connect the 132kV harmonic filter to the Coalburn 132kV 'B' substation, development of this option is not as economic or efficient as Option 5a. It should also be noted that cable routing between Coalburn North and Coalburn may be difficult due to the Coalburn area being congested with underground cables connecting high volume of contracted renewable developments to the electricity system in the area.

The estimated total cost for this option is £11.84m.

4.6.3. Option 5c – Installation of 132kV standard harmonic filter at Cumberhead 132kV collector substation

This option involves connecting a 132kV 20MVAr standard damped (C-type) harmonic filter to the network served from the Coalburn 132kV 'B' busbar system, at Cumberhead 132/33kV collector substation (i.e., a remote substation site as indicated in Figure 1), has been considered.

Based on the power system analysis in Appendix C, section D1 Table 6, should the harmonic filter be connected to this location, the outage of the 132kV circuit between Coalburn 132kV substation and the Cumberhead 132/33kV collector substation would effectively disconnect the filter from the wider network and give rise to harmonic performance issues at the sites which would continue to be served from the Coalburn 132kV 'B' busbar system.

Due to this reason, Option 5c was discounted in advance of detailed cost estimating exercise.

4.6.4. Option 5d – Installation of 132kV standard harmonic filter at Douglas North 132kV collector substation

This option involves connecting a 132kV 20MVAr standard damped (C-type) harmonic filter to the network served from the Coalburn 132kV 'B' busbar system, at Douglas North 132kV collector substation (i.e., a remote substation site as indicated in Figure 1), has been considered.

Based on the power system analysis in Appendix C, section D1 Table 3, should the harmonic filter be connected to this location, the outage of the 132kV circuit between Coalburn 132kV substation and the Douglas North 132kV collector substation would effectively disconnect the filter from the wider network and give rise to harmonic performance issues at the sites which would continue to be served from the Coalburn 132kV 'B' busbar system.

Due to this reason, Option 5d was discounted in advance of detailed cost estimating exercise.

4.6.5. Option 5e – Installation of 132kV standard harmonic filter at Kype Muir 132kV substation

This option involves connecting a 132kV 20MVAr standard damped (C-type) harmonic filter to the network served from the Coalburn 132kV 'B' busbar system, at Kype Muir 132kV substation (i.e., a remote substation site as indicated in Figure 1), has been considered.

Based on the power system analysis in Appendix C, section D1 Table 2, should the harmonic filter be connected to this location, the outage of the 132kV circuit between Coalburn 132kV substation and the Kype Muir 132kV substation would effectively disconnect the filter from the wider network and give rise to harmonic performance issues at the sites which would continue to be served from the Coalburn 132kV 'B' busbar system.

Due to this reason, Option 5e was discounted in advance of detailed cost estimating exercise.

4.6.6. Option 5f – Installation of 132kV standard harmonic filter at [redacted] 132kV substation

This option involves connecting a 132kV 20MVAr standard damped (C-type) harmonic filter to the network served from the Coalburn 132kV 'B' busbar system, at [redacted] wind farm 132kV substation. [redacted] wind farm substation is a new customer substation contracted for connection to Coalburn 'A' board, the scope if which is outside this EJP.

Based on the power system analysis in Appendix C, section D1 Table 5, should the harmonic filter be connected to this location, the outage of the 132kV circuit between Coalburn 132kV substation and the [redacted] 132kV substation would effectively disconnect the filter from the wider network and give rise to harmonic performance issues at the sites which would continue to be served from the Coalburn 132kV 'B' busbar system.

Additionally, there is risk associated with the installation of harmonic filter at a developer's substation.

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

4.6.7. Option 5g – Installation of 132kV standard harmonic filter at [redacted] 132kV substation

This option involves connecting a 132kV 20MVAr standard damped (C-type) harmonic filter to the network served from the Coalburn 132kV 'B' busbar system, at [redacted] wind farm 132kV substation. [redacted] wind farm substation is a new customer substation contracted for connection to Coalburn 'B' board, the scope if which is outside this EJP.

Based on the power system analysis in Appendix C, section D1 Table 4, should the harmonic filter be connected to this location, the outage of the 132kV circuit between Coalburn 132kV substation and the [redacted] 132kV substation would effectively disconnect the filter from the wider network and give rise to harmonic performance issues at the sites which would continue to be served from the Coalburn 132kV 'B' busbar system.

Additionally, there is risk associated with the installation of harmonic filter at a developer's substation.

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

4.7. Selected Option – Installation of a 132kV harmonic filter adjacent to Coalburn 400kV substation (Option 5a)

As discussed above, the most appropriate option to enable the economic, technically feasible and co-ordinated mitigation of harmonic issues in South Lanarkshire, near Coalburn substation, is to install a 132kV 20MVAr standard damped (C-type) harmonic filter for direct connection to Coalburn 'B' 132kV substation and locate it adjacent to Coalburn 400kV substation (i.e., Option 5a).

4.8. Whole System Outcomes

Our optioneering approach has additionally considered the appropriate 'Whole System' outcome by proposing a technology solution which manages network characteristics (i.e., harmonic issues).

Table 6: Summary of Considered Options to Mitigate Harmonic Issues

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
Preferred – Option 5a: Installation of 132kV standard harmonic filters adjacent to Coalburn 400kV substation	Refer to Figure A-9, Appendix A	Refer to Figure A-7, Appendix A	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.	Twelve 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.	N/A
Rejected – Baseline: Do Nothing / Delay	N/A	N/A	N/A	N/A	N/A	N/A	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.
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.

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
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 at Coalburn North 400kV substation	N/A	Refer to Figure A-10, Appendix A	N/A	N/A	Difficult to consent considering the longer route compared to the Option 5a.	N/A	The cost associated with this option is £11.84m. This option is more expensive than the preferred option. This option does not provide an efficient electricity system, considering the need for a longer cable route compared to Option 5a.
Rejected – Option 5c: Installation of 132kV standard harmonic filter at Cumberhead 132kV collector substation	N/A	N/A	N/A	N/A	N/A	N/A	This option is ineffective at harmonic mitigation compared to the proposed option.
Rejected – Option 5d: Installation of 132kV standard harmonic filter at Douglas North 132kV collector substation	N/A	N/A	N/A	N/A	N/A	N/A	This option is ineffective at harmonic mitigation compared to the proposed option.
Rejected – Option 5e: Installation of 132kV standard harmonic filter at Kype Muir 132kV substation	N/A	N/A	N/A	N/A	N/A	N/A	This option is ineffective at harmonic mitigation compared to the proposed option.
Rejected – Option 5f: Installation of 132kV standard harmonic filter	N/A	N/A	N/A	N/A	N/A	N/A	This option is ineffective at harmonic mitigation compared to the proposed option. Additionally, there is risk

Options	Map	Layout of Substation/ Connection	Layout of all Route Works	Relevant Survey Works	Narrative Consenting Risks	Narrative Preferred Option	Narrative Rejection
at [redacted] 132kV substation							associated with the installation at a developer's substation.
Rejected – Option 5g: Installation of 132kV standard harmonic filter at [redacted] 132kV substation	N/A	N/A	N/A	N/A	N/A	N/A	This option is ineffective at harmonic mitigation compared to the proposed option. Additionally, there is risk associated with the installation at a developer's substation.

Table 7 – System Requirements and Design Parameters for the considered options

System Design Table	**Circuit/Project**	**Preferred – Option 5a:** Installation of 132kV standard harmonic filters adjacent to Coalburn 400kV 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
Thermal and Fault Design	Existing Voltage (if applicable)	132kV	132kV	132kV	132kV
	New Voltage	N/A	N/A	N/A	N/A
	Existing Continuous Rating (if applicable)	N/A	N/A	N/A	N/A
	New Continuous Rating	N/A	N/A	N/A	N/A
	Existing Fault Rating (if applicable)	N/A	N/A	N/A	N/A
	New Fault Rating	20/25kA	20/25kA	20/25kA	20/25kA
ESO Dispatchable Services	Existing MVAR Rating (if applicable)	N/A	N/A	N/A	N/A
	New MVAR Rating (if applicable)	N/A	N/A	N/A	N/A
	Existing GVA Rating (if applicable)	N/A	N/A	N/A	N/A
	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	N/A	N/A	N/A	N/A
	Future Generation Capacity	N/A	N/A	N/A	N/A
Initial Design Considerations	Limiting Factor	Land availability	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.
	AIS/ GIS	AIS	N/A	N/A	N/A
	Busbar Design	Double Busbar	N/A	N/A	N/A
	Cable/ OHL/ Mixed	Cable	N/A	N/A	N/A
	SI	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.	N/A	N/A	N/A

System Design Table	Circuit/Project	**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 at Coalburn North 400kV substation	**Rejected – Option 5c:** Installation of 132kV standard harmonic filter at Cumberhead 132kV collector substation
Thermal and Fault Design	Existing Voltage (if applicable)	132kV	132kV	132kV	132kV
	New Voltage	N/A	N/A	N/A	N/A
	Existing Continuous Rating (if applicable)	N/A	N/A	N/A	N/A
	New Continuous Rating	N/A	N/A	N/A	N/A
	Existing Fault Rating (if applicable)	N/A	N/A	N/A	N/A
	New Fault Rating	20/25kA	20/25kA	20/25kA	20/25kA
ESO Dispatchable Services	Existing MVAR Rating (if applicable)	N/A	N/A	20MVAr	20MVAr
	New MVAR Rating (if applicable)	N/A	N/A	N/A	N/A
	Existing GVA Rating (if applicable)	N/A	N/A	N/A	N/A
	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	N/A	N/A	N/A	N/A
	Future Generation Capacity	N/A	N/A	N/A	N/A
Initial Design Considerations	Limiting Factor	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.	- Land availability. - It does not enable the most economic and efficient electricity system in the area.	It is ineffective at harmonic mitigation compared to the proposed option.
	AIS/ GIS	N/A	N/A	N/A	N/A
	Busbar Design	N/A	N/A	Double Busbar	Double Busbar
	Cable/ OHL/ Mixed	N/A	N/A	Cable	Cable

System Design Table	Circuit/Project	**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 at Coalburn North 400kV substation	**Rejected – Option 5c:** Installation of 132kV standard harmonic filter at Cumberhead 132kV collector substation
	SI	N/A	N/A	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.

System Design Table	Circuit/Project	**Rejected – Option 5d:** Installation of 132kV standard harmonic filter at Douglas North 132kV collector substation	**Rejected – Option 5e:** Installation of 132kV standard harmonic filter at Kype Muir 132kV substation	**Rejected – Option 5f:** Installation of 132kV standard harmonic filter at [redacted] 132kV substation	**Rejected – Option 5g:** Installation of 132kV standard harmonic filter at [redacted] 132kV collector substation
Thermal and Fault Design	Existing Voltage (if applicable)	132kV	132kV	132kV	132kV
	New Voltage	N/A	N/A	N/A	N/A
	Existing Continuous Rating (if applicable)	N/A	N/A	N/A	N/A
	New Continuous Rating	N/A	N/A	N/A	N/A
	Existing Fault Rating (if applicable)	N/A	N/A	N/A	N/A
	New Fault Rating	20/25kA	20/25kA	20/25kA	20/25kA
ESO Dispatchable Services	Existing MVAR Rating (if applicable)	20MVAr	20MVAr	20MVAr	20MVAr
	New MVAR Rating (if applicable)	N/A	N/A	N/A	N/A
	Existing GVA Rating (if applicable)	N/A	N/A	N/A	N/A
	New GVA Rating	N/A	N/A	N/A	N/A
	Present Demand (if applicable)	N/A	N/A	N/A	N/A
	2050 Future Demand	N/A	N/A	N/A	N/A

System Design Table	Circuit/Project	**Rejected – Option 5d:** Installation of 132kV standard harmonic filter at Douglas North 132kV collector substation	**Rejected – Option 5e:** Installation of 132kV standard harmonic filter at Kype Muir 132kV substation	**Rejected – Option 5f:** Installation of 132kV standard harmonic filter at [redacted] 132kV substation	**Rejected – Option 5g:** Installation of 132kV standard harmonic filter at [redacted] 132kV collector substation
System Requirements	Present Generation (if applicable)	N/A	N/A	N/A	N/A
	Future Generation Count	N/A	N/A	N/A	N/A
	Future Generation Capacity	N/A	N/A	N/A	N/A
Initial Design Considerations	Limiting Factor	It is ineffective at harmonic mitigation compared to the proposed option.	It is ineffective at harmonic mitigation compared to the proposed option.	This option is ineffective at harmonic mitigation compared to the proposed option. Additionally, there is risk associated with the installation at a developer's substation.	This option is ineffective at harmonic mitigation compared to the proposed option. Additionally, there is risk associated with the installation at a developer's substation.
	AIS / GIS	N/A	N/A	N/A	N/A
	Busbar Design	Double Busbar	Double Busbar	Double Busbar	Double Busbar
	Cable / OHL / Mixed	Cable	Cable	Cable	Cable
	SI	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.	The proposed standardised harmonic filter mitigates the harmonic issues in the 132kV network in South Lanarkshire area.

5. Proposed Works & Associated Cost

5.1. Project Summary

As discussed above, the proposed scheme in this scheme entails installation and connection of a new 132kV 20MVAr damped harmonic filter to the existing Coalburn 132kV 'B' substation. The new 132kV 20MVAr harmonic filter is located adjacent to the existing Coalburn 400kV substation.

The proposed electrical layout of the existing Coalburn 132kV 'B' busbar is shown in Appendix A, Figure A-7. Also, the indicative location for the proposed harmonic filter is shown in Appendix A, Figure A-8. The associated Works in this stage are summarised in the following –

<u>Pre-Engineering Works</u>

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 access for the new equipment.
- Environmental study.

<u>Coalburn 132kV 'B' Substation</u>

The works at the existing Coalburn 132kV 'B' substation shall include:

- At Coalburn 132kV substation 'B' board, install a 132kV circuit breaker and associated 132kV busbar disconnector at the spare double busbar feeder bay. This spare feeder bay is adjacent to the feeder bay earmarked for future [redacted] connection, as shown in Figure A-7, in Appendix A.
- Terminating the 132kV underground cable circuit (i.e., 250m of 132kV 800mm^2 Aluminium conductor) into the Coalburn 132kV 'B' busbar to facilitate the connection from the 132kV harmonic filter.
- The design and construction of foundations and structures necessary to accommodate the underground cable connection between the 132kV 20MVAr harmonic filter and the Coalburn 132kV 'B' board.
- All control and protection works.
- All environmental and civil works.

<u>Coalburn 400kV Substation</u>

The works at the existing Coalburn 400kV substation shall include:

- The design and construction of foundations and structures necessary to construct the harmonic filter's site civil platform, adjacent to the existing Coalburn 400kV substation area.
- The design and construction of foundations and structures necessary to accommodate the underground cable (i.e., 250m of 132kV 800mm^2 Aluminium conductor) connection between the 132kV 20MVAr harmonic filter and the Coalburn 132kV 'B' board.

- 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.
- All control and protection works.
- All environmental and civil works.

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

A Business Plan provision and estimated cost of the Coalburn 'B' 132kV harmonic filter project is indicated in Table 8. Costs provided below include direct, indirect, and contingency costs.

Project costs for Coalburn 'B' 132kV 20MVAr harmonic filter installation are summarised in the cost breakdown below:

Table 8: Project Cost Breakdown – Harmonic Filter Installation

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

Expenditure incidence is summarised below:

Table 9: Summary of Expenditure Incidence – Harmonic Filter Installation

Energisation Year	Yr. 2025: CAPEX	Yr. 2026: CAPEX	Yr. 2027: CAPEX	Yr. 2028: CAPEX	Yr. 2029: CAPEX	Yr. 2030: CAPEX	RIIO-T2 Total: CAPEX	RIIO-T3 Total: CAPEX	Total: CAPEX
2029	£0.06m	£0.91m	£2.83m	£4.07m	£2.91m	£0.33m	£0.97m	£10.13m	£11.10m

5.3. Regulatory Outputs

The indicative primary asset outputs for the Coalburn B 132kV harmonic filter project are identified in Table 10:

Table 10: Indicative Primary Asset Outputs

Asset Category	Asset Sub-Category Primary	Voltage	Intervention	Forecast Addition[4]	Forecast Disposal
Circuit Breaker	CB (Air Insulated Busbar)	132kV	Addition	1 unit	-
Flexible AC Transmission Systems (FACTS)	FACTS Equipment	132kV	Addition	1 unit	-
Cable	Substation Cable – 1 core per phase	132kV	Addition	250m	-

5.4. Environmental and Consents Works

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

6. Deliverability

We have applied SPT project management approach to ensure that this project work is delivered safely, and in line with the agreed time, cost, and quality commitments. We have a proven track record of delivering essential transmission network upgrade projects and will draw upon this knowledge and experience to effectively manage these works. We work closely with our supply chain partners and this relationship is critical to the successful delivery of our plans. Our supply chain provides the support and agility to respond to changes in workload over the course of a price review.

[4] Forecast Additions are indicative pending further detail design.

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 11 summarises the key milestones within the delivery schedule of this project. Complete detail on the energisation dates and delivery schedules for the proposed scheme can be found in Appendix D.

Table 11: Summary of Key Milestones within the Project Delivery Schedule

Item	Project Milestone	Estimated Completion Date
1	SCA (Design) Approval	March 2025
2	Harmonic Filter ITT	March 2026
3	ITT Building/Civils	June 2026
4	Civil Works	August 2026
5	Town & Country Planning Application	December 2026
6	ITT Cable Supply & Installation	April 2027
7	Gaining Site Access	October 2028
8	Commissioning	June 2029

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 will be developed, collaboratively, during the initial project kick-off meeting to identify any risks to the delivery plan. Mitigation strategies will be 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 12 - Main Scheme Risks and Mitigation Plans

Risk Title	Risk Description	Mitigation Plan
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 with SPEN's project and construction management teams will be undertaken to identify and assess candidate manufactures.
Coordination with other projects in Coalburn area	The Coalburn area is highly congested due to high volume of contracted and connected connection developments in South Lanarkshire.	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:

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 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 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.

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.

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 install one unit of 20MVAr damped (C-type) harmonic filter at the existing Coalburn 'B' 132kV substation.

This reinforcement scheme primarily is to ensure network compliance with harmonic level standards set by EREC G5/5 in the 132kV electricity system in Coalburn area in South Lanarkshire.

The increasing number of large wind farm connections into South Lanarkshire area risks 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 132kV network connected to South Lanarkshire, there are two harmonic filters already approved during RIIO-T2. The Coalburn 'B' 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 South Lanarkshire area.

The main conclusions of this EJP are:

- To ensure network compliance with EREC G5/5 it's necessary to install a 132kV 20MVAr damped (C-type) harmonic filter at the existing Coalburn 132kV 'B' substation.
- The proposed reinforcement scheme plays a vital role in reaching legislated net zero targets.

We have submitted this EJP 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 this project will be funded under the proposed Load Use It Or Use It (UIOLI) pot within the RIIO-T3 period.

8. Appendices

Appendix A – Maps and Diagrams

Appendix B – Reference to Supporting Documents

[redacted]

[redacted]

Appendix A: Maps and Diagrams

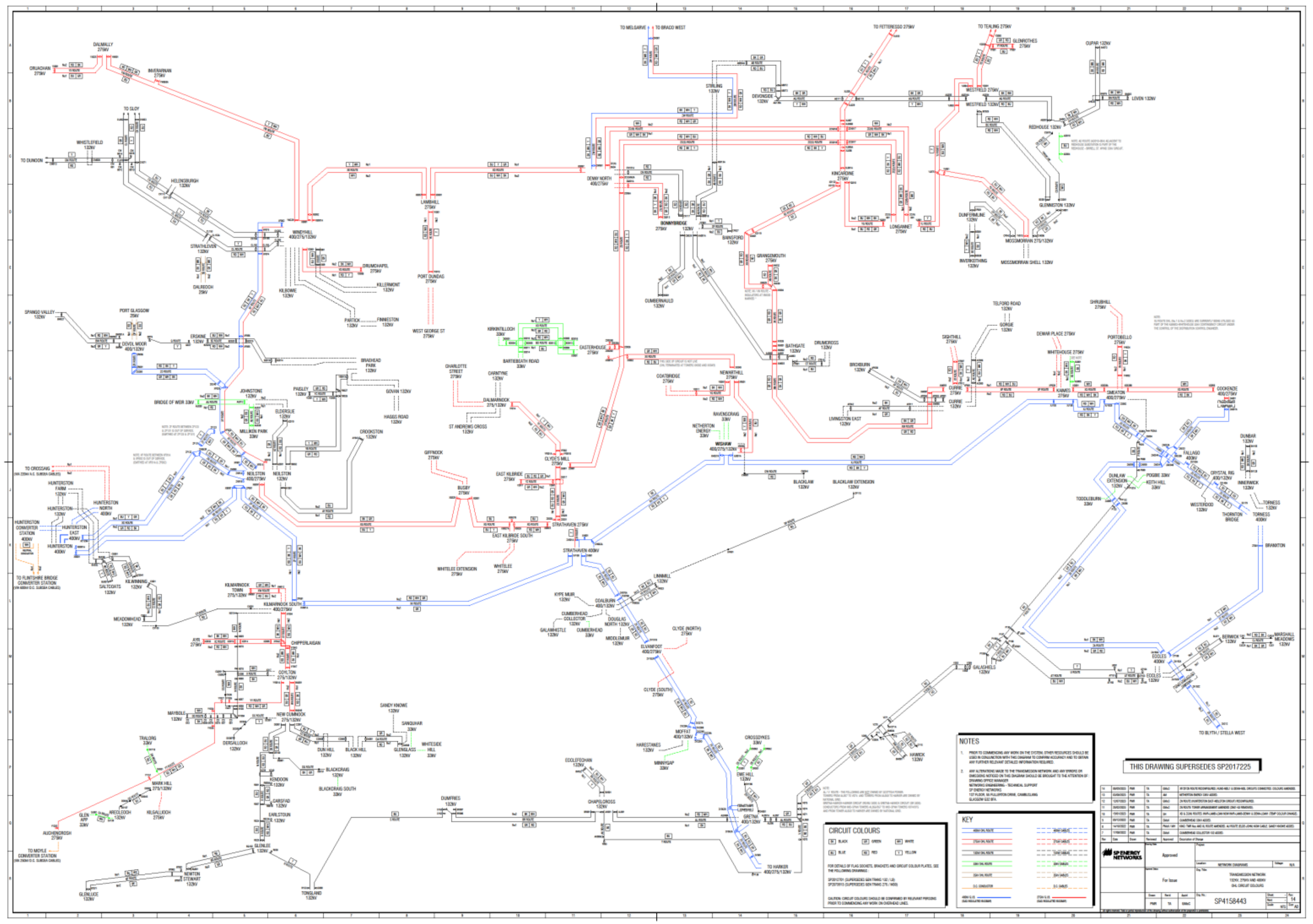

Figure A-1: Networks diagram of the existing SPT systems – single line diagram.

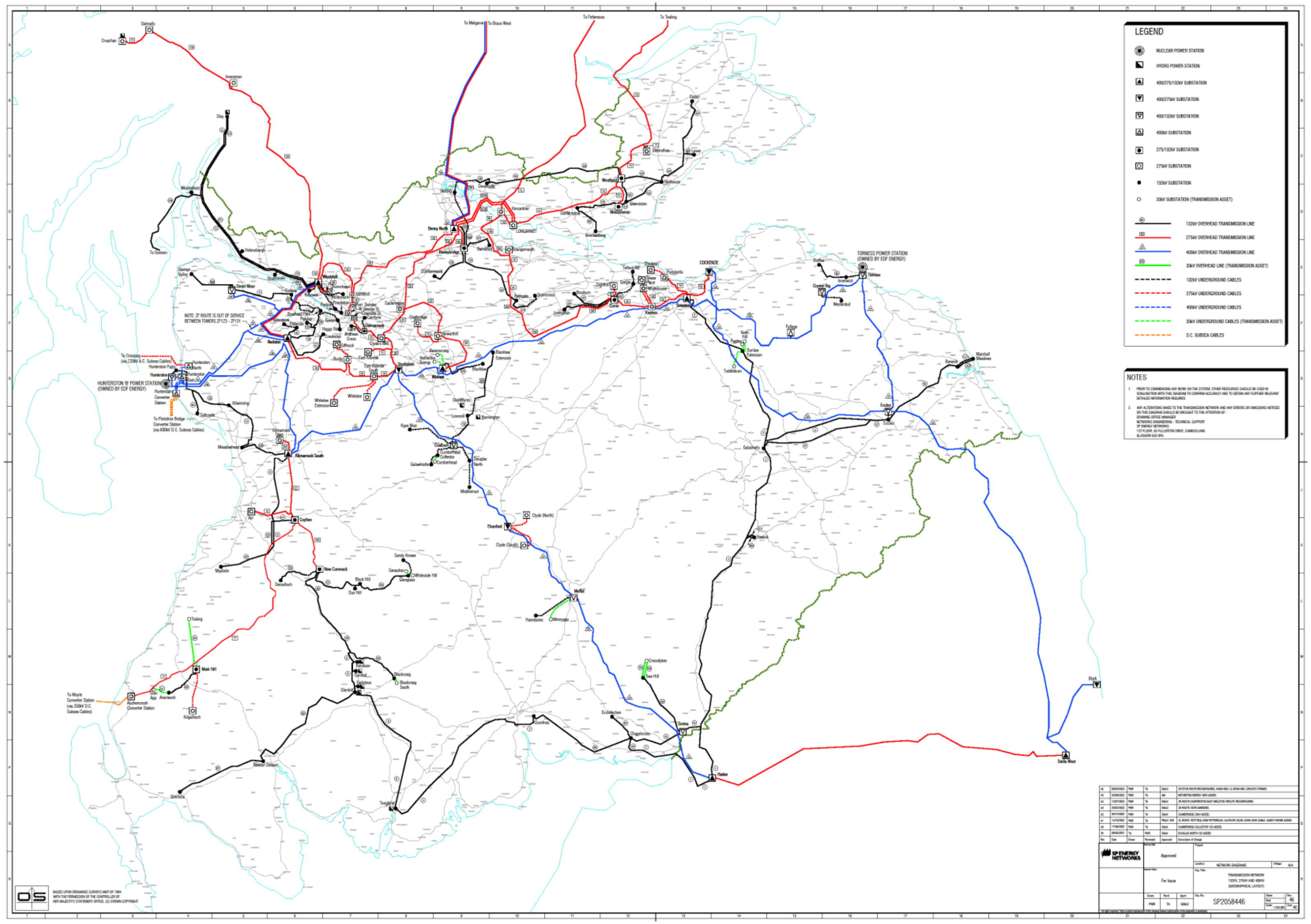

Figure A-2: Networks diagram of the existing SPT system - geographical layout.

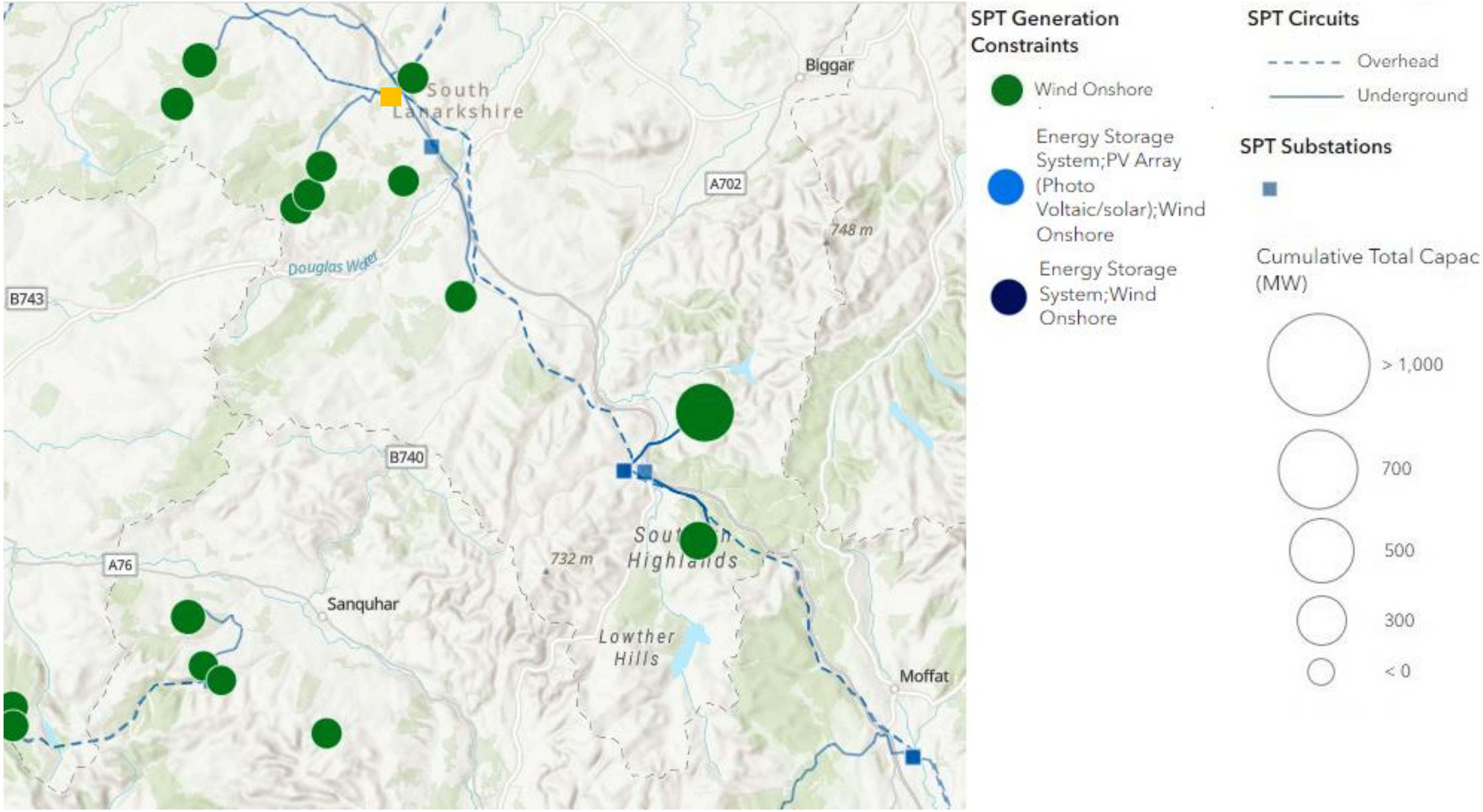

Figure A-3: Currently connected renewable developments, with wind power generation technology, in South Lanarkshire area as a scale to indicate the network's background harmonic level – Extracted from Transmission Generation Heat Map*.

* NB – The Coalburn 'B' 132kV substation, where the Coalburn 'B' 132kV harmonic filter will be connected to, has been highlighted in yellow.

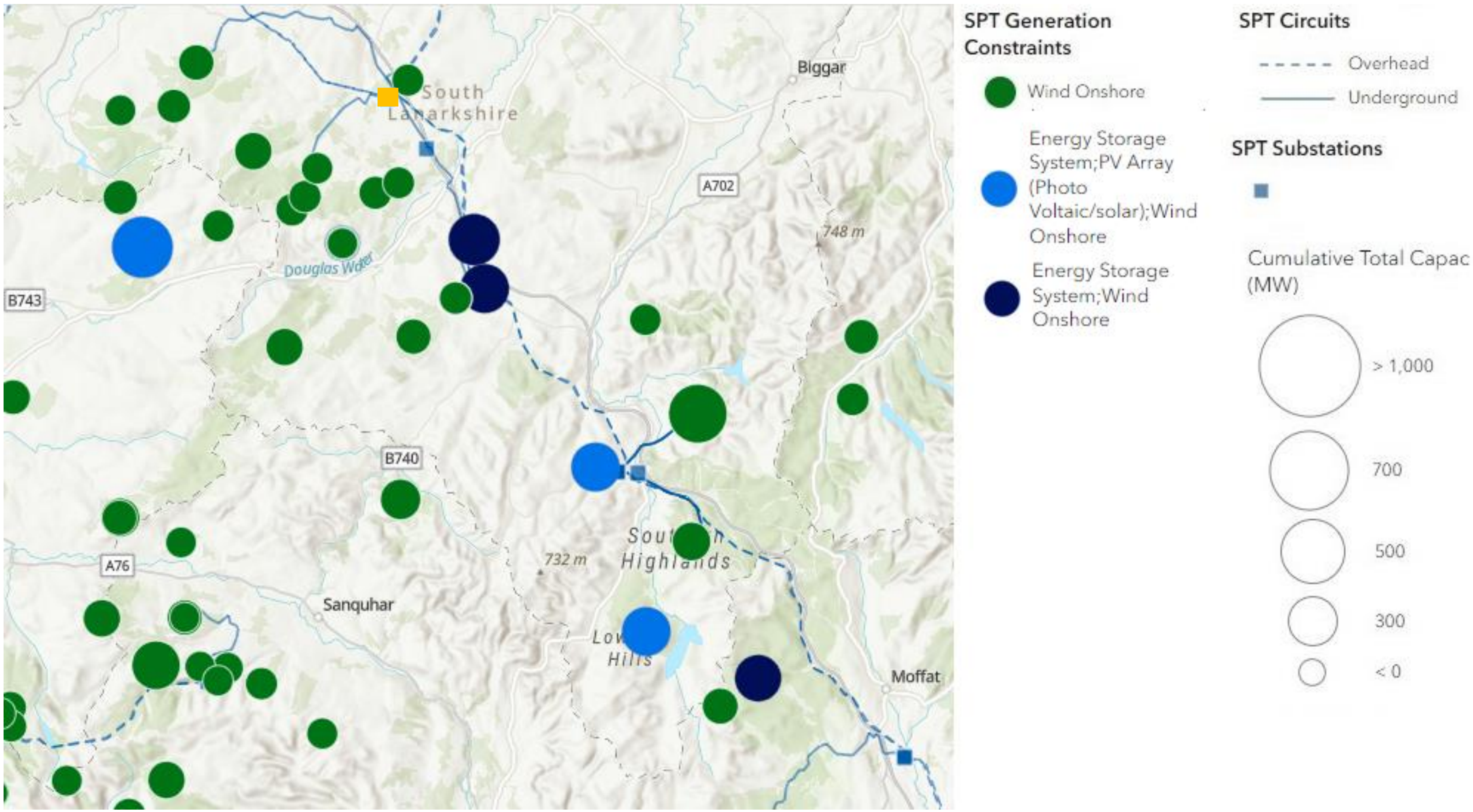

Figure A-4: Contracted and connected renewable developments, with wind farm technology, in South Lanarkshire area as a scale to indicate the network's background harmonic level – extracted from Transmission Generation Heat Map.*

* NB – The Coalburn 'B' 132kV substation, where the Coalburn 'B' 132kV harmonic filter will be connected to, has been highlighted in yellow.

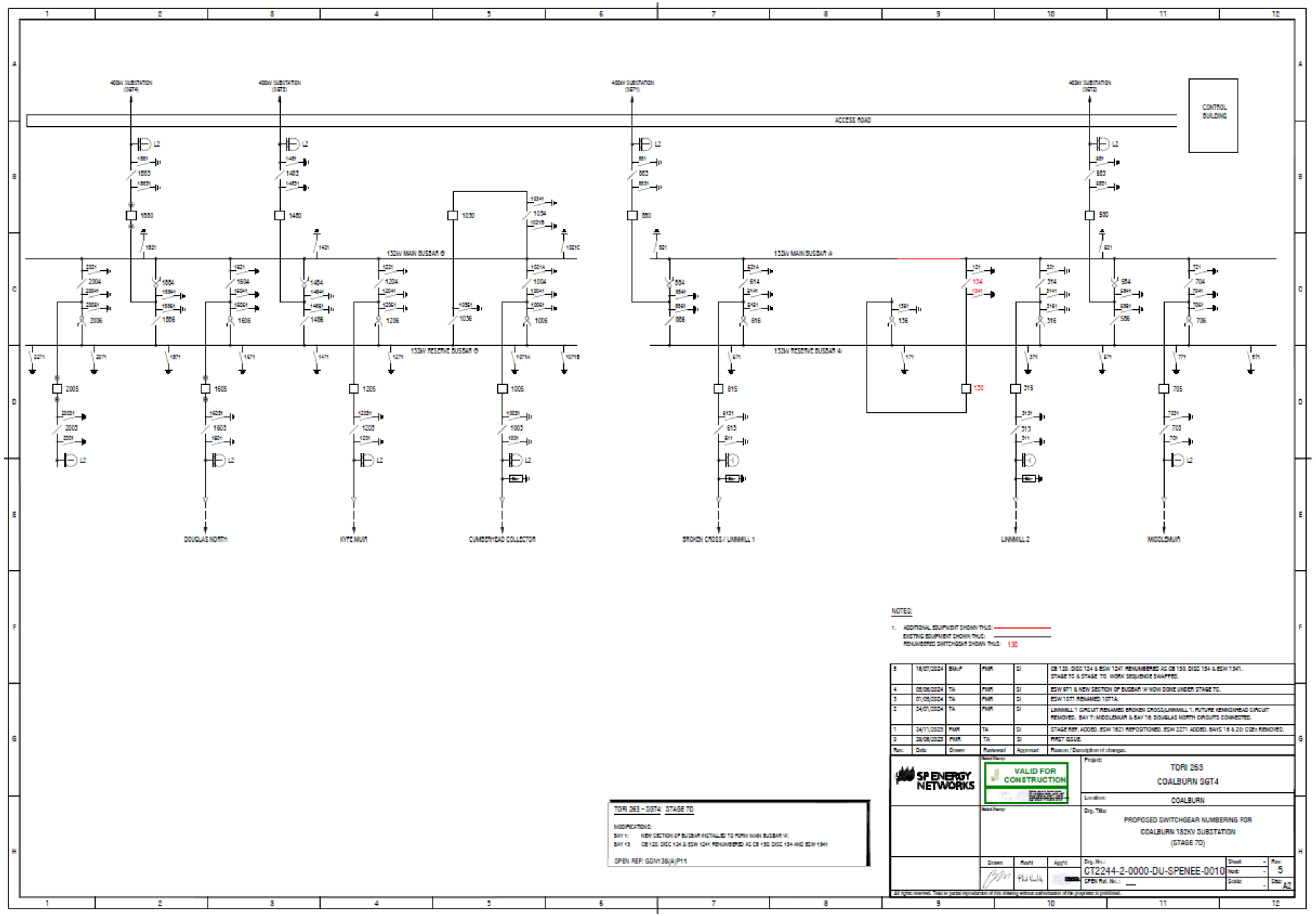

Figure A-5: Existing Coalburn 132kV configuration.

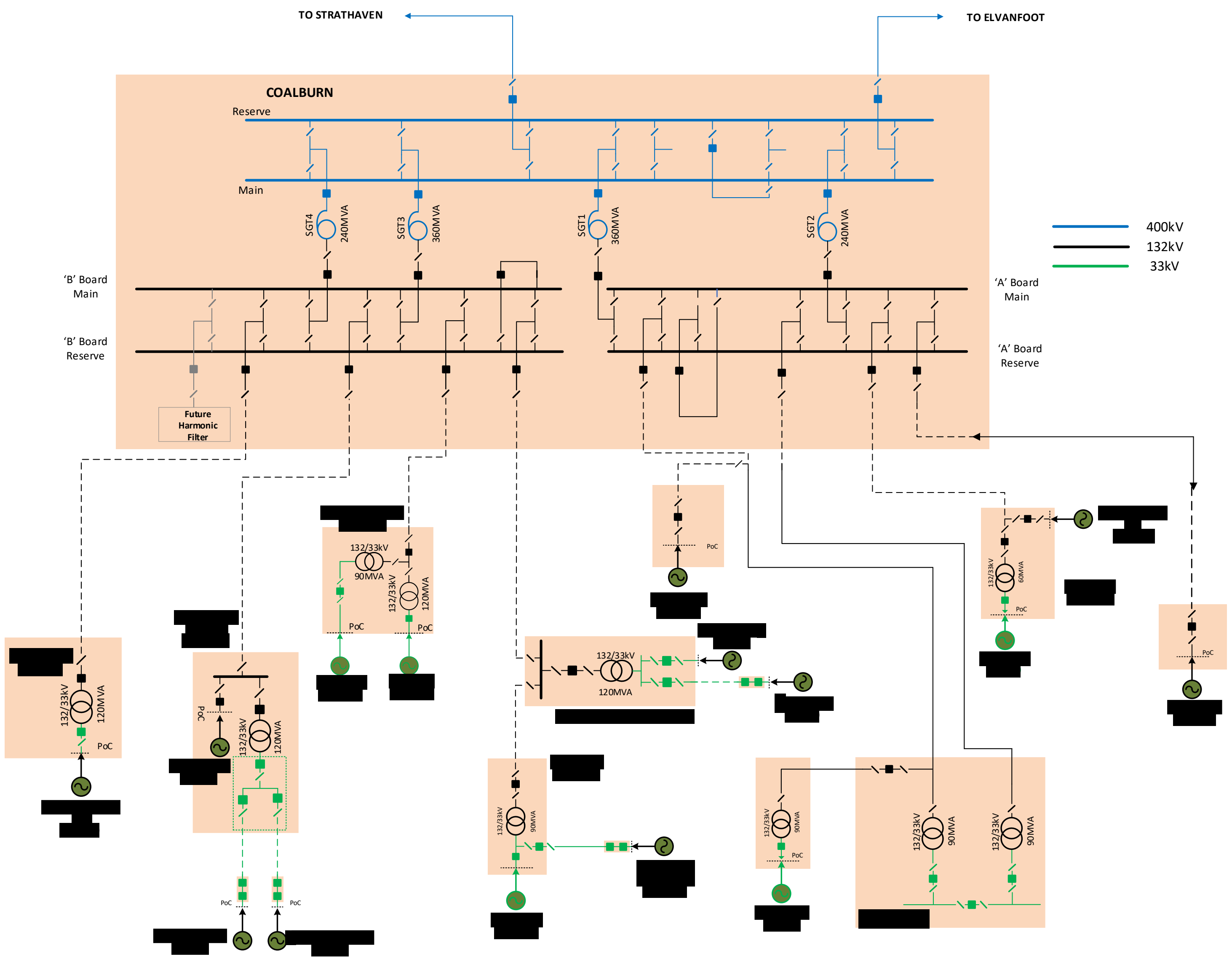

Figure A-6: Single line diagram of Coalburn substation.

[redacted]

Figure A-7: Indication of spare bay to be utilised by harmonic filter.

[redacted]

Figure A-8: Indicative harmonic filter layout.

[redacted]

FigureA-9: Indicative harmonic filter location.

[redacted]

Figure A-10: Coalburn North 400kV 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