Whitlawburn Primary Fault Level Mitigation

ED2 Engineering Justification Paper

ED2-LRE-SPD-009-CV3-EJP

Issue	Date	Comments
Issue 0.1	Jan 2021	Issue to internal governance and external assurance
Issue 0.2	Apr 2021	Reflecting comments from internal governance
Issue 0.3	May 2021	Reflecting external assurance feedback
Issue 1.0	Jun 2021	Issue for inclusion in Draft Business Plan submission
Issue 1.1	Oct 2021	Reflecting updated DFES forecasts
Issue 1.2	Nov 2021	Reflecting updated CBA results
Issue 2.0	Dec 2021	Issue for inclusion in Final Business Plan submission

Scheme Name	Whitlawburn Primary Fault Level Mitigation		
Activity	Fault Level Reinforcement		
Primary Investment Driver	Fault Level Mitigation		
Reference	ED2-LRE-SPD-009-CV3		
Output	Fault Level Reinforcement		
Cost	£3.690m		
Delivery Year	2026-2028		
Reporting Table	CV3		
Outputs included in ED1	~~Yes~~/No		
Business Plan Section	Develop the Network of the Future		
Primary Annex	Annex 4A.2: Load Related Expenditure Strategy: Engineering Net Zero Annex 4A.6: DFES		
Spend Apportionment	**ED1**	**ED2**	**ED3**
	£m	**£3.690m**	**£m**

SP ENERGY NETWORKS

Technical Governance Process

Project Scope Development

IP1(S)

To be completed by the Service Provider or Asset Management. The completed form, together with an accompanying report, should be endorsed by the appropriate sponsor and submitted for approval.
IP1 – To request project inclusion in the investment plan and to undertake project design work or request a modification to an existing project
IP1(S) – Confirms project need case and provides an initial view of the Project Scope
IP2 – Technical/Engineering approval for major system projects by the System Review Group (SRG)
IP2(C) – a Codicil or Supplement to a related IP2 paper. Commonly used where approval is required at more than one SRG, typically connection projects which require connection works at differing voltage levels and when those differing voltage levels are governed by two separate System Review Groups.
IP2(R) – Restricted Technical/Engineering approval for projects such as asset refurbishment or replacement projects which are essentially on a like-for-like basis and not requiring a full IP2
IP3 – Financial Authorisation document (for schemes > £100k prime)
IP4 – Application for variation of project due to change in cost or scope

PART A – PROJECT INFORMATION

Project Title:	**Whitlawburn Primary Fault Level Mitigation**
Project Reference:	**ED2-LRE-SPD-009-CV3**
Decision Required:	**To give concept approval for the establishment of Cathkin primary substation to reduce demand on Whitlawburn primary transformers and resolve the 11kV fault level issue at Whitlawburn substation.**

Summary of Business Need:

Whitlawburn 33/11kV primary substation provides supplies to ca. 14,305 customers via a 17-panel 11kV switchboard fed from two 20/40MVA 33/11kV transformers. The peak-make fault level at Whitlawburn primary 11kV busbar is presently 103.5% of the switchgear's fault level design rating (250MVA) and the RMS break duty is at 95%.

In order to comply with section 9 of the Electricity Act and Condition 21 of our licence obligation "to develop and maintain an efficient, coordinated and economical system for the distribution of electricity" an enduring design solution is required in order to satisfy the existing requirements and accommodate future growth and this proposal will meet that requirement.

Summary of Project Scope, Change in Scope or Change in Timing:

The proposal is to establish Cathkin primary substation with two 20MVA 33/11kV transformers and a 9-panel 11kV switchboard, located in a housing. Cathkin primary will be connected at 33kV to the Westburn Road (Clyde's Mill) GSP 33kV busbar. Each of the underground cable circuits feeding the Whitlawburn 33/11kV transformers comprises two parallel cables. One cable from each circuit will remain connected to the respective Whitlawburn transformer, while the second cable will be de-coupled, then extended from Whitlawburn to Cathkin with approximately 1.35km of 33kV cable. At Westburn Road (Clyde's Mill) GSP, a new circuit breaker will be added to each half of the busbar to control the two new Cathkin primary circuits. Once Cathkin primary substation is established and the demand on the Whitlawburn 33/11kV transformers is reduced, the Whitlawburn 33/11kV transformers will be renewed, replacing the 20/40MVA units 20MVA transformers.

The estimated cost for the above is £3.690m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Expenditure Forecast (in 2020/21)

Licence Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPD	CV3	Fault Level Reinforcement	**3.690**	-	-	0.738	1.476	1.476
SPD	**Total**		**3.690**	**-**	**-**	**0.738**	**1.476**	**1.476**

PART B – PROJECT SUBMISSION

Proposed by	Milana Plecas	Signature	Milana Plecas	Date:	30/11/2021
Endorsed by	Russell Bryans	Signature		Date:	30/11/2021

PART C – PROJECT APPROVAL

Approved by	Malcolm Bebbington	Signature		Date:	30/11/2021

Contents

1 Introduction

Whitlawburn 33/11kV primary group is geographically located in Cambuslang in Glasgow district. The group currently serves 14,305 customers.

The peak make fault level at Whitlawburn primary 11kV already exceed the switchgear's fault level design rating (250MVA) and the RMS break duty is at 95%.

In order to comply with section 9 of the Electricity Act and Condition 21 of our licence obligation "to develop and maintain an efficient, coordinated and economical system for the distribution of electricity" it is proposed to establish Cathkin primary substation with two 20MVA 33/11kV transformers and a 9-panel 11kV switchboard, located in a housing. Cathkin primary will be connected at 33kV to the Westburn Road (Clyde's Mill) GSP 33kV busbar. Each of the underground cable circuits feeding the Whitlawburn 33/11kV transformers comprises two parallel cables. One cable from each circuit will remain connected to the respective Whitlawburn transformer, while the second cable will be de-coupled, then extended from Whitlawburn to Cathkin with approximately 1.35km of 33kV cable. At Westburn Road (Clyde's Mill) GSP, a new circuit breaker will be added to each half of the busbar to control the two new Cathkin primary circuits. Once Cathkin primary substation is established and the demand on the Whitlawburn 33/11kV transformers is reduced, the Whitlawburn 33/11kV transformers will be renewed, replacing the 20/40MVA units 20MVA transformers.

The estimated cost for the above is £3.690m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Existing peak make fault level issue is managed operationally during switching and the system studies indicate that the constraint can continue to be operationally managed during the first half of RIIO-ED2. However, due to the predicted increase in fault levels, operational management is not an enduring solution and hence it is proposed to start the works in 2025/26 to revolve the fault level issues, with project completion in 2027/28. We will maintain fault levels at this substation under review and priorities this scheme in earlier years if necessary. The proposed option provides an additional 68MVA of fault level headroom at Whitlawburn. The fault level scheme output will be claimed in 2027/28 at the end of the project.

2 Background Information

2.1 Existing / Authorised Network

The network under consideration is Whitlawburn primary demand group. The site is surrounded with private gardens and a main road and there is no option to expand it. The geographical layout of the site is depicted in Figure 1.

Figure 1. Whitlawburn primary site geographical layout

The Whitlawburn primary supplies 14,305 customers. The high number of customers supplied from Whitlawburn primary is due to the removal of the 33kV circuit routes supplying the former Cathkin 33/11kV substation (from East Kilbride GSP). A landfill site was developed on an area of land to the South of the former Cathkin primary, where the 33kV overhead lines between East Kilbride GSP and Cathkin primary were constructed, but new 33kV circuit routes could not be secured, so Cathkin primary substation was de-commissioned. The Cathkin primary 11kV demand was absorbed into the Whitlawburn 11kV network by cross-jointing to existing circuits.

The existing 11kV network comprises of underground cable. Whitlawburn primary is interconnected at 11kV with Cambuslang, Westburn Rd, Markethill, Westfield Av, Castlemilk, Carmunnock Rd and College Milton primary substations as highlighted in purple in Figure 2.

The 11kV switchboard consists of 17 panels, 14 of which are feeder breakers, a bus section and two incomer breakers.

Whitlawburn primary substation is served by two 20/40MVA, Bonar Long 33/11kV transformers (1971) which will have health index 5 by the end of RIIO-ED2. The 11kV group is fed from Westburn Road (Clyde's Mill) Grid Supply Point (GSP) via the 33kV network shown in Figure 3.

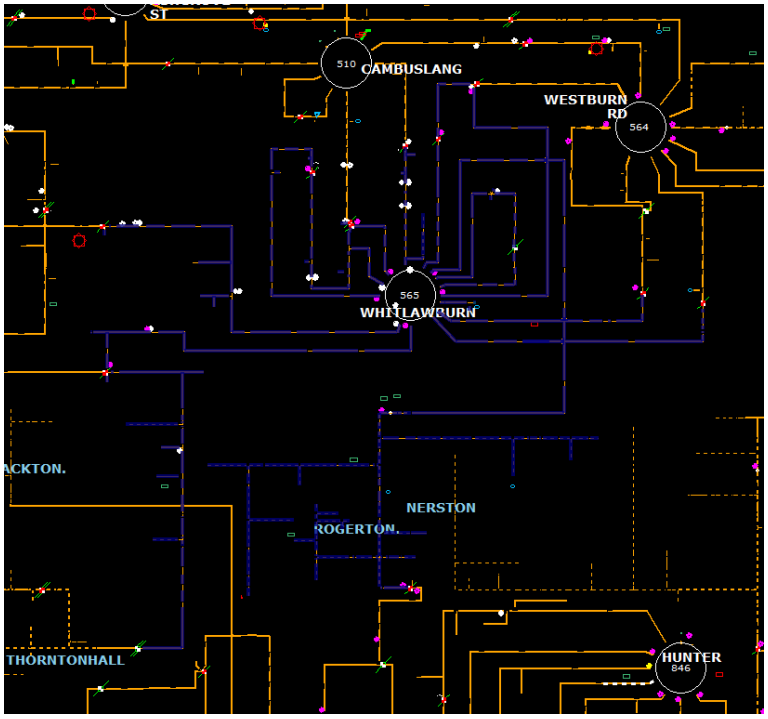

Figure 2. Existing Whitlawburn primary 11kV network

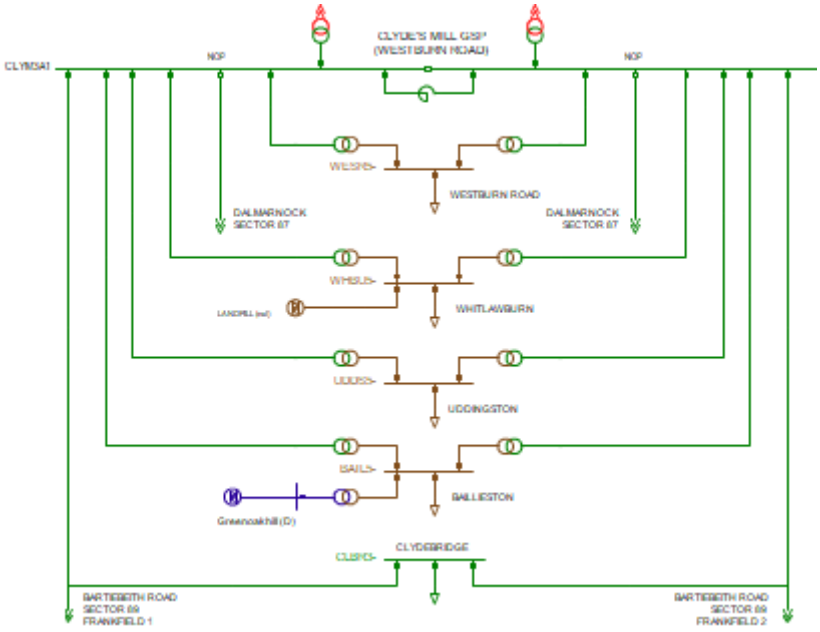

Figure 3. Existing Whitlawburn primary 33kV network

2.2 Network Supply / Circuit Capacity

Historically, the group demand has been ca. 20MVA, against the group firm capacity of 40MVA and is load index 1. The group is a class 'C' of supply as per ENA Engineering Recommendation (EREC) P2/7. The 33kV connection circuits extend from Westburn Road (Clyde's Mill) GSP and each 33kV circuit comprises twin 185mm^2 Cu / 300mm^2 Al, three core P.I.L.C. cables, to match the thermal rating of the transformers.

2.3 Embedded Generation

Embedded generation connected to the network is shown in Table 2.1.

Table 2.1. Embedded generation connected to Whitlawburn primary

Primary	Voltage (kV)	Site	Capacity (MW)	Type	Status
Whitlawburn	11	Cathkin Landfill Extension	3.2	Waste Incineration (not CHP)	Connected

2.4 Fault Levels / Design Limits

Switchgear is required to have the capability of "making" fault current i.e. closing onto an existing fault and "breaking" fault current i.e. opening and so disconnecting a fault from the system, these duties are defined in terms of Peak Make and RMS Break.

Typical planning limits for fault level duties on the SPD network are shown in Table 2.2. These are the design limits for the 11kV network.

Table 2.2. Fault level design limits

System Voltage (kV)	3phase Fault Level Limits (kA)		1-phase Fault Level Limits (kA)	
	Peak Make	RMS Break	Peak Make	RMS Break
HV	32.80	13.12	32.80	13.12

The switchgear fault level duty assessments are based on the SP Energy Networks (SPEN) design policies ESDD-02-006[1], under which the design principles effectively ensure with regards to the equipment duty, the prospective network fault levels shall never be more than 100% of the plant capability. However, to reflect the potential for under-estimation due to generic assumptions and modelling errors, sites exceeding 95% of design rating are considered for mitigation.

Table 2.3 shows the current 11kV 3-phase and 1-phase fault levels as a percentage of the lowest of switchgear ratings / design limits at the Whitlawburn primary substation.

Table 2.3. Whitlawburn primary fault level (LTDS 2020)

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		1-phase Fault Levels (kA)		Max 3-phase and 1-phase Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitlawburn primary	32.80	13.12	33.74	12.45	33.10	12.61	**102.87**	**96.11**

[1] ESDD-02-006 – Calculation of System Fault Levels

3 Needs Case

Switchgear are network assets which keep the higher voltage network safe in the event of a fault. They safely isolate the faulted section of the network. Switchgear are rated to cope with a certain level of fault current. Fault level constraints limit the safe operation of this group.

The 11kV peak make fault level exceeds the equipment rating and the RMS break duty is at 95%. Although, there is one landfill generation site (Cathkin Landfill) pushing 3.2MW into the Whitlawburn 11kV network that contributes to the fault level issue, the main reason for the high fault level is attributed to the impedance on rating (31.1%) of the 33/11kV, 20/40MVA transformers and the configuration of the 33kV network. For these reasons, it is necessary to mitigate the existing fault levels, to continue to maintain a safe and secure network.

3.1 Forecast Demand

The system is forecast to grow within the RIIO-ED2 period. This forecast is based on actual system measurement data from the Process Instrumentation (PI) system and stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers our pipeline of known developments.

DFES includes granular forecasts to 2050 for demand, generation and Low Carbon Technologies. They assess credible future scenarios covering a range of uncertainties, including differing levels of consumer ambition, policy support, economic growth and technology development and the forecasts are underpinned by extensive stakeholder engagement.

The peak demand forecast based on the SPD Distribution Future Energy Scenarios are depicted in Figure 4.

The scenario range considers the range of Net Zero compliant scenarios developed by us, the Electricity System Operator (ESO), and the Climate Change Committee (CCC). These are the five scenarios from the CCC 6th carbon budget, and the Leading the Way and Consumer Transformation scenarios from our DFES and the ESO Future Energy Scenarios (FES). We haven't included the System Transformation (ST) scenario as it is an outlier against the other Net Zero compliant scenarios and does not achieve interim carbon targets.

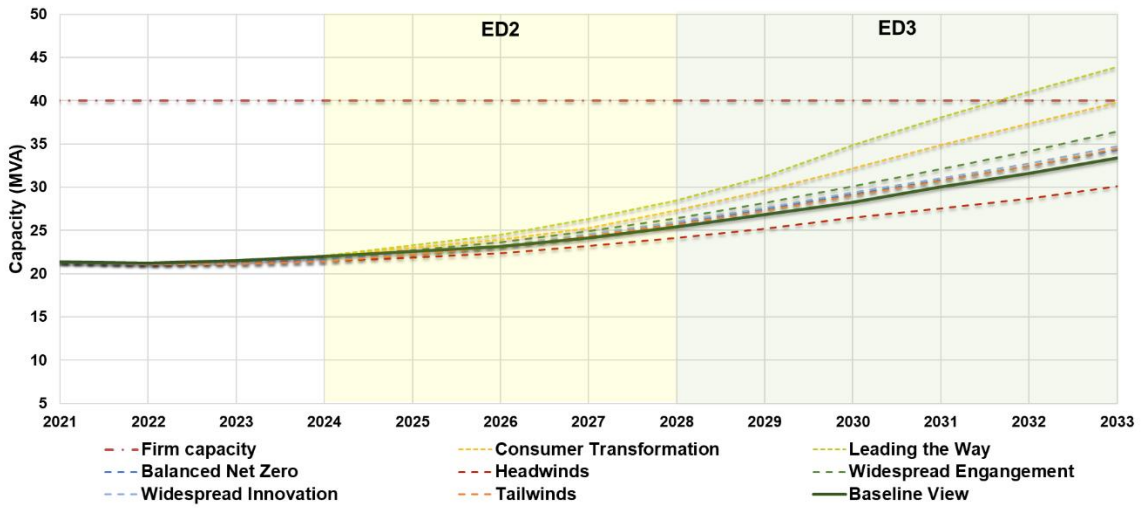

Figure 4. Demand (MVA) forecast for Whitlawburn demand group

3.2 Forecast Generation

There is around 0.5MW generation forecasted to be connected to Whitlawburn primary based on Distribution Future Energy Scenarios.

3.3 Network Impact Assessment

The Whitlawburn group have been assessed with the forecast demand growth, covering thermal and fault level constraints while considering the different demand forecast scenarios.

3.3.1 Thermal Constraints

No additional thermal constraints have been identified in the group under intact and outage conditions with the forecast demand growth.

3.3.2 Fault Level Constraints

The fault level issues at Whitlawburn primary will persist and continue into RIIO-ED2, likely exacerbate with the connection of new generation on the upstream networks and require operational measures to manage the fault level exceedances. The DFES HV generation forecast at Whitlawburn primary is not significant over the RIIO-ED2 period.

Table 3.1 shows the 11kV 3-phase and 1-phase fault levels as a percentage of the lowest of switchgear ratings / design limits at the Whitlawburn primary substation by the end of RIIO-ED2 which includes DFES generation and demand forecasts.

Table 3.1.Whitlawburn primary fault level (2028)

Substation Name	Year of Study	3-phase Fault Levels (kA)		1-phase Fault Levels (kA)		Max 3-phase and 1-phase Duty (%)	
		Make	Break	Make	Break	Make	Break
Whitlawburn primary	2028	34.8	12.72	33.38	12.70	**106.10**	**96.95**

4 Optioneering

Table 4.1 shows a summary of the options considered for this reinforcement. The baseline option represents the lowest cost conventional option, i.e. the minimum level of intervention without application of innovation.

Table 4.1. Longlist of solution options

#	Options	Status	Reason for rejection
(a)	Do nothing	Rejected	Rejected as it does not address the network fault level issues.
(b)	Intervention plan using only Energy Efficiency	Rejected	Rejected as it does not address the network fault level issues.
(c)	Establish Cathkin primary and replace Whitlawburn transformers	Shortlisted as **Baseline** option in Detailed Analysis	
(d)	Replace 33kV circuits, relocate generator to Cambuslang primary and transfer 10MW of demand	Shortlisted as **Option 1** in Detailed Analysis	
(e)	Install Active Fault Level Management AFLM) with Real-Time Fault Level Monitoring (RTFLM) scheme	Rejected	Rejected as unable to mitigate the risk of already high fault levels.
(f)	Install an 11kV bus section reactor	Rejected	Rejected due to Transient Recovery Voltages (TRV) when switching the bus section reactor in/out. Upgrading the 11kV primary switchboard would not fully mitigate the issue as current chopping would cause voltage spikes which could damage downstream SPEN and customer equipment.
(g)	Install 11kV series reactors in the tails of the primary transformers	Rejected	Rejected due to Transient Recovery Voltages (TRV) when switching the bus section reactor in/out. Upgrading the 11kV primary switchboard would not fully mitigate the issue as current chopping would cause voltage spikes which could damage downstream SPEN and customer equipment.
(h)	Relocate 11kV generator to Cambuslang primary substation	Rejected	This option would decrease the peak make fault level to 97% which is still above the threshold for fault level mitigation under SPEN design policy.
(i)	Relocate 11kV generator to Cambuslang primary substation and change 33kV circuits	Rejected	This option would decrease the peak make fault level to 96% which is still above the threshold for fault level mitigation under SPEN design policy.
(j)	Replace Whitlawburn primary transformers with higher impedance units	Rejected	SP Energy Networks transformer framework provides a choice of 10, 20 & 32MVA units. Due to the forecast demand, 32MVA units are required. Studies show that 32MVA transformers

#	Options	Status	Reason for rejection
			would not resolve the fault level issues, and fault level duty would still be above 100% of the network design limit.

5 Detailed Analysis & Costs

5.1 Proposed Option (Baseline) – Establish Cathkin Primary and Replace Whitlawburn Transformers

The proposed solution is to establish Cathkin primary substation with two 20MVA 33/11kV transformers and a 9-panel 11kV switchboard, located in a housing. The ground occupied by the former Cathkin 33/11kV substation is owned by SPEN. Cathkin primary will be connected at 33kV to the Westburn Road (Clyde's Mill) GSP 33kV busbar. Each of the underground cable circuits feeding the Whitlawburn 33/11kV transformers comprises two parallel cables. One cable from each circuit will remain connected to the respective Whitlawburn transformer, while the second cable will be de-coupled, then extended from Whitlawburn to Cathkin with approximately 1.35km of 33kV cable. At Westburn Road (Clyde's Mill) GSP, a new circuit breaker will be added to each half of the busbar to control the two new Cathkin primary circuits. Once Cathkin primary substation is established and the demand on the Whitlawburn 33/11kV transformers is reduced, the Whitlawburn 33/11kV transformers will be renewed, replacing the 20/40MVA units with standard impedance 20MVA transformers. Table 5.1 shows the scheme summary.

Table 5.1. Baseline option summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional	Whitlawburn Primary Fault Level Mitigation	Establish Cathkin primary and replace Whitlawburn transformers	3.690	-

This solution creates significant additional fault level headroom, 68MVA at Whitlawburn primary and 87MVA at Cathkin primary. Fault level results for both sites are shown in Table 5.2.

Table 5.2. Baseline option fault levels at Whitlawburn and Cathkin primary substations

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		1-phase Fault Levels (kA)		Max 3-phase and 1-phase Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitlawburn primary	32.80	13.12	25.52	9.57	24.24	9.19	**77.80**	**72.94**
Cathkin primary	32.80	13.12	21.33	7.86	22.56	8.53	**68.78**	**65.02**

Additionally, Cathkin area is seeing a major housing development with over 250 houses to be built within the next few years which will increase the demand in the area by 5MVA. This housing development is right beside the location of the new Cathkin primary. This will see the new Cathkin primary substation being in the centre of the load in the area.

The proposed layout of Cathkin primary is shown in Figure 5 and the proposed 33kV network is shown in Figure 6.

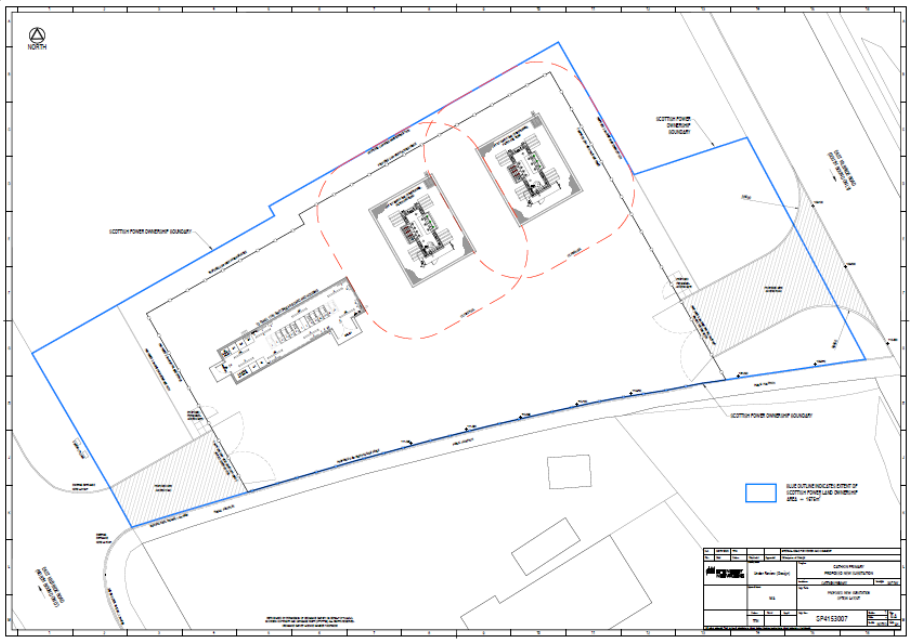

Figure 5. Cathkin primary proposed layout

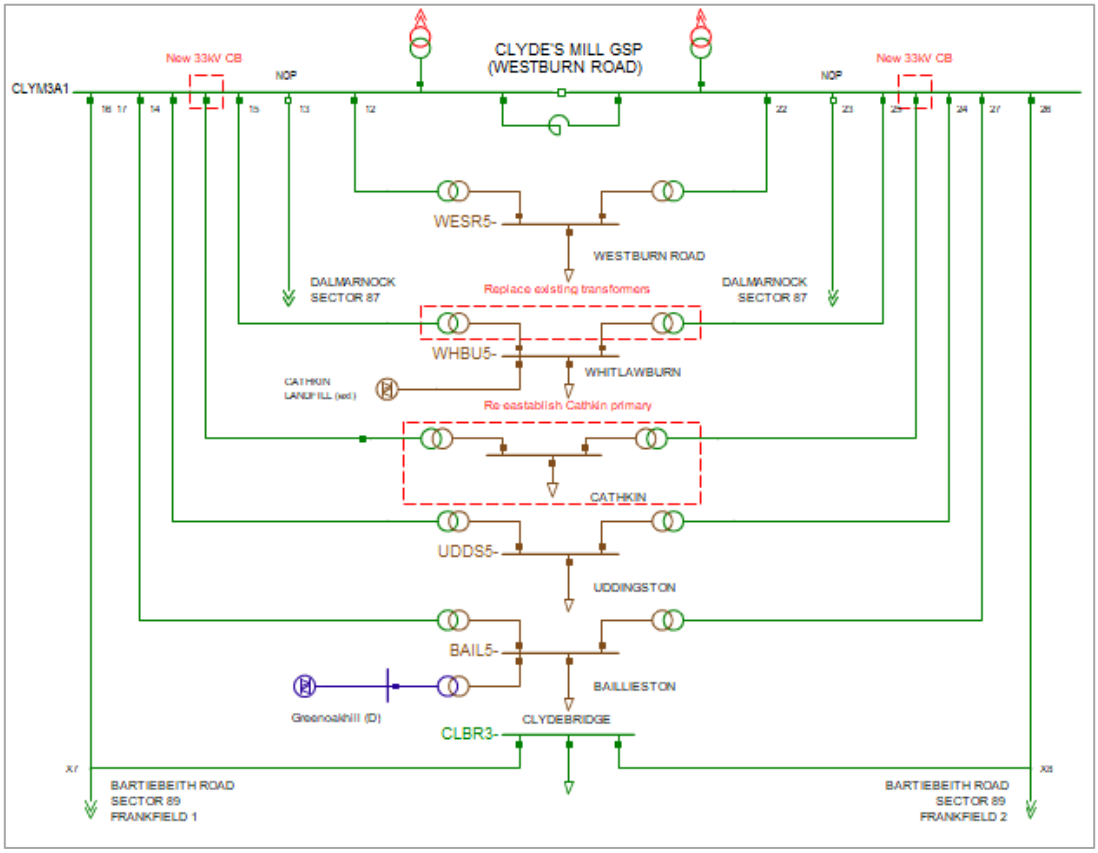

Figure 6. Schematic of the proposed 33kV network

Table 5.3 shows a summary of reinforcement costs and volumes for the proposed scheme under RIIO-ED2.

Table 5.3. Baseline option summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.15	0.018	0.018	-
6.6/11kV CB (GM) Primary	9	0.250	0.250	-
33kV UG Cable (Non Pressurised)	2.8	0.559	0.559	-
33kV CB (Air Insulated Busbars)(ID) (GM)	2	0.334	0.334	-
33kV Transformer (GM)	4	1.477	1.477	-
Batteries at 33kV Substations	2	0.018	0.018	-
Pilot Wire Underground	2.8	0.310	0.310	-
Civil Works at 33 kV & 66 kV Substations		0.503	0.503	-
Wayleaves/Easements/Land Purchase		0.013	0.013	-
Other Costs (Identify Below)		0.209	0.209	-
Total Costs		3.690	3.690	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£80k)				
RTU/SCADA (£10k)				
33kV telecoms upgrade (£30k)				
Remote end protection (£42k)				
Environmental consideration (£15k)				
Fault recorder (£32k)				

Existing peak make fault level issue is managed operationally during switching and the system studies indicate that the constraint can continue to be operationally managed during the first half of RIIO-ED2. However, due to the predicted increase in fault levels, operational management is not an enduring solution and hence it is proposed to start the works in 2025/26 to revolve the fault level issues, with project completion in 2027/28. We will maintain fault levels at this substation under review and priorities this scheme in earlier years if necessary. The proposed option provides an additional 68MVA of fault level headroom at Whitlawburn. The fault level scheme output will be claimed in 2027/28 at the end of the project.

5.2 Option 1 – Replace 33kV Circuits, Relocate Generator to Adjacent Primary and Transfer 10MW of Demand

In order to provide enough future fault level headroom, this option considers re-connection of the 11kV generator to the Cambuslang primary, which is the closest primary with the fault level headroom, replacement of the twin 33kV circuits with 400mm Al XLPE (winter cyclic rating of 31.1MVA) and offloading of ca. 10MVA demand to adjacent primaries via 11kV network.

Table 5.4 shows the scheme summary. This option is rejected based on cost, limited additional fault level headroom compared to the proposed solution and the location of future load growth.

Table 5.4. Option 1 summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)

Conventional	Whitlawburn Primary Fault Level Mitigation	Replace 33kV circuits, relocate generator to Cambuslang primary and transfer 10MW of demand	4.058	-

This solution creates only 30MVA of additional fault level headroom at Whitlawburn primary, while reducing fault level headroom at Cambuslang, from 92MVA, to 54MVA. This investment option provides an overall net loss in fault level headroom. Fault level results are shown in Table 5.5.

Table 5.5. Option 1 fault levels at Whitlawburn and Cambuslang primary substations

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		1-phase Fault Levels (kA)		Max 3-phase and 1-phase Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitlawburn primary	32.80	13.12	28.54	10.51	30.45	11.57	**92.84**	**88.19**
Cambuslang primary	32.80	13.12	27.24	10.3	26.22	10.15	**83.05**	**78.51**

Table 5.6 shows a summary of reinforcement costs and volumes for Option 1 under RIIO-ED2. Option 1 33kV network configuration in shown Figure 7.

Table 5.6. Option 1 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	20	2.350	2.350	-
33kV UG Cable (Non Pressurised)	6	1.198	1.198	-
6.6/11kV CB (GM) Primary	7	0.194	0.194	-
Civil Works at 33 kV & 66 kV Substations		0.077	0.077	-
Wayleaves/Easements/Land Purchase		0.090	0.090	-
Other Costs (Identify Below)		0.150	0.150	-
Total Costs		4.058	4.058	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£50k)				
Environmental consideration (£100k)				

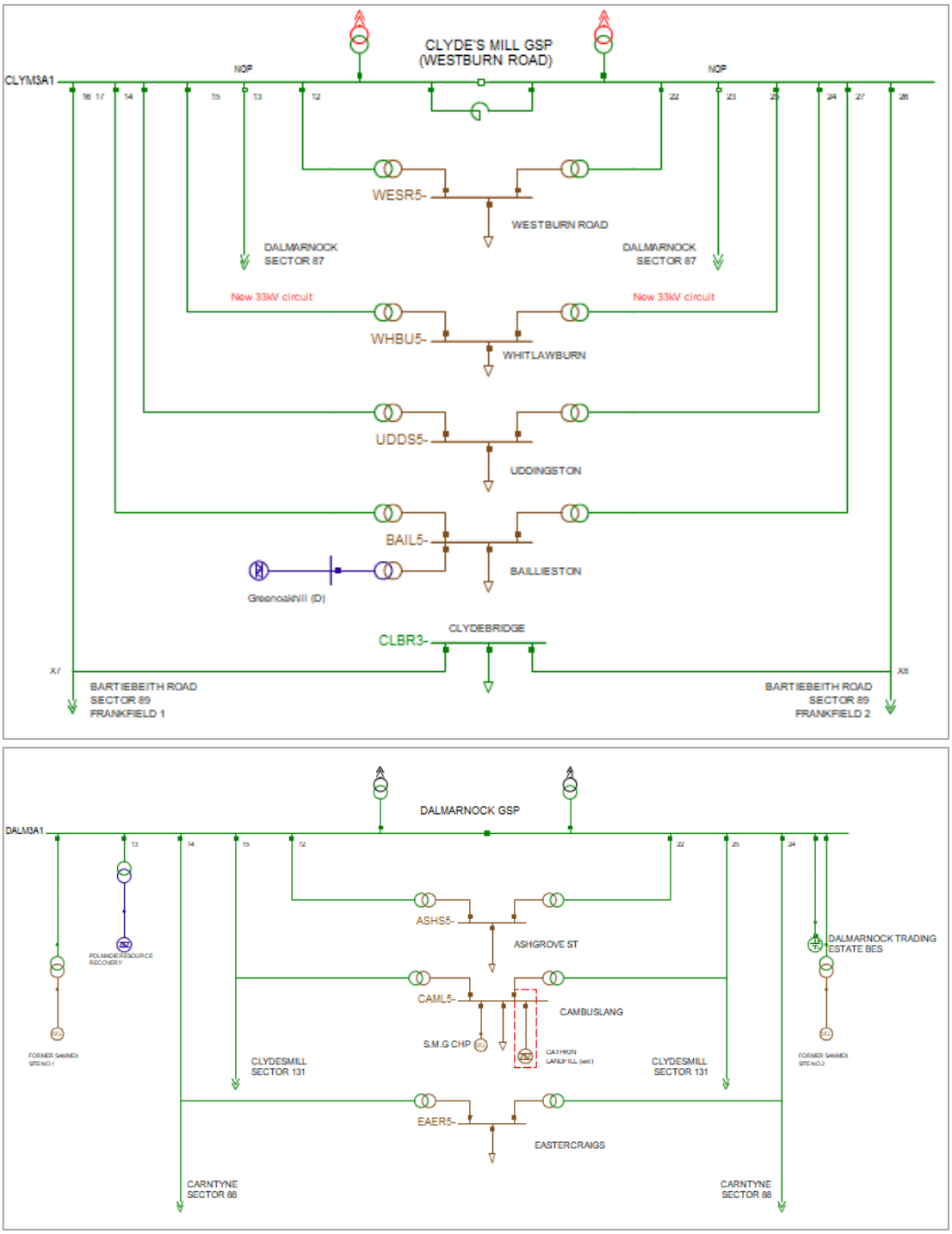

Figure 7. Schematic of Option 1 33kV network

5.3 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.7.

Table 5.7. Cost summary for considered options

Options	Option Summary	RIIO-ED2 Cost (£m)
Baseline	Establish Cathkin primary and replace Whitlawburn transformers	3.690
Option 1	Replace 33kV circuits, relocate generator to Cambuslang primary and transfer 10MW of demand	4.058

Derivation of costs for these options are based on the SPEN RIIO-ED2 Unit Cost Manual for intervention. This is based on bottom up cost assessment of the components of activity detailed within the RIGs Annex A for the above activities, SPEN's contractual rates for delivery, market available rates and historic spend levels.

6 Deliverability & Risk

6.1 Preferred Options & Output Summary

The adopted option is the baseline option to establish Cathkin primary and replace Whitlawburn transformers.

6.2 Cost Benefit Analysis Results

A cost benefit analysis (CBA) was carried out to compare the NPV of the options discussed in the previous sections. Considering the lowest forecast capital expenditure, the proposed option has the highest total NPV against other options. The summary of the cost benefit analysis is presented in Table 6.1. The full detailed CBA is provided within 'ED2-LRE-SPD-009-CV3-CBA – Whitlawburn Primary Fault Level Mitigation'.

Table 6.1. Cost benefit analysis results

Options considered	Decision	Comment	NPVs based on payback periods, £m (2020/21 prices)			
			10 years	20 years	30 years	45 years
Baseline – Establish Cathkin primary and replace Whitlawburn transformers	**Adopted**					
Option 1 – Replace 33kV circuits, relocate generator to adjacent primary and transfer 10MW of demand	Rejected	Discounted on NPV, limited additional fault level headroom compared to the proposed solution and the location of future load growth*.	-0.08	-0.16	-0.21	-0.24

*Cathkin area is seeing a major housing development with over 250 houses to be built within the next few years which will increase the demand in the area by 5MVA. This housing development is right beside the location of the new Cathkin primary.

6.3 Cost & Volumes Profile

Table 6.2 shows the breakdown of expenditure for the proposed scheme (in 2020/21 prices) and the cost incidence (in 2020/21 prices) over the RIIO-ED2 period is shown in Table 6.3. The total cost of the proposed scheme is £3.690m.

Table 6.2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.15	0.018	0.018	-
6.6/11kV CB (GM) Primary	9	0.250	0.250	-
33kV UG Cable (Non Pressurised)	2.8	0.559	0.559	-
33kV CB (Air Insulated Busbars)(ID) (GM)	2	0.334	0.334	-
33kV Transformer (GM)	4	1.477	1.477	-
Batteries at 33kV Substations	2	0.018	0.018	-
Pilot Wire Underground	2.8	0.310	0.310	-
Civil Works at 33 kV & 66 kV Substations		0.503	0.503	-
Wayleaves/Easements/Land Purchase		0.013	0.013	-
Other Costs (Identify Below)		0.209	0.209	-
Total Costs		3.690	3.690	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£80k)				
RTU/SCADA (£10k)				
33kV telecoms upgrade (£30k)				
Remote end protection (£42k)				
Environmental consideration (£15k)				
Fault recorder (£32k)				

Table 6.3: Cost incidence over the RIIO-ED2 period, £m (2020/21 Prices)

Total Investment	Total (£m)	Incidence (£m)				
		2023/24	2024/25	2025/26	2026/27	2027/28
CV3 Expenditure	**3.690**	-	-	0.738	1.476	1.476

6.4 Risks

The main delivery risks are the land for the new cable route. The ground occupied by the former Cathkin 33/11kV substation is owned by SPEN. We would mitigate these risks by seeking alternatives for the primary location and engaging with local authorities.

Existing peak make fault level issue is managed operationally during switching and the system studies indicate that the constraint can continue to be operationally managed during the first half of RIIO-ED2. However, there is a risk that the fault levels will be higher if generation greater than the DFES forecast occurs and/or if there is an increase in upstream fault levels. We would mitigate this risk by coordinating generation connection process and/or moving the delivery of this scheme to earlier years if required.

6.5 Outputs Included in RIIO-ED1 Plans

There are no outputs expected to be delivered in RIIO-ED1 that are funded within this proposal.

6.6 Future Pathways – Net Zero

6.6.1 Primary Economic Driver

The primary drivers for this investment based on the maximum short circuit rating of substation equipment being exceeded.

6.6.2 Payback Periods

The CBA indicates that for the proposed option demonstrates better NPV results in all assessment periods (10, 20, 30 & 45 years) against other two options. As the intervention is forecast to carry at least a 45-year asset life expectancy, the CBA at this time justifies the intervention. Consumers will also benefit from reduced network risk immediately on completion of the project.

6.6.3 Sensitivity to Future Pathways

The network capacity and capability that result from the proposed option is consistent with the network requirements determined in line with the section 9 of the Electricity Act and Condition 21. Additionally, the proposed option is consistent with the SPEN's Distribution System Operator (DSO) Strategy and Distribution Future Energy Scenarios.

Table 6.4 shows electric vehicle and heat pump uptakes across a range of future pathways and there is around 0.5MW generation forecasted. Both will contribute to the existing fault levels.

Table 6.4: Electric Vehicle and Heat Pump uptakes across a range of future pathways

End of RIIO-ED2	SPEN	DFES			CCC				
	Baseline	System Transformation*	Consumer Transformation	Leading the Way	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
EVs	3,592		4,301	4,942	4,309	2,967	4,688	4,270	4,270
HPs	1,689		1,791	3,104	1,395	1,334	1,546	1,303	1,415

*Note: We have excluded System Transformation from our future pathways assessment as it does not meet interim greenhouse gas emission reduction targets.

Table 6.5 shows the sensitivity of the proposed solution and Table 6.6 shows the sensitivity of the proposed RIIO-ED2 expenditure against the full ranges of Net Zero complaint future pathways other Climate Change Committee (CCC) scenarios.

Table 6.5: Sensitivity of the proposed solution against future pathways

	RIIO-ED1				RIIO-ED2					RIIO-ED3				
Solution Requirements	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Baseline									R1					
Consumer Transformation									R1					
Leading the Way									R1					
Balanced Net Zero Pathway									R1					
Headwinds									R1					
Widespread Engagement									R1					
Widespread Innovation									R1					
Tailwinds									R1					

R1 – Establish Cathkin primary and replace Whitlawburn transformers

The proposed solution is robust across all pathways. As this is the minimum requirement to mitigate the fault levels in the group, it is not sensitive to the future pathways and is expected that proposed

solution is required under all the future pathways. In all cases this solution is expected to endure beyond RIIO-ED3.

Table 6.6: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	3.690	N/A
Comment	Proposed option	

6.6.4 Asset Stranding Risks & Future Asset Utilisation

Electricity demand and generation loadings are forecast to increase under all scenarios. The stranding risk is therefore considered to be low.

6.6.5 Losses / Sensitivity to Carbon Prices

Losses have been considered in accordance with Licence Condition SLC49 and the SP Energy Networks Losses Strategy and Vision to "consider all reasonable measures which can be applied to reduce losses and adopt those measures which provide benefit for customers". Reasonable design efforts have been taken to minimise system losses without detriment to system security, performance, flexibility or economic viability of the scheme. This includes minimising conductor lengths/routes, the choice of appropriate conductor sizes, designing connections at appropriate voltage levels and avoiding higher impedance solutions or network configurations leading to higher losses.

Losses have been considered as part of this design solution and it has not been necessary to carry out any losses justified upgrades. MWh losses for each of the options have been included within the cost benefit analysis and solution selection was not found to be sensitive to the impact of the carbon cost of losses.

During the evaluation of the options associated with the proposed scheme, we have embedded within the CBA, where data are available, an assessment of the embodied carbon and the associated carbon cost to inform our NPV evaluation. The mass of carbon dioxide emitted (CO2e) during the manufacture of the main equipment deployed to deliver this scheme is estimated to be 575 tonnes. The monetised embodied carbon value associated with this emission is £38k. It should be noted that the embodied carbon evaluation undertaken has only considered the manufacture and supply of materials. Further collaborative industry-wide work is planned for the RIIO-ED2 price review period to better understand the overall embodied carbon values including, for example installation and commissioning services, decommissioning and disposal activities as well as refurbishment opportunities. More information regarding this can be found in Section 3.1.2 of our Environmental Action Plan[2].

6.6.6 Whole Systems Benefits

Whole system solutions have been considered as part of this proposal. No alternatives have been identified that could be provided through a whole systems solution. The completion of this scheme will maintain the integrity of the distribution network and its enduring ability to facilitate wider whole system benefits.

[2] Annex 4C.3: Environmental Action Plan, SP Energy Networks, Issue 2, 2021.

6.7 Environmental Considerations

6.7.1 Operational and Embodied Carbon Emissions

The Whitlawburn Primary Fault Level Mitigation programme has the potential to impact on the embodied carbon resulting from the delivery of the programme. The replacement of transformers at Whitlawburn, and the extension of 33 kV cable from Whitlawburn to Cathkin may have an impact on network losses and therefore on SPEN's Business Carbon Footprint (BCF).

6.7.2 Supply Chain Sustainability

For us to take full account of the sustainability impacts associated of the Whitlawburn Primary Fault Level Mitigation programme, we need access to reliable data from our suppliers. The need for carbon and other sustainability credentials to be provided now forms part of our wider sustainable procurement policy.

6.7.3 Resource Use and Waste

The Whitlawburn primary fault level mitigation programme will result in the consumption of resources and the generation of waste materials from end of life assets.

Where waste is produced it will be managed in accordance with the waste hierarchy which ranks waste management options according to what is best for the environment. The waste hierarchy gives top priority to preventing waste in the first instance, then preparing for re-use, recycling, recovery, and last of all disposal (e.g. landfill).

6.7.4 Biodiversity / Natural Capital

The Whitlawburn Primary Fault Level Mitigation programme will affect both developed and undeveloped sites containing existing assets. However, the impact on, and the opportunity to improve biodiversity and natural capital is expected to be minimal.

6.7.5 Preventing Pollution

SPEN will always follow all relevant waste regulations and will make sure that special (hazardous) waste produced or handled by our business is treated in such a way as to minimise any effects on the environment.

6.7.6 Visual Amenity

SPEN continually seeks to reduce the landscape and visual effects of our networks and assets but recognises that the nature of our substations makes it challenging to minimise their visual impact.

6.7.7 Climate Change Resilience

In addition to our efforts to minimise our direct carbon emissions in line with our Net Zero ambitions, we are also conscious of the need to secure the resilience of our assets and networks in the face of a changing climate. We have also modified our policy on vegetation control in the face of higher temperatures and longer growing seasons.

7 Conclusion

Whitlawburn 33/11kV primary group is geographically located in Cambuslang in Glasgow district. The group currently serves 14,305 customers. The peak-make fault level at Whitlawburn primary 11kV already exceed the switchgear's fault level design rating (250MVA) and the RMS break duty is at 95%.

In order to continue to maintain a safe and secure network, the proposed fault level mitigation solution is to establish Cathkin Primary substation which will be connected at 33kV to the Westburn Road (Clyde's Mill) GSP 33kV busbar replace the Whitlawburn 33/11kV transformers, with standard impedance 20MVA transformers, once Cathkin Primary substation is established and the demand on the Whitlawburn 33/11kV transformers is reduced. The ground occupied by the former Cathkin 33/11kV substation is owned by SPEN. Cathkin area is seeing a major housing development with over 250 houses to be built within the next few years which will increase the demand in the area by 5MVA. This housing development is right beside the location of the new Cathkin Primary. This will see the new Cathkin Primary substation being in the centre of the load in the area.

The estimated cost for the above is £3.690m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Existing peak make fault level issue is managed operationally during switching and the system studies indicate that the constraint can continue to be operationally managed during the first half of RIIO-ED2. However, due to the predicted increase in fault levels, operational management is not an enduring solution and hence it is proposed to start the works in 2025/26 to revolve the fault level issues, with project completion in 2027/28. We will maintain fault levels at this substation under review and priorities this scheme in earlier years if necessary. The proposed option provides an additional 68MVA of fault level headroom at Whitlawburn. The fault level scheme output will be claimed in 2027/28 at the end of the project.