Whitehouse GSP Fault Level Mitigation

ED2 Engineering Justification Paper

ED2-LRE-SPD-015-CV3-EJP

Issue	Date	Comments
Issue 0.1	Mar 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 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	Whitehouse GSP Fault Level Mitigation		
Activity	Fault Level Reinforcement		
Primary Investment Driver	Fault Level Mitigation		
Reference	ED2-LRE-SPD-015-CV3		
Output	Fault Level Reinforcement		
Cost	£2.122m		
Delivery Year	2024-2026		
Reporting Table	CV3/CV4		
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	**£2.122m**	**£0.075m**

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:	**Whitehouse GSP Fault Level Mitigation**
Project Reference:	**ED2-LRE-SPD-015-CV3**
Decision Required:	**To give concept approval for the replacement of the existing 33kV switchboards at Whitehouse Grid Supply Point.**

Summary of Business Need:

Whitehouse Grid Supply Point (GSP) has been identified as a candidate for load reinforcement during the RIIO-ED2 price control period due to the fault level issues. The peak make fault level at Whitehouse GSP 33kV switchboards is approaching the switchgear peak make limit. The peak make rating of this legacy switchgear is 43.75kA which is considerably lower than the 33kV peak make design limit of 50kA. Under system intact conditions the peak make fault level is above 95% of the switchgear fault level rating. Under design policy, the fault level mitigation is deemed necessary above 95% threshold. In addition, the peak make fault level can exceed 104% of the equipment rating under outages in the adjacent Kaimes GSP, when Whitehouse GSP is required to provide support to Kaimes.

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 replace the existing indoor 33kV switchboards, 'A' and 'B' boards, with a new rationalised indoor 33kV board to resolve the fault level issue and provide headroom for future demand growth and connection of embedded generation. It is proposed to build the new board offline. The new board will comprise of 11 panels, eight of which are feeder breakers, a bus section and two transmission incomer breakers, with the facility for an additional three circuit breakers on each side for future connections. The costs of nine distribution panels and associated environmental, engineering, civil and commissioning works are included in CV3 allowance and the costs for two SP Transmission breakers will be claimed under CV4 (New Transmission Capacity Charges). The full cost of transmission works will be charged to SP Distribution under New Transmission Capacity Charges (NTCC), over a 40-year payback period starting from 2025/26. The estimated cost for the above is £2.122m (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	**2.075**	-	1.037	1.037	-	-
SPD	CV4	New Transmission Capacity Charges	**0.047**	-	-	0.016	0.016	0.016
SPD	**Total**		**2.122**	**-**	**1.037**	**1.053**	**0.016**	**0.016**

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

Whitehouse 132/33kV Grid Supply Point (GSP) is located in the Edinburgh & Borders district of SP Distribution, providing supplies to ca. 35,352 customers.

Fault levels at Whitehouse GSP 33kV switchboards is approaching the switchgear's fault level peak make rating and is above 95%. Under design policy, the fault level mitigation is deemed necessary above 95% threshold. In addition, the peak make fault level can exceed 104% of the equipment rating under outages in the adjacent Kaimes GSP, when Whitehouse GSP is required to provide support to Kaimes.

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 replace the existing indoor 33kV switchboards, 'A' and 'B' boards, with a new rationalised indoor 33kV board. The SP Distribution works for this solution involves the installation of 9 distribution panels and associated environmental, engineering, civil. The SP Transmission works for this solution involves the installation of two incomer breakers which is included in the RIIO-T2 plan. SP Distribution will submit a Modification Application (£38k) to National Grid Electricity System Operator (NGESO) for this work in 2024/25. The full cost of transmission works will be charged to SP Distribution under New Transmission Capacity Charges (NTCC), over a 40-year payback period starting in 2025/26 upon 33kV switchboard energisation.

The estimated cost for the above is £2.075m under the CV3 expenditure and £0.047m (in 2020/21 prices) under the CV4 expenditure with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Existing peak make fault level is below 100% of the switchgear rating. However, due to the predicted increase in fault levels, it is proposed to start the works in 2024/25 and the fault level scheme output will be claimed in 2025/26 upon 33kV switchboard energisation. The proposed option provides an additional 74MVA (peak make)/29MVA (RMS break) fault level headroom, on equipment rating; and 74MVA (peak make)/0MVA (RMS break), on design rating.

2 Background Information

2.1 Existing / Authorised Network

Whitehouse GSP supplies six primary substations (George Square Lane, Martin Miller, Maxwell Street, Mortonhall, Oxgang Road and Park Road). It has interconnections to Kaimes GSP and Portobello GSP. The existing 33kV network comprises of underground cable and overhead lines. The authorised network is shown in Figure 1.

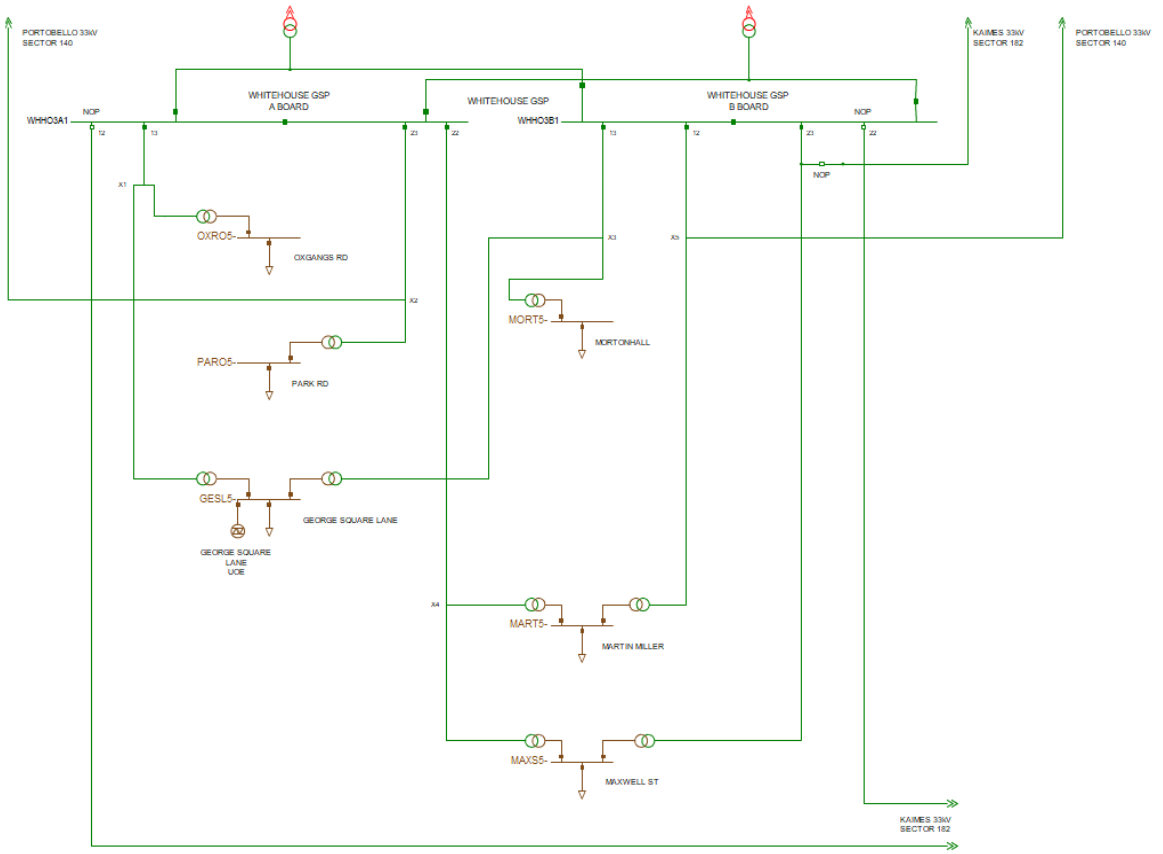

Figure 1. Whitehouse GSP 33kV network

Whitehouse GSP has indoor 33kV 'A' and 'B' switchboards arranged as two transmission incomers, one distribution bus-section and four distribution feeder circuit breakers (CBs). SP Distribution CBs consist of eight GEC KDJ8S and two GEC KDJ12S oil circuit breakers installed in 1966.

The two-section 'A' and 'B' 33kV busbars have a transmission system infeed onto each half from two 120MVA 132/33kV grid transformers.

2.2 Network Supply / Circuit Capacity

The existing Whitehouse GSP peak demand is around 55MW which is a class 'C' of supply as per ENA Engineering Recommendation (EREC) P2/7. The firm capacity (N-1) of Whitehouse GSP is 120MVA. Whitehouse GSP has the following interconnectors for supporting N-1 and N-2 contingencies:

- three 33kV interconnectors to Kaimes GSP (Normally Open Points at Whitehouse GSP)
- two 33kV interconnector to Portobello GSP (Normally Open Points at Portobello GSP)

2.3 Embedded Generation

At present there is less than 1MW of small embedded generation connected into Whitehouse GSP.

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 2.1. These are the design limits for the 33kV network.

Table 2.1. Fault level design limits

Switchgear Type	System Voltage (kV)	3-phase Fault Level Limits (kA)	
		Peak Make	RMS Break
IEC 62271-100; Rating >= 20kA (Installed after 2010)	EHV	50.00	17.50
Legacy Switchgear	EHV	43.75	17.50

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 2.2 shows the current 33kV 3-phase fault levels as a percentage of the lowest of switchgear ratings / design limits at the Whitehouse GSP substation. The peak make rating of this legacy switchgear is considerably lower than the 33kV peak make design limit of 50kA.

Table 2.2. Whitehouse GSP fault level (LTDS 2020)

Substation Name	Design Rating (kA)		Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitehouse GSP	43.75	17.50	43.75	17.50	42.13	14.75	**96.30**	**84.29**

[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 is rated to safely operate with a certain level of fault current. Fault level constraints limit the safe operation of this group.

The peak make fault level at Whitehouse GSP 33kV switchboards is above 95% of the switchgear ratings which would prevent connection of future generation, even small embedded 11kV generation as it would require a high-level cost for the fault level mitigation. The peak make rating of this legacy switchgear is considerably lower than the 33kV peak make design limit of 50kA. Under design policy, the fault level mitigation is deemed necessary above 95% threshold. In addition, this GSP is important for supporting Kaimes GSP in N-2 situation which introduces higher fault levels as shown in Table 3.1.

Table 3.1. Whitehouse GSP fault level in N-2 situation at Kaimes GSP

Substation Name	Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Whitehouse GSP	43.75	17.5	46.61	15.50	**106.54**	**88.57**

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 DFES is depicted in Figure 2.

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.

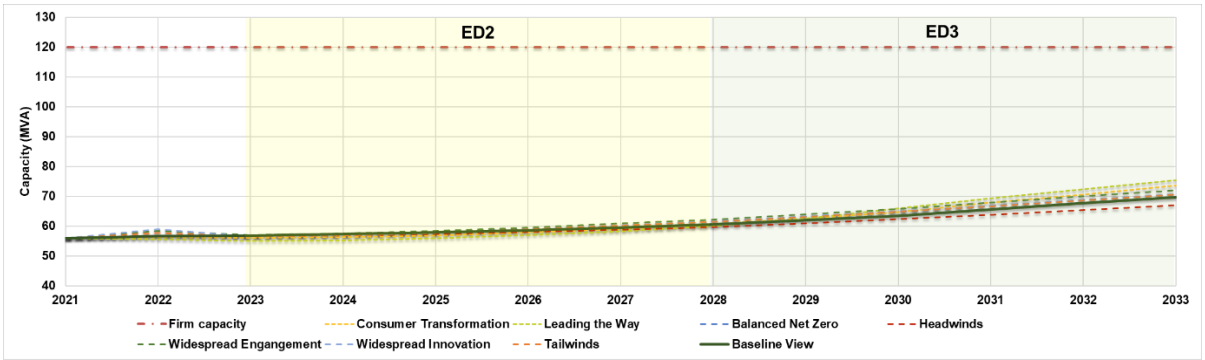

Figure 2. Demand (MVA) forecast for Whitehouse GSP demand group

3.2 Forecast Generation

There is around 2.4-5.1MW generation forecasted to be connected to Whitehouse GSP based on Distribution Future Energy Scenarios.

3.3 Network Impact Assessment

The Whitehouse GSP 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 Whitehouse GSP will persist and continue into RIIO-ED2, likely exacerbate with the connection of new load and generation and require operational measures to manage the fault level exceedances.

Table 3.2 shows the 33kV 3-phase fault levels as a percentage of the lowest of switchgear ratings / design limits at the Whitehouse GSP substation by the end of RIIO-ED2 which includes DFES generation and demand forecasts.

Table 3.2. Whitehouse GSP fault level (2028)

Substation Name	Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Whitehouse GSP	43.75	17.50	44.49	15.74	**101.69**	**89.94**

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)	Replace 'A' and 'B' 33kV switchboards with a rationalised 33kV board	Shortlisted as **Baseline** option in Detailed Analysis	
(d)	Replace 'A' and 'B' 33kV switchboards with two new indoor boards	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 sufficiently mitigate the risk. Also, considering the age of the 33kV switchboards, this option would not be expected to be an enduring solution.
(f)	Install a 33kV bus section reactor	Rejected	Rejected as not technically feasible to install a 33kV bus section reactor given the dual 33kV switchboards at Whitehouse GSP. The installation of a bus section reactor on this site would require four 33kV circuit breakers and a complex operational scheme to ensure the fault level is correctly mitigated.
(g)	Install 33kV series reactors in the tails of the grid transformers	Shortlisted as **Option 2** in Detailed Analysis	

5 Detailed Analysis & Costs

5.1 Proposed Option (Baseline) – Rationalise 33kV Switchboard

The proposed solution is to replace the existing indoor 33kV switchboards, 'A' and 'B' boards, with a new rationalised indoor 33kV board of at least 20kA RMS break rating. Table 5.1 shows the scheme summary.

Table 5.1. Proposed option summary

Category	Scheme Name	Scheme Summary	Reporting Table	RIIO-ED2 Contribution (£m)	Post RIIO-ED2 (£m)	Customer Contribution (£m)
Conventional	Whitehouse GSP Fault Level Mitigation	Replace indoor 33kV switchboards with a new rationalised indoor 33kV board	CV3 Expenditure	2.075	-	-
			CV4 Expenditure	0.047	0.451	-

The new board will comprise of 11 panels, eight of which are feeder breakers, a bus section and two transmission incomer breakers, with the facility for additional three circuit breakers on each side for future connections. It is proposed to build the new board offline. The SP Distribution works for this solution involves the installation of nine distribution panels and associated environmental, engineering, civil. The costs of SPD works are included within the CV3 expenditure. The SP Transmission works for this solution involves the installation of two incomer breakers which is included in the RIIO-T2 plan. The full cost of transmission works will be charged to SP Distribution under New Transmission Capacity Charges (NTCC), over a 40-year payback period starting in 2025/26 upon 33kV switchboard energisation.

SP Distribution will submit a Modification Application (£38k) to NGESO for this work in 2024/25. This solution creates additional fault level headroom at Whitehouse GSP substation as shown in Table 5.2 and Table 5.3 as a percentage of the lowest of switchgear ratings / design limits at the Whitehouse GSP substation.

Table 5.2. Proposed option fault levels at Whitehouse GSP substation

Substation Name	Design Rating (kA)		Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitehouse GSP	50.00	17.50	50.00	20.00	44.49	15.74	**88.98**	**89.94**

Table 5.3. Proposed option fault levels at Whitehouse GSP substation in N-2 situation at Kaimes GSP

Substation Name	Design Rating (kA)		Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitehouse GSP	50.00	17.50	50.00	20.00	46.61	15.50	**93.22**	**88.57**

The location of the new rationalised 33kV board is highlighted in red in Figure 3 and the 33kV layout of the new board is shown in Figure 4. If the site demand increases beyond the 75MVA level in the future, there is enough space to accommodate a future 'B' board if required.

Figure 3. Proposed Whitehouse GSP new rationalised 33kV switchboard location

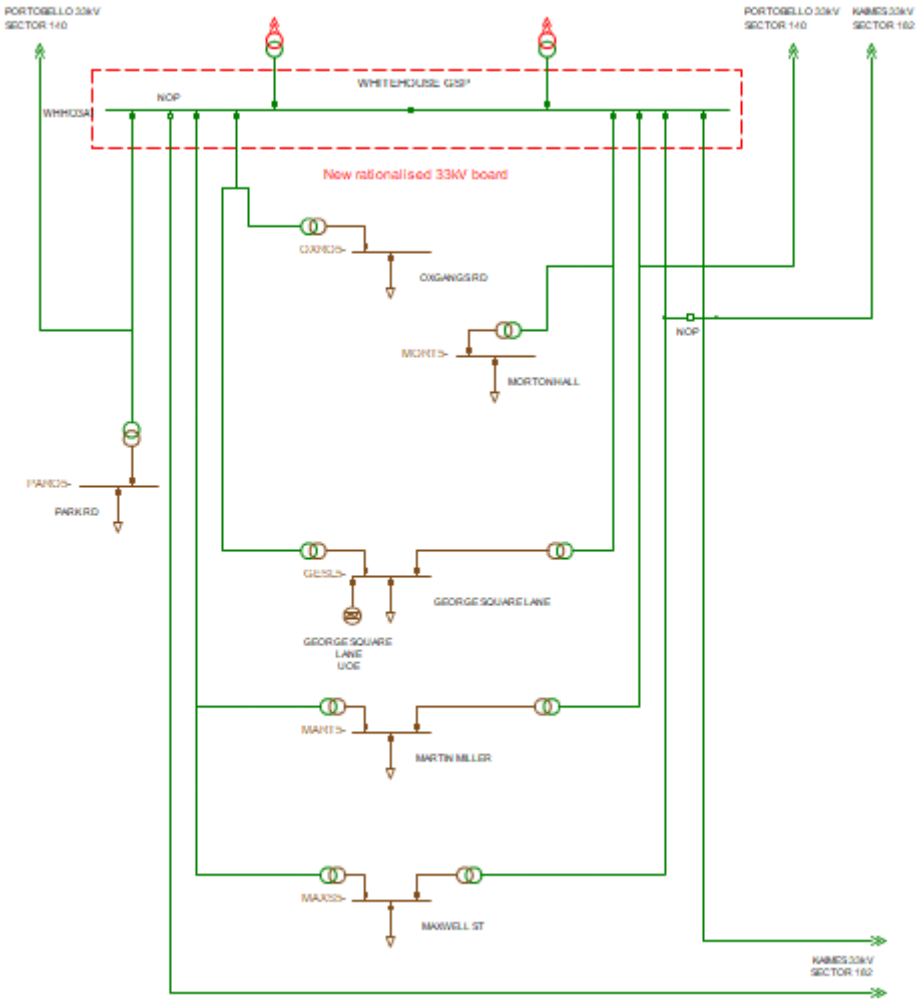

Figure 4. Proposed rationalised 33kV board at Whitehouse GSP

Table 5.4 shows a summary of reinforcement costs and volumes for the proposed scheme under RIIO-ED2.

Table 5.4. Proposed option summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Post RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV CB (Gas Insulated Busbars)(ID) (GM)	9	1.503	1.503	-	-
Civil Works at 33 kV & 66 kV Substations		0.180	0.180	-	-
Other Costs CV3 (Identify Below)		0.392	0.392	-	-
Other Costs CV4 (Identify Below)		0.498	0.047	0.451	-
Total Costs		2.573	2.122	0.451	-
Identify activities included within other costs (please provide high-level detail of cost areas)					
CV3 – Planning and design (£50k)					
CV3 – Remote end protection (£189k)					
CV3 – RTU/SCADA (£45k)					
CV3 – Telecoms infrastructure upgrade to modern intertripping (£70k)					
CV3 – NGESO ModApp fee (£38k based on NGESO charges from 1st April 2021)					
CV4 – NTCC (New Transmission Capacity Charges) (£47k)					

Existing peak make fault level is below 100% of the switchgear rating. However, due to the predicted increase in fault levels, it is proposed to start the works in 2024/25 and the fault level scheme output will be claimed in 2025/26 upon 33kV switchboard energisation. The proposed option provides an additional 74MVA (peak make)/29MVA (RMS break) fault level headroom, on equipment rating; and 74MVA (peak make)/0MVA (RMS break), on design rating.

5.2 Option 1 – Like for Like Replacement of 'A' and 'B' 33kV Switchboards

This solution is to replace the existing indoor 33kV switchboards with two new indoor 33kV switchboards of at least 20kA RMS break rating. Table 5.5 shows the scheme summary. This option is not considered to offer value for money and has been discounted.

Table 5.5. Option 1 summary

Category	Scheme Name	Scheme Summary	Reporting Table	RIIO-ED2 Contribution (£m)	Post RIIO-ED2 (£m)	Customer Contribution (£m)
Conventional	Whitehouse GSP Fault Level Mitigation	Replace indoor 33kV switchboards with two new indoor 33kV boards	CV3 Expenditure	2.290	-	-
			CV4 Expenditure	0.095	0.902	-

The new boards will comprise of seven panels each, four of which are feeder breakers, a bus section and two transmission incomer breakers, with the facility for an additional two circuit breakers on each bar of both new 'A' and 'B' boards for future connections. It is proposed to build the new boards offline. The SP Distribution works for this solution involves the installation of 10 distribution panels and associated environmental, engineering, civil. The costs of SPD works are included within the CV3 expenditure. The SP Transmission works for this solution involves the installation of two incomer breakers. The full cost of transmission works will be charged to SP Distribution under New Transmission Capacity Charges (NTCC), over a 40-year payback period starting in 2025/26 upon 33kV switchboard energisation.

SP Distribution will submit a Modification Application (£38k) to NGESO for this work in 2024/25. This solution creates additional fault level headroom at Whitehouse GSP substation as shown in Table 5.6 and Table 5.7 as a percentage of the lowest of switchgear ratings / design limits at the Whitehouse GSP substation.

Table 5.6. Option 1 fault levels at Whitehouse GSP substation

Substation Name	Design Rating (kA)		Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitehouse GSP	50.00	17.50	50.00	20.00	44.49	15.74	**88.98**	**89.94**

Table 5.7. Option 1 fault levels at Whitehouse GSP substation in N-2 situation at Kaimes GSP

Substation Name	Design Rating (kA)		Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break	Make	Break
Whitehouse GSP	50.00	17.50	50.00	20.00	46.61	15.50	93.22	88.57

The location of the new 33kV boards is highlighted in red in Figure 5 and the 33kV layout of the new board is shown n Figure 6.

Figure 5. Location of Whitehouse GSP new 33kV switchboards for Option 1

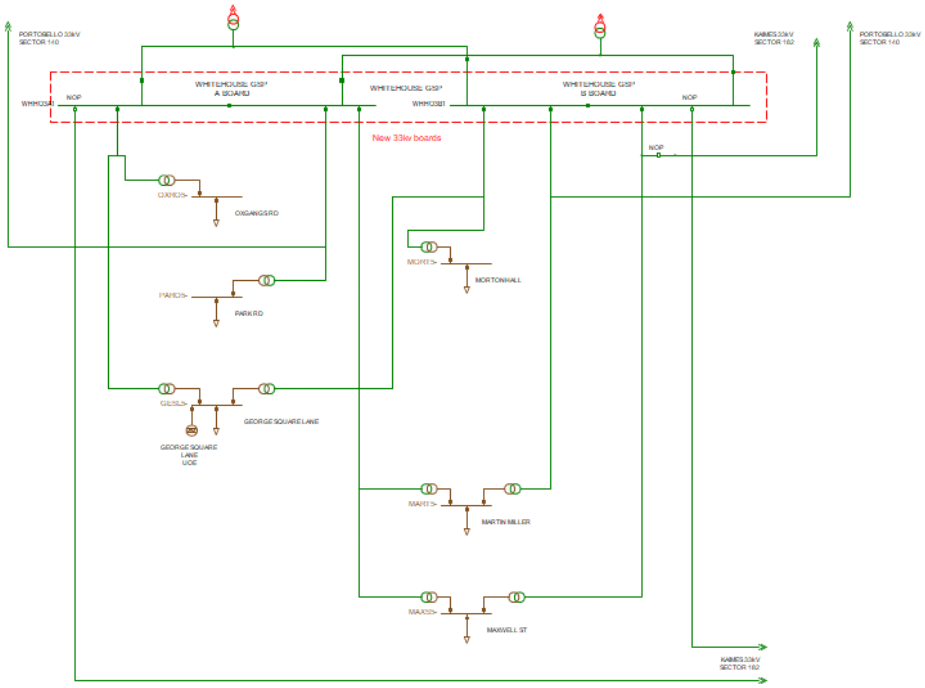

Figure 6. New 33kV boards at Whitehouse GSP for the Option 1

Table 5.8 shows a summary of reinforcement costs and volumes for the proposed scheme under RIIO-ED2.

Table 5.8. Option 1 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Post RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV CB (Gas Insulated Busbars)(ID) (GM)	10	1.670	1.670	-	-
Civil Works at 33 kV & 66 kV Substations		0.192	0.192	-	-
Other Costs CV3 (Identify Below)		0.428	0.428	-	-
Other Costs CV4 (Identify Below)		0.996	0.095	0.902	-
Total Costs		3.286	2.384	0.902	-
Identify activities included within other costs (please provide high-level detail of cost areas)					
CV3 – Planning and design (£50k)					
CV3 – Remote end protection (£210k)					
CV3 – RTU/SCADA (£50k)					
CV3 – Telecomms infrastructure upgrade to modern intertripping (£70k)					
CV3 – NGESO ModApp fee (£38k based on NGESO charges from 1st April 2021)					
CV4 – NTCC (New Transmission Capacity Charges) (£95k)					

Existing peak make fault level is below 100% of the switchgear rating. However, due to the predicted increase in fault levels, it is proposed to start the works in 2024/25 and the fault level scheme output will be claimed in 2025/26 upon 33kV switchboard energisation. Option 1 provides an additional 74MVA (peak make)/29MVA (RMS break) fault level headroom, on equipment rating; and 74MVA (peak make)/0MVA (RMS break), on design rating.

5.3 Option 2 – Series Reactors

This solution is an SP Transmission solution. SP Distribution would submit a Modification Application to NGESO to request a reduction of the fault level infeed into the 33kV switchboards from the transmission network. This option considers installation of two 33kV series reactors and associated protection into the GSP transformer tails. The SP Transmission capital costs associated with this option are ca. £2.3m which is an average cost estimated based on previous costs for series reactors provided by SP Transmission. The full cost of transmission works will be charged to SP Distribution under New Transmission Capacity Charges (NTCC), over a 40-year payback period starting in 2024/25 upon installation of series reactors.

Table 5.9 shows the scheme summary. This option is not considered to offer value for money and has been discounted.

Table 5.9. Option 2 summary

Category	Scheme Name	Scheme Summary	Reporting Table	RIIO-ED2 Contribution (£m)	Post RIIO-ED2 (£m)	Customer Contribution (£m)
Conventional	Whitehouse GSP Fault Level Mitigation	Install series reactors in the tails of grid transformers	CV3 Expenditure	0.038	-	-
			CV4 Expenditure	0.492	4.688	-

Due to the age and the health index of the current 33kV boards, it is considered that the 33kV switchboards at Whitehouse GSP would need to be replaced under Asset Replacement within the RIIO-ED3 which has been added to Cost Benefit Analysis. Figure 7 shows Whitehouse GSP with series reactors.

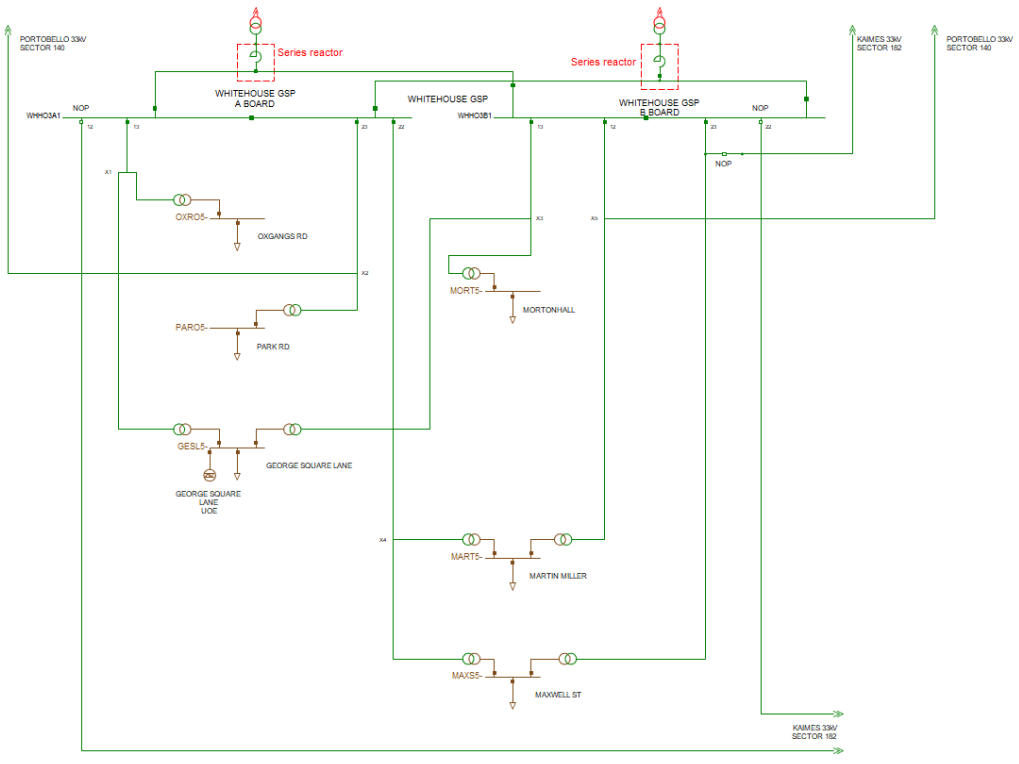

Figure 7. Option 2 Whitehouse GSP 33kV network with series reactors

Option 2 provides an additional 376MVA (peak make)/142MVA (RMS break) fault level headroom, on equipment rating; and 376MVA (peak make)/94MVA (RMS break), on design rating. Fault level results are shown in Table 5.10.

Table 5.10. Option 2 fault levels at Whitehouse GSP substation

Substation Name	Switchgear Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Whitehouse GSP	43.75	17.5	28.65	9.81	**65.55**	**56.06**

Table 5.11 shows a summary of reinforcement costs and volumes for Option 2 under RIIO-ED2.

Table 5.11. Option 2 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Post RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Other Costs CV3 (Identify Below)		0.038	0.038	-	-
Other Costs CV4 (Identify Below)		5.180	0.492	4.688	-
Total Costs		5.218	0.530	4.688	-
Identify activities included within other costs (please provide high-level detail of cost areas)					
CV3 – NGESO ModApp fee (£38k based on NGESO charges from 1st April 2021)					
CV4 – NTCC (New Transmission Capacity Charges) (£492k)					

5.4 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.12.

Table 5.12. Cost summary for considered options

Options	Option Summary	RIIO-ED2 Cost (£m)
Baseline	Replace indoor 33kV switchboards with a new rationalised indoor 33kV board	2.122
Option 1	Replace indoor 33kV switchboards with two new indoor 33kV boards	2.384
Option 2	Install series reactors in the tails of grid transformers	0.530*

*Note: This option considers that the 33kV switchgear at Whitehouse GSP would need to be replaced under Asset Replacement within the RIIO-ED3 period due to their Health Index. £2.075 has been added to CBA in RIIO-ED3 for these works.

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 to replace the existing indoor 33kV switchboards, 'A' and 'B' boards, with a new rationalised indoor 33kV board of at least 20kA RMS break rating.

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-015-CV3-CBA – Whitehouse GSP 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 – Replace indoor 33kV switchboards with a new rationalised indoor 33kV board	**Adopted**					
Option 1 – Replace indoor 33kV switchboards with two new indoor 33kV boards	Rejected	Discounted based on NPV.	-0.11	-0.16	-0.18	-0.20
Option 2 – Install series reactors in the tails of grid transformers	Rejected	Discounted based on NPV.	-0.21	-0.87	-1.48	-2.13

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 £2.122m.

Table 6.2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Post RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV CB (Gas Insulated Busbars)(ID) (GM)	9	1.503	1.503	-	-
Civil Works at 33 kV & 66 kV Substations		0.180	0.180	-	-
Other Costs CV3 (Identify Below)		0.392	0.392	-	-
Other Costs CV4 (Identify Below)		0.498	0.047	0.451	-
Total Costs		2.573	2.122	0.451	-
Identify activities included within other costs (please provide high-level detail of cost areas)					
CV3 – Planning and design (£50k)					
CV3 – Remote end protection (£189k)					
CV3 – RTU/SCADA (£45k)					
CV3 – Telecomms infrastructure upgrade to modern intertripping (£70k)					
CV3 – NGESO ModApp fee (£38k based on NGESO charges from 1st April 2021)					
CV4 – NTCC (New Transmission Capacity Charges) (£47k)					

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	2.075	-	1.037	1.037	-	-
CV4 Expenditure*	0.047	-	-	0.016	0.016	0.016

*The full cost of transmission works will be charged to SP Distribution under New Transmission Capacity Charges (NTCC), over a 40-year payback period starting in 2025/26 upon 33kV switchboard energisation.

6.4 Risks

The switchboard replacement is a BaU activity and hence the risks associated with the delivery of the scheme are very minimal. The past track record for delivery of switchgear replacements is presented in the section 5 of Annex 4A.10: Substations & Switchgear; EHV to LV in our RIIO-ED2 business plan.

The delivery of this scheme will be co-ordinated with the delivery of SPD non-load EHV switchgear modernisation (under CV7) for operational efficiencies and minimize the network impact.

All major connections will be secure during the construction period. However, during the changeover from the existing to the proposed system, the demand associated with individual 11kV circuits will be on reduced security of supply. This risk will be minimised by using an offline build approach and having suitable plans for the reconnection of lost supplies in the event of loss of remaining infeed's during construction outages.

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.

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	5,617		6,066	7,298	6,738	4,640	7,331	6,677	6,677
HPs	1,094		1,288	1,583	952	759	1,088	1,003	924

*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 – Replace the existing indoor 33kV switchboards, 'A' and 'B' boards, with a new rationalised indoor 33kV board of at least 20kA RMS break rating

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)	2.122	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 4.4 tonnes. The monetised embodied carbon value associated with this emission is £0.24k. 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. The completion of this scheme will maintain the integrity of the distribution network and its enduring ability to facilitate wider whole system benefits.

6.7 Environmental Considerations

6.7.1 Operational and Embodied Carbon Emissions

The Whitehouse GSP Fault Level Mitigation programme has the potential to impact on the embodied carbon resulting from the delivery of the programme. There is likely to be little or no impact 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 Whitehouse GSP 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 Whitehouse GSP 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

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

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 Whitehouse GSP Fault Level Mitigation programme will only affect a single named site containing existing assets. Therefore, 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. However, as the Whitehouse GSP Fault Level Mitigation programme consists of works within existing substation buildings, there is anticipated to be little or no impact on visual amenity.

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

Whitehouse132/33kV Grid Supply Point (GSP) is located in the Edinburgh & Borders district of SP Distribution, providing supplies to ca. 35,352 customers.

Fault levels at Whitehouse GSP 33kV switchboards is approaching the switchgear's fault level peak make rating and is above 95%. Under design policy, the fault level mitigation is deemed necessary above 95% threshold. In addition, the peak make fault level can exceed 104% of the equipment rating under outages in the adjacent Kaimes GSP, when Whitehouse GSP is required to provide support to Kaimes.

In order to continue to maintain a safe and secure network, the proposed fault level mitigation solution is to replace the existing indoor 33kV switchboards, 'A' and 'B' boards, with a new rationalised indoor 33kV board. The SP Distribution works for this solution involves the installation of 9 distribution panels and associated environmental, engineering, civil. The SP Transmission works for this solution involves the installation of two incomer breakers which is included in the RIIO-T2 plan. SP Distribution will submit a Modification Application (£38k) to NGESO for this work in 2024/25. The full cost of transmission works will be charged to SP Distribution under New Transmission Capacity Charges (NTCC), over a 40-year payback period starting in 2025/26 upon 33kV switchboard energisation.

The proposed solution gives sufficient fault level headroom when compared with the alternative schemes identified and it is also the best solution from the operational perspective and to enable future connections.

The estimated cost for the above is £2.075m under the CV3 expenditure and £0.047m (in 2020/21 prices) under the CV4 expenditure with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Existing peak make fault level is below 100% of the switchgear rating. However, due to the predicted increase in fault levels, it is proposed to start the works in 2024/25 and the fault level scheme output will be claimed in 2025/26 upon 33kV switchboard energisation. The proposed option provides an additional 74MVA (peak make)/29MVA (RMS break) fault level headroom, on equipment rating; and 74MVA (peak make)/0MVA (RMS break), on design rating.