Currie GSP Fault Level Mitigation

ED2 Engineering Justification Paper

ED2-LRE-SPD-004-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 to 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	Currie GSP Fault Level Mitigation		
Activity	Fault Level Reinforcement		
Primary Investment Driver	Fault Level Mitigation		
Reference	ED2-LRE-SPD-004-CV3		
Output	Fault Level Reinforcement		
Cost	£2.710m		
Delivery Year	2023-2026		
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	**£2.710m**	**£1.570m**

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:	**Currie GSP Fault Level Mitigation**
Project Reference:	**ED2-LRE-SPD-004-CV3**
Decision Required:	**To give concept approval to standardise the Currie GSP site by establishing a 132/33kV 60MVA Currie GSP and a local 33/11kV 20MVA Currie primary.**

Summary of Business Need:

Currie 132/11kV Grid Supply Point (GSP) substation provides supplies to ca. 5,015 customers via a 12-panel 11kV switchboard fed from two 30MVA 132/11kV transformers. The peak make fault level is presently above 100% of the 11kV fault level design limits and the RMS break duty is approaching 95% of the fault level design limits (250MVA). Whilst the design limits are exceeded, the fault duties remain within the rating of the 11kV switchgear installed at Currie GSP, however, this results in operational issues for the wider 11kV network fed from Currie GSP which is not designed to this higher rating and limits and expected connections to the network.

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 standardise the site by establishing a 132/33kV GSP (2 x 60MVA), a new indoor 33kV board and a local Currie primary 33/11kV (2 x 20MVA) substation. SP Distribution will submit a Modification Application (£26.8k) to National Grid Electricity System Operator (NGESO) for this work in 2021. Based on our discussion with SPT, it is envisaged that the SPT works will be completed in late 2025. 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 £2.562m (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	**1.722**	0.172	0.861	0.689	-	-
SPD	CV4	New Transmission Capacity Charges	**0.988**	-	-	0.333	0.329	0.326
SPD	**Total**		**2.710**	**0.172**	**0.861**	**1.022**	**0.329**	**0.326**

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

Currie 132/11kV Grid Supply Point (GSP) group is geographically located in a suburb of Edinburgh, 7miles south west from the city centre. The group currently serves 5,015 customers.

The peak-make fault levels at Currie GSP 11kV already exceed 100% of the design fault level limits and the RMS break duty is approaching 95% of the design fault level limits (250MVA).

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 standardise the site by establishing a 132/33kV 60MVA GSP, a new indoor 33kV board and a local 33/11kV 20MVA Currie primary substation. The SP Distribution works for this solution involves the installation of a new 33kV switchboard and two 33/11kV 20MVA transformers. The new transformers will connect to the existing 11kV board. The SP Transmission works for this solution involves installation of two 132/33kV 60MVA grid transformers, associated cable works and two transmission incomer breakers. SP Distribution will submit a Modification Application (£26.8k) to National Grid Electricity System Operator (NGESO) for this work in 2021. Based on our discussion with SPT, it is envisaged that the SPT works will be completed in late 2025. 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 GSP energisation.

The estimated cost for the above is £1.722m under the CV3 expenditure and £0.988m (in 2020/21 prices) under the CV4 expenditure with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Due to already high fault levels at the site, it is proposed to start the works in 2023/24 and the fault level scheme output will be claimed in 2025/26 at the end of the project. The proposed option would release 94MVA of fault level headroom on the Currie HV network.

2 Background Information

2.1 Existing / Authorised Network

The network under consideration is Currie GSP demand group. The geographical layout of the site is depicted in Figure 1.

Figure 1. Currie GSP site geographical layout

The existing 11kV network comprises of underground cable and overhead lines. Currie GSP is interconnectable at 11kV with Kirknewton primary substation as highlighted in red in Figure 2.

The 11kV switchboard consists of 12 panels, eight of which are feeder breakers, a bus section, two incomer breakers and one spare circuit breaker.

Currie GSP substation is served by two 30MVA, Ferranti 132/11kV transformers (1967) which will have health index 4 by the end of RIIO-ED2. The SP Transmission electrical layout of Currie GSP is shown in Figure 3.

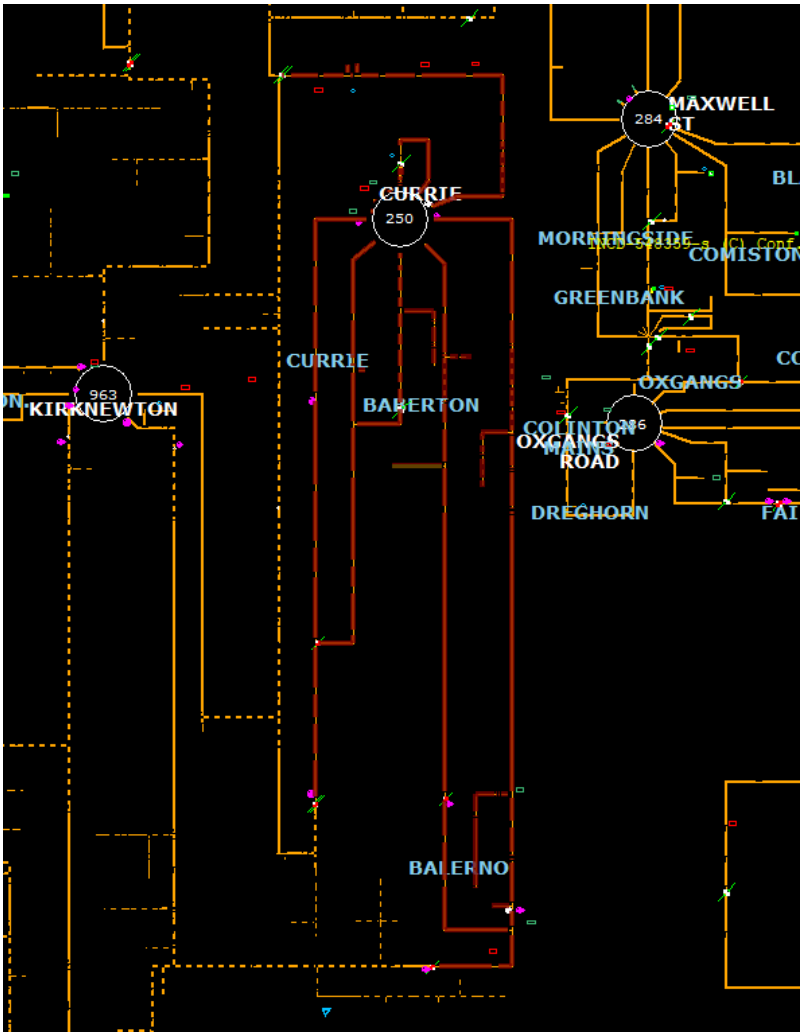

Figure 2. Existing Currie GSP 11kV network

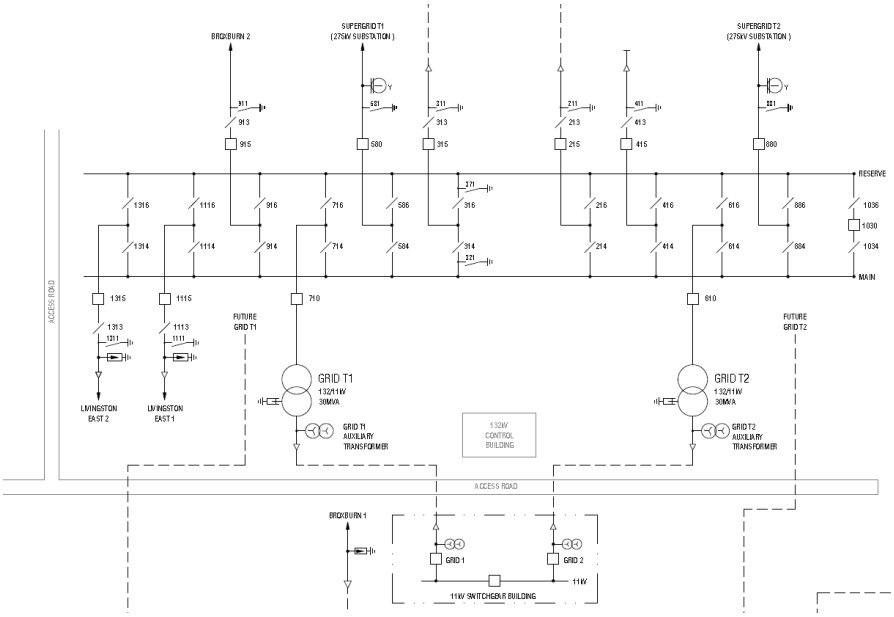

Figure 3. Currie GSP SP Transmission electrical layout

2.2 Network Supply / Circuit Capacity

Historically, the group demand has been ca. 11MVA, against the group firm capacity of 30MVA. The group is a class 'B' of supply as per ENA Engineering Recommendation (EREC) P2/7.

2.3 Embedded Generation

At present there is ca. 0.5MW of small embedded generation connected into Currie 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 respective voltage networks.

Table 2.1. Fault level design limits

System Voltage (kV)	3-phase Fault Level Limits (kA)	
	Peak Make	RMS Break
EHV	50.00*	17.50
HV	32.80	13.12

*Enhanced design limit of new circuit breakers, legacy switchgear site can vary.

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 11kV 3-phase fault levels as a percentage of the lowest of switchgear ratings / design limits at the Currie GSP substation.

Table 2.2. Currie GSP fault level (LTDS 2020)

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Currie GSP	32.80	13.12	33.93	12.36	**103.45**	**94.21**

[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 11kV peak make fault level exceeds the design fault level limit and the RMS break duty is approaching 95%. The main reason for the high fault level is due to high fault level infeed from the transmission network. Although the 11kV switchgear at Currie is rated at 350MVA, the 11kV network design fault level limit of 250MVA should not be exceeded due to the wider impact on downstream equipment and customers (particularly customers connected at 11kV with unknown equipment capability), which will have been designed up to a maximum fault level infeed of no greater than 250MVA. Since 2018 several applications have been withdrawn due to the issue of fault level infeed into the site with approximately 20MW of generation applications unable to proceed due to the fault level constraints at the site.

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 is 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.

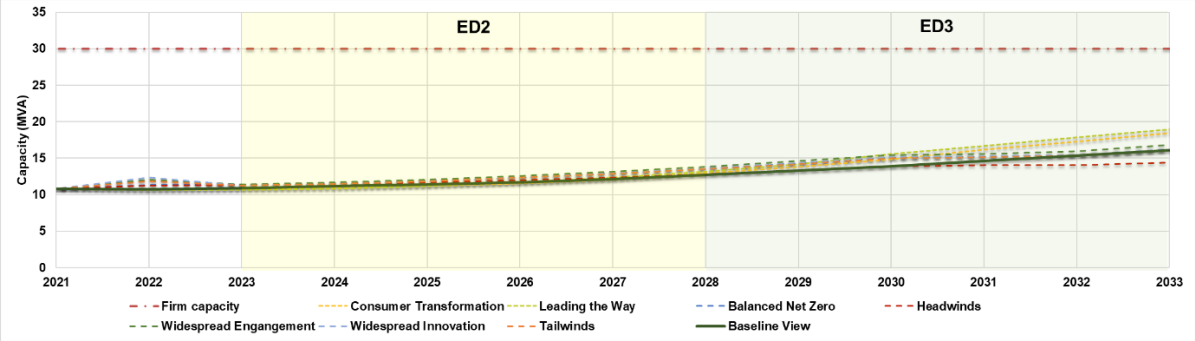

Figure 4. Demand (MVA) forecast for Currie demand group

3.2 Forecast Generation

There is around 1.5-3.5MW generation forecasted to be connected to Currie GSP based on Distribution Future Energy Scenarios. In addition to this, Heriot Watt University which is supplied from Currie GSP has aspirations of installing solar panels and small-scale batteries onto their network which.

3.3 Network Impact Assessment

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

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

Table 3.1. Currie GSP fault level (2028)

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Currie GSP	32.8	13.12	35.11	12.61	**107.04**	**96.11**

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 a new 132/33kV GSP and a 33/11kV primary substation to standardise the configuration of the site	Shortlisted as **Baseline** in Detailed Analysis	
(d)	Establish a new primary substation from Sighthill GSP	Shortlisted as **Option 1** option in Detailed Analysis	
(e)	Establish a new primary substation from Broxburn GSP	Shortlisted as **Option 2** in Detailed Analysis	
(f)	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. Also, the distance between Currie GSP and the nearest secondary substation is too far to get accurate fault level measurements.
(g)	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.
(h)	Install 11kV series reactors in the tails of the grid 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.

5 Detailed Analysis & Costs

5.1 Proposed Option (Baseline) – Establish a new 132/33kV GSP and a 33/11kV Primary

The proposed solution is to standardise the site by establishing a 132/33kV 60MVA Currie GSP, a new indoor 33kV board and a local 33/11kV 20MVA Currie primary. Table 5.1 shows the scheme summary.

Table 5.1. Proposed option summary

Category	Scheme Name	Scheme Summary	Reporting Table	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional	Currie GSP Fault Level Mitigation	Establish a new 132/33kV GSP and a 33/11kV primary substation to standardise the configuration of the site	CV3 Expenditure	1.722	-
			CV4 Expenditure	0.988	-

The SP Distribution works for this solution involves the installation of a new 5-panel indoor 33kV switchboard with space for an additional panel on each side and two 33/11kV primary transformers. The new 33kV board will comprise of five panels, two of which are feeder breakers, a bus section and two transmission incomer breakers, with the facility for an additional circuit breaker on each side for future connections. The new 33/11kV 20MVA transformers will connect to the existing 11kV board. The costs of SPD works are included within the CV3 expenditure.

The SP Transmission works for this solution involves the installation of two 132/33kV 60MVA grid transformers, associated cable works and two transmission 33kV 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 GSP energisation.

This substation configuration would reduce the transmission fault level infeed to the 11kV network and allow for the standardisation of the site. SP Distribution will submit a Modification Application (£26.8k) to NGESO for this work in 2021. Based on our discussion with SPT, it is envisaged that the SPT works will be completed in late 2025.This solution creates additional fault level headroom at Currie substation as shown in Table 5.2.

Table 5.2. Proposed option fault levels at Currie substations

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Currie primary	32.80	13.12	20.68	7.45	**63.05**	**56.78**
Currie GSP	50.00	17.50	31.73	11.40	**63.46**	**65.14**

The proposed layout of the installation considered is shown in Figure 5. The new 33kV board and two 33/11kV transformers at Currie primary will be installed within the substation boundary as highlighted in red in Figure 6.

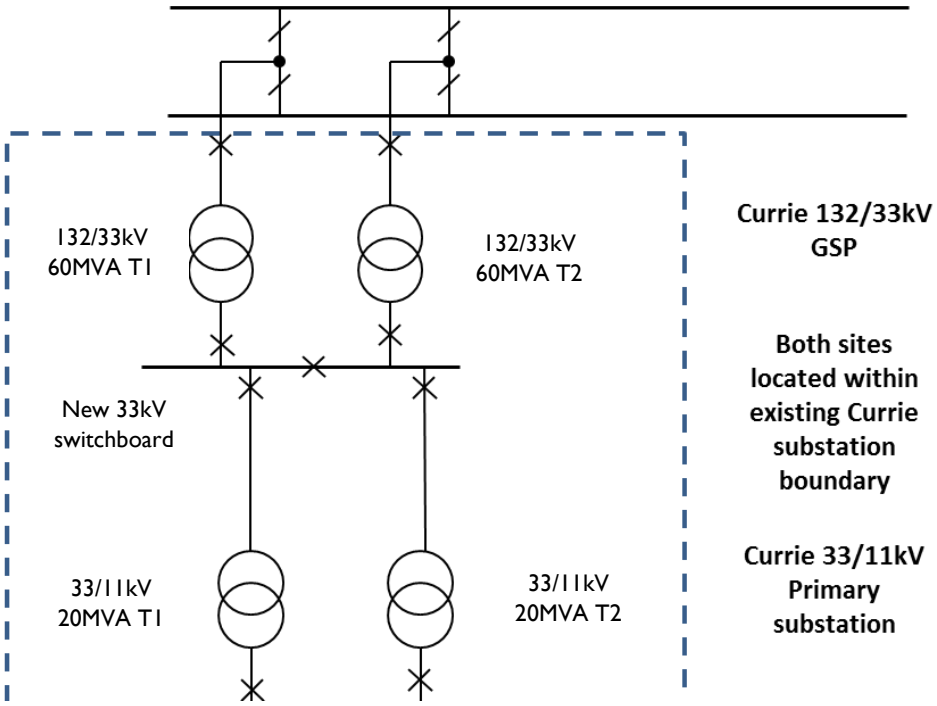

Figure 5. Proposed new transformer layout at Currie GSP

Figure 6. Proposed location for two new 33/11kV transformers at Currie primary

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

Table 5.3. 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)
6.6/11kV UG Cable	0.3	0.035	0.035	-	-
33kV UG Cable (Non Pressurised)	0.2	0.040	0.040	-	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	3	0.501	0.501	-	-
33kV Transformer (GM)	2	0.738	0.738	-	-
Batteries at 33kV Substations	1	0.009	0.009	-	-
Civil Works at 33 kV & 66 kV Substations		0.200	0.200	-	-
Other Costs CV3 (Identify Below)		0.198	0.198	-	-
Other Costs CV4 (Identify Below)		10.400	0.988	9.412	-
Total Costs		12.122	2.710	9.412	-
Identify activities included within other costs (please provide high-level detail of cost areas)					
CV3 – Planning and design (£100k)					
CV3 – Remote end protection (£63k)					
CV3 – RTU/SCADA (£15k)					
CV3 – Telecoms infrastructure (£20k)					
CV3 – Remedial work on the existing site (£5k)					
CV4 – NTCC (New Transmission Capacity Charges) (£988k)					

Due to already high fault levels at the site, it is proposed to start the works in 2023/24 and the fault level scheme output will be claimed in 2025/26 at the end of the project. The proposed option would release 94MVA of fault level headroom on the Currie HV network.

5.2 Option 1 – New Primary from Sighthill GSP

This option considers the removal of two 132/11kV transformers and the establishment of a 33/11kV primary substation in its place to supply the demand currently fed from the 132/11kV units. The new primary substation would be supplied from Sighthill GSP ('A' 33kV board) by installing two new 33kV circuit breakers and two new 33kV circuits (4.7km each). This will utilise the last two spare bays at the 'A' board leaving only one spare bay at the 'B' board for the future connections. The new 33/11kV transformers will be 20MVA units to accommodate present and future demand from the substation. It is envisaged that the new 33/11kV transformers will be sited in the area of removed 132/11kV transformers, but this decision will be finalised at the engineering design stage. The new transformers will connect to the existing 11kV board. Due to high connections activity at Sighthill GSP there is no space to extend any of the 33kV switchboards and Sighthill GSP 'A' board would need to be replaced to accommodate this. SP Distribution will submit a Modification Application (£26.8k) to NGESO for the removal of two 132/11kV transformers.

Table 5.4 shows the scheme summary. This option is not considered to offer value for money and has been discounted.

Table 5.4. Option 1 summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional	Currie GSP Fault Level Mitigation	Establish a new primary substation from Sighthill GSP	7.138	-

The peak demand forecast for Sighthill GSP based on DFES is 108MVA by the end of RIIO-ED3 and additional demand of ca. 13MVA by the end of RIIO-ED3 from Currie would still be within the firm capacity of 180MVA of Sighthill GSP.

The proposed route for two new 33kV circuits from Sighthill GSP to Currie primary is shown in Figure 8 and Figure 7 shows 33kV network.

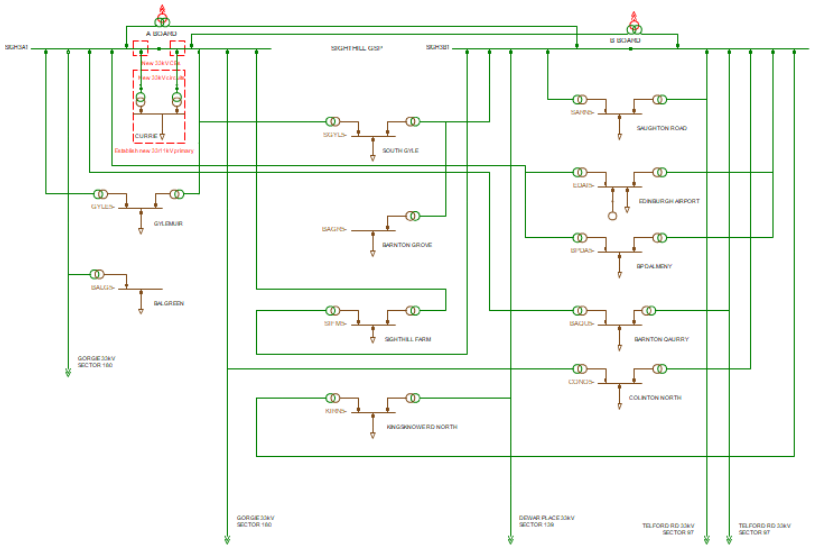

Figure 7. Sighthill GSP 33kV network with Currie primary

Figure 8. Proposed route for 33kV circuits from Sighthill GSP to Currie primary

This option would release 90MVA of fault level headroom on the Currie HV network, as shown in Table 5.5.

Table 5.5. Option 1 fault levels at Currie primary and Sighthill GSP substations

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Currie primary	32.8	13.12	20.03	7.61	**61.89**	**58.00**
Sighthill GSP	50.00	17.50	42.8	15.17	**85.60**	**86.69**

Table 5.6 shows a summary of reinforcement costs and volumes for Option 1 under RIIO-ED2.

Table 5.6. Option 1 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non Pressurised)	9.4	1.876	1.876	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	12	2.004	2.004	-
33kV Transformer (GM)	2	0.738	0.738	-
Pilot Wire Underground	9.4	1.041	1.041	-
Civil Works at 33 kV & 66 kV Substations		0.308	0.308	-
Wayleaves/Easements/Land Purchase		0.086	0.086	-
Other Costs (Identify Below)		1.084	1.084	-
Total Costs		7.138	7.138	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£50k)				
Environmental consideration (£45k)				
Remote end protection (252)				
Telecoms upgrade (£100k)				
Directional drilling (£250k)				
RTU/SCADA (£60k)				
NGESO ModApp fee (£26.8k based on NGESO charges from 1st April 2021), Decommissioning of SPT transformers (£300k)				

5.3 Option 2 – New Primary from Broxburn GSP

This option considers the removal of two 132/11kV transformers and the establishment of a 33/11kV primary substation in its place to supply the demand currently fed from the 132/11kV units. The new primary would be supplied from Broxburn GSP by installing two new 33kV circuit breakers and two new 33kV circuits (ca. 12km each). The new 33/11kV transformers will be 20MVA units to accommodate present and future demand from the substation. It is envisaged that the new 33/11kV transformers will be sited in the area of removed 132/11kV transformers, but this decision will be finalised at the engineering design stage. The new transformers will connect to the existing 11kV board. SP Distribution will submit a Modification Application (£26.8k) to NGESO for the removal of two 132/11kV transformers.

Table 5.7 shows the scheme summary. This option is not considered to offer value for money and has been discounted.

Table 5.7. Option 2 summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional	Currie GSP Fault Level Mitigation	Establish a new primary substation from Broxburn GSP	9.576	-

The peak demand forecast for Broxburn GSP based on DFES is 70MVA by the end of RIIO-ED2 and additional demand of ca. 13MVA by the end of RIIO-ED2 from Currie would still be within the firm capacity of 90MVA of Broxburn GSP.

The proposed route for two new 33kV circuits from Broxburn GSP to Currie primary is shown in Figure 10 and Figure 9 shows 33kV network.

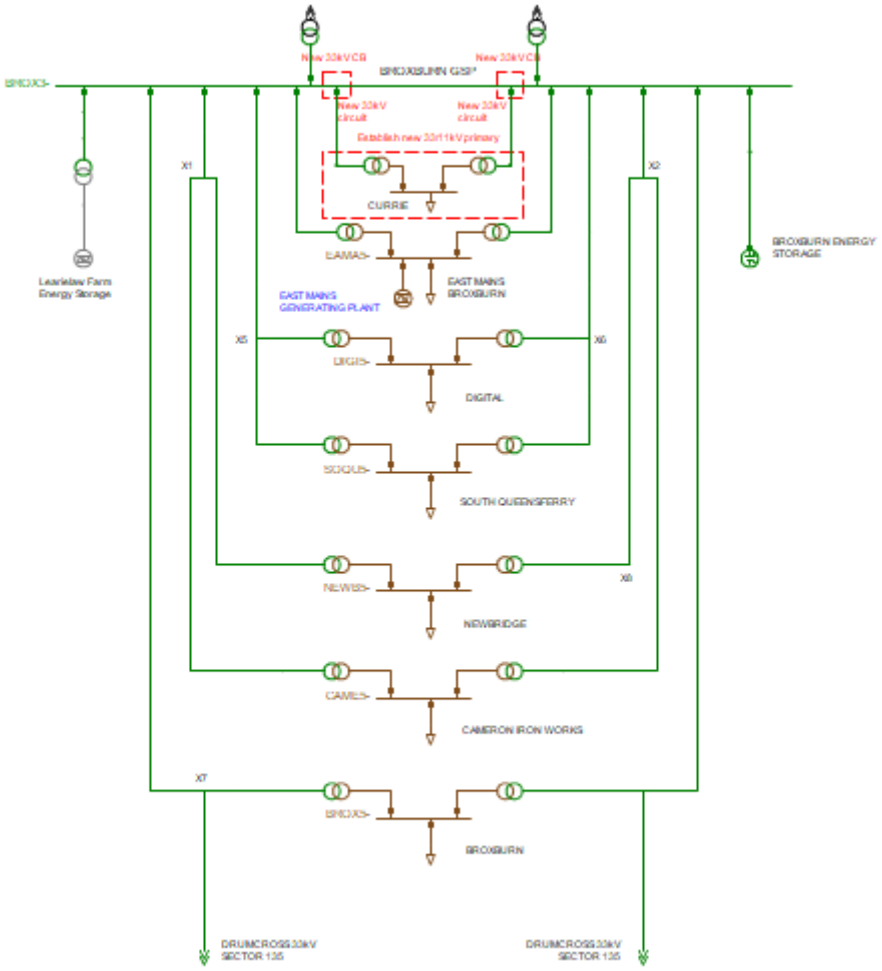

Figure 9. Option 2 Broxburn GSP 33kV network with Currie primary

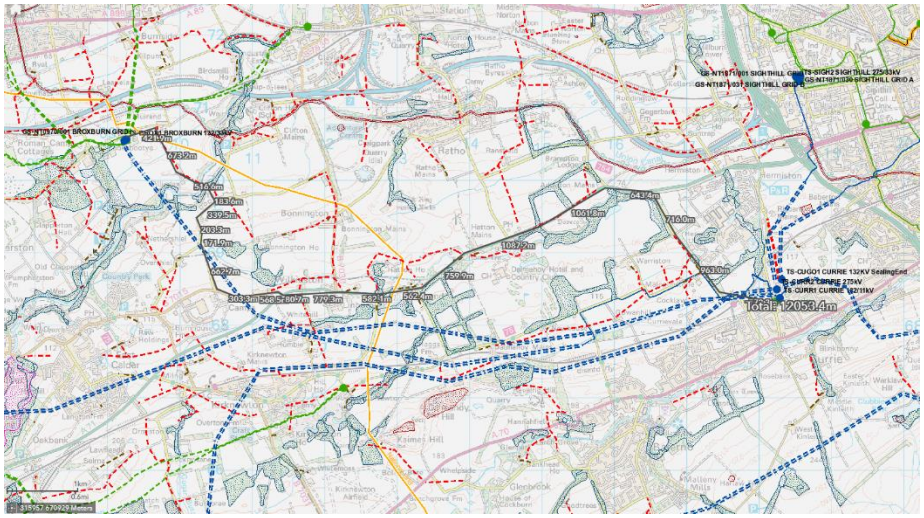

Figure 10. Proposed route for 33kV circuits from Broxburn GSP to Currie primary

This option would release 106MVA of fault level headroom on the Currie HV network, as shown in Table 5.8.

Table 5.8. Option 2 fault levels at Currie primary and Broxburn GSP substations

Substation Name	Design Rating (kA)		3-phase Fault Levels (kA)		Duty (%)	
	Make	Break	Make	Break	Make	Break
Currie primary	32.8	13.12	17.33	6.82	**52.84**	**51.98**
Broxburn GSP	50.00	17.50	32.10	11.08	**64.20**	**63.31**

Table 5.9 shows a summary of reinforcement costs and volumes for Option 2 under RIIO-ED2.

Table 5.9. Option 2 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non Pressurised)	24.3	4.851	4.851	-
33kV Transformer (GM)	2	0.738	0.738	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	2	0.334	0.334	-
Pilot Wire Underground	24.3	2.692	2.692	-
Civil Works at 33 kV & 66 kV Substations		0.164	0.164	-
Wayleaves/Easements/Land Purchase		0.147	0.147	-
Other Costs (Identify Below)		0.650	0.650	-
Total Costs		9.576	9.576	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£50k)				
Environmental consideration (£121k)				
Remote end protection (42)				
Telecoms upgrade (£100k)				
RTU/SCADA (£10k)				
NGESO ModApp fee (£26.8k based on NGESO charges from 1st April 2021), Decommissioning of SPT transformers (£300k)				

5.4 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.10.

Table 5.10. Cost summary for considered options

Options	Option Summary	RIIO-ED2 Cost (£m)
Baseline	Establish a new 132/33kV GSP and a 33/11kV primary substation to standardise the configuration of the site	2.710
Option 1	Establish a new primary substation from Sighthill GSP	7.138
Option 2	Establish a new primary substation from Broxburn GSP	9.576

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 standardise the site by establishing a 132/33kV 60MVA Currie GSP, a new indoor 33kV board and a local 33/11kV 20MVA Currie primary.

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-004-CV3-CBA – Currie 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 – Establish a new 132/33kV GSP and a 33/11kV primary substation to standardise the configuration of the site	**Adopted**					
Option 1 – Establish a new primary substation from Sighthill GSP	Rejected	Discounted based on NPV.	-2.02	-1.77	-1.14	-0.27
Option 2 – Establish a new primary substation from Broxburn GSP	Rejected	Discounted based on NPV.	-3.50	-3.75	-3.43	-2.79

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 £2.710m.

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)
6.6/11kV UG Cable	0.3	0.035	0.035	-	-
33kV UG Cable (Non Pressurised)	0.2	0.040	0.040	-	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	3	0.501	0.501	-	-
33kV Transformer (GM)	2	0.738	0.738	-	-
Batteries at 33kV Substations	1	0.009	0.009	-	-
Civil Works at 33 kV & 66 kV Substations		0.200	0.200	-	-
Other Costs CV3 (Identify Below)		0.198	0.198	-	-
Other Costs CV4 (Identify Below)		10.400	0.988	9.412	-
Total Costs		12.122	2.710	9.412	-
Identify activities included within other costs (please provide high-level detail of cost areas)					
CV3 – Planning and design (£100k)					
CV3 – Remote end protection (£63k)					
CV3 – RTU/SCADA (£15k)					
CV3 – Telecoms infrastructure (£20k)					
CV3 – Remedial work on the existing site (£5k)					
CV4 – NTCC (New Transmission Capacity Charges) (£988k)					

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	**1.722**	0.172	0.861	0.689	-	-
CV4 Expenditure*	**0.988**	-	-	0.333	0.329	0.326

*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 GSP energisation.

6.4 Risks

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.

Additionally, the delivery of this scheme will be co-ordinated with the delivery of SP Transmission works for operational efficiencies and to minimize the network impact.

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	2.131		2,363	2,737	2,556	1,760	2,781	2,533	2,533
HPs	659		694	1,158	562	482	635	566	555

*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 a new 132/33kV GSP and a 33/11kV primary substation to standardise the configuration of the site

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)	2.710	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 262 tonnes. The monetised embodied carbon value associated with this emission is £13.8k. 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.

[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 Currie 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 Currie 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 Currie 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 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 Currie GSP Fault Level Mitigation programme will only affect a single developed 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 Currie 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

Currie 132/11kV Grid Supply Point (GSP) group is geographically located in a suburb of Edinburgh, 7miles south west from the city centre. The group currently serves 5,015 customers.

The peak-make fault levels at Currie GSP 11kV already exceed 100% of the design fault level limits and the RMS break duty is approaching 95% of the design fault level limits (250MVA).

In order to continue to maintain a safe and secure network, the proposed fault level mitigation solution is a conventional solution involving a standardisation of the Currie site by establishing a 132/33kV 60MVA Currie GSP and a local 33/11kV 20MVA Currie primary within the substation boundary. The SP Distribution works for this solution involves the installation of a new 33kV switchboard and two 33/11kV 20MVA transformers. The new transformers will connect to the existing 11kV board. The SP Transmission works for this solution involves installation of two 132/33kV 60MVA grid transformers, associated cable works and two transmission incomer breakers. SP Distribution will submit a Modification Application (£26.8k) to NGESO for this work in 2021. Based on our discussion with SPT, it is envisaged that the SPT works will be completed in late 2025. 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 GSP 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 £1.722m under the CV3 expenditure and £0.988m (in 2020/21 prices) under the CV4 expenditure with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Due to already high fault levels at the site, it is proposed to start the works in 2023/24 and the fault level scheme output will be claimed in 2025/26 at the end of the project. The proposed option would release 94MVA of fault level headroom on the Currie HV network.