Leven Primary Fault Level Mitigation

ED2 Engineering Justification Paper

ED2-LRE-SPD-011-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	Leven Primary Fault Level Mitigation		
Activity	Fault Level Reinforcement		
Primary Investment Driver	Fault Level Mitigation		
Reference	ED2-LRE-SPD-011-CV3		
Output	Fault Level Reinforcement		
Cost	£1.218m		
Delivery Year	2025-2027		
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	**£1.218m**	**£m**

SP ENERGY NETWORKS

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:	**Leven Primary Fault Level Mitigation**
Project Reference:	**ED2-LRE-SPD-011-CV3**
Decision Required:	**To give concept approval for the establishment of a new primary substation to resolve the 11kV fault level issue at Leven Primary substation.**

Summary of Business Need:

Leven 33/11kV primary substation provides supplies to ca. 1,634 customers via a 15-panel 11kV switchboard fed from two 12/24MVA 33/11kV transformers. Both the peak make and the RMS break duty fault levels at Leven primary 11kV busbar are presently in excess of 110% of the design fault level limits (250MVA). Operational measures are in place to mitigate the fault level.

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 a new Leven 'B' Primary substation with two 20MVA 33/11kV transformers and a 5-panel 11kV switchboard, located in a housing. One of the connected generators at Leven primary will be moved to the new primary. Leven 'B' primary will be double banked at the existing Leven primary 33kV circuit breakers connected at 33kV to the Leven Grid Supply Point (GSP) 33kV busbar.

The estimated cost for the above is £1.218m (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	**1.218**	-	-	0.731	0.487	-
SPD	**Total**		**1.218**	**-**	**-**	**0.731**	**0.487**	**-**

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

Leven 33/11kV primary group is geographically located in Leven town in Central & Fife district. The group currently serves 1,634 customers.

The peak-make and the RMS break duty fault levels at Leven primary 11kV already exceed the design fault level limits (250MVA) and are at around 110%. The main reason for the high fault level is due to the connected generation. The 11kV primary switchgear is rated at 350MVA and independent design limits (IDL) of 20kA RMS break duty is in place. However, as IDL is higher than the 11kV fault level design limits of the wider secondary network (250MVA), there is an operational measure to mitigate the fault level issue in terms of keeping the 33/11kV transformer T2 on open stand by.

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 a new Leven 'B' Primary substation with two 20MVA 33/11kV transformers and a 5-panel 11kV switchboard, located in a housing. One of the connected generators at Leven primary will be moved to the new primary. Leven 'B' primary will be double banked at the existing Leven primary 33kV circuit breakers connected at 33kV to the Leven Grid Supply Point (GSP) 33kV busbar.

The estimated cost for the above is £1.218m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Open standby is a temporary measure as it increases security of supply risk, leads to premature asset aging and does not fully utilise existing assets. 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 40MVA of fault level headroom at Leven Primary and 35MVA of fault level headroom at Leven 'B' Primary.

2 Background Information

2.1 Existing / Authorised Network

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

Figure 1. Leven primary site geographical layout

The existing 11kV network comprises of underground cable and overhead lines. Leven primary is interconnected at 11kV with Durie House, Levenbank and Methilhill primary substations as highlighted in green in Figure 2.

The 11kV switchboard consists of 15 panels, 12 of which are feeder breakers, a bus section and two incomer breakers.

Leven primary substation is served by two 12/24MVA, Brush 33/11kV transformers (2011) which will have health index 1 by the end of RIIO-ED2. The 11kV group is fed from Leven Grid Supply Point (GSP) via the 33kV network shown in Figure 3.

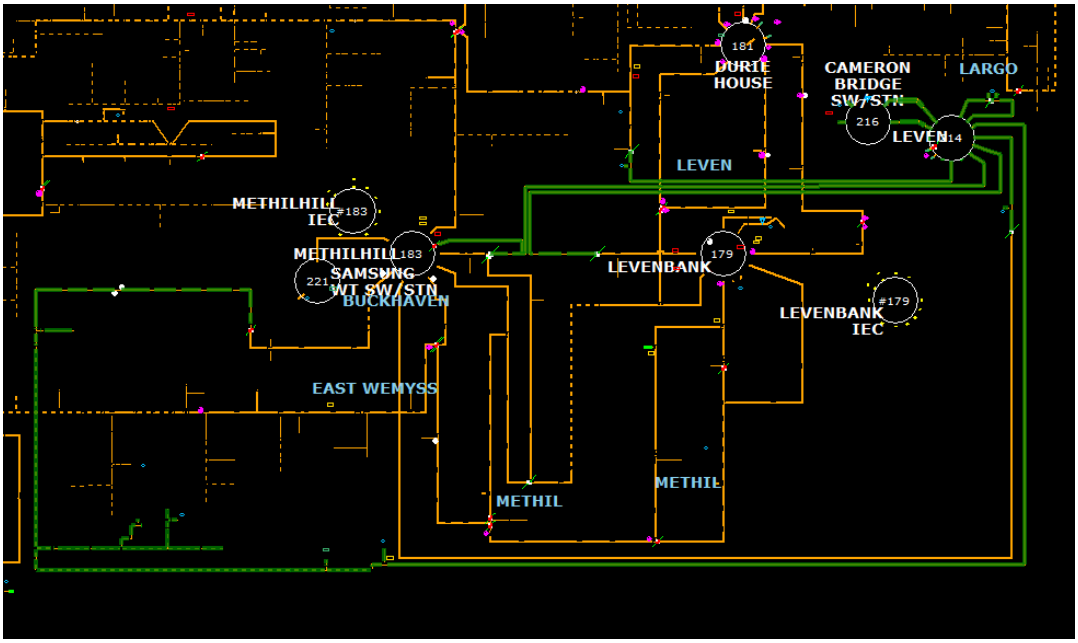

Figure 2. Existing Leven primary 11kV network

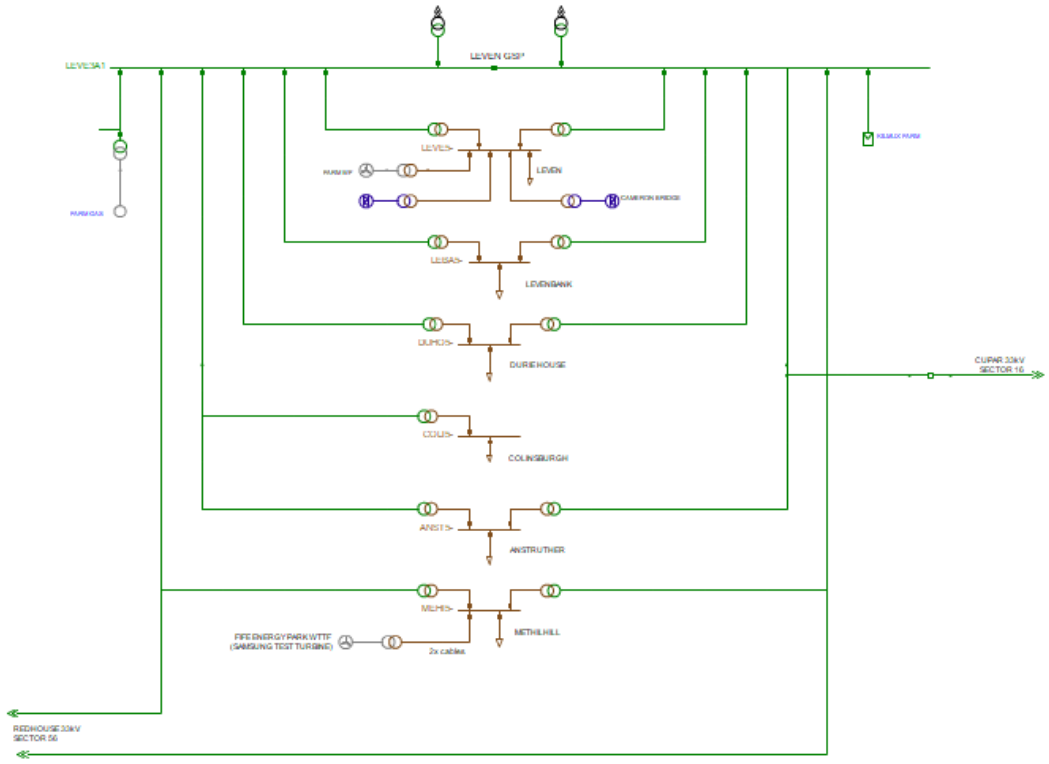

Figure 3. Existing Leven primary 33kV network

2.2 Network Supply / Circuit Capacity

Historically, the group demand has been ca. 11MVA, against the group firm capacity of 24MVA and is load index 1. The group is a class 'B' of supply as per ENA Engineering Recommendation (EREC) P2/7.

The 33kV connection circuits extend from Leven GSP and each 33kV circuit comprises twin 150mm^2 Cu cables.

2.3 Embedded Generation

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

Table 2.1. Embedded generation connected to Leven primary

Primary	Voltage (kV)	Site	Capacity (MW)	Type	Status
Leven	11	Cameron Bridge Distillery CHP	10.63	Medium CHP (>=5MW, <50MW)	Connected
	11	Diageo Bottling Plant CHP	7.16	Medium CHP (>=5MW, <50MW)	Connected
	11	Woodbank Farm	1.5	Onshore Wind (>=1MW)	Connected
	11/LV	Embedded generation (<1MW)	0.73	Onshore Wind/Solar/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)	3-phase 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 Leven primary substation.

Table 2.3.Leven 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
Leven primary	32.80	13.12	36.96	14.16	26.27	10.14	**112.68**	**107.93**

[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.

Both the 11kV peak make and RMS break duty fault level exceed the design rating and are around 110%. The main reason for the high fault level is due to the connected generation. The 11kV primary switchgear is rated at 350MVA and independent design limits (IDL) of 20kA RMS break duty is in place. However, as IDL is higher than the 11kV fault level design limits of the wider secondary network (250MVA), there is an operational measure to mitigate the fault level issue in terms of keeping the 33/11kV transformer T2 on open stand by. Open standby is a temporary measure as it increases security of supply risk, leads to premature asset aging and does not fully utilise existing assets. It is therefore necessary to mitigate the existing fault levels, to continue to maintain a safe and secure network.

3.1 Forecast Demand

No other thermal or voltage constraints were identified in the group during the RIIO-ED2 period with the forecast demand growth. With the forecast demand growth, group still operates within the limits of the requirements of a class 'B' of supply as per EREC P2/7 and is compliant through RIIO-ED2.

3.2 Forecast Generation

There is around 0.5MW generation forecasted to be connected to Leven primary based on Distribution Future Energy Scenarios. However, an application for 4MW of solar generation was received for Leven primary, and, due to fault level restrictions, the connection offer was proposed at an adjacent primary, which was significantly more expensive for the customer.

3.3 Network Impact Assessment

The Leven 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 Leven 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. 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 Leven primary substation by the end of RIIO-ED2 which includes DFES generation and demand forecasts.

Table 3.1. Leven primary fault level (2028)

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
Leven primary	32.80	13.12	37.39	14.36	26.48	10.2	**113.99**	**109.45**

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 and operational measure.
(b)	Intervention plan using only Energy Efficiency	Rejected	Rejected as it does not address the network fault level issues.
(c)	Establish Leven 'B' primary and relocate generation from Leven primary	Shortlisted as **Baseline** option in Detailed Analysis	
(d)	Relocate Diageo Bottling Plant CHP to Levenbank primary and Woodbank Farm to Methilhill primary	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)	Replace 12/24MVA 33/11kV transformers with higher impedance transformers	Rejected	Rejected, as no transformer is available, with high enough impedance to resolve the fault level issues at Leven Primary.

5 Detailed Analysis & Costs

5.1 Proposed Option (Baseline) – Establish a new Leven 'B' Primary and Relocate Generation from Leven Primary

The proposed solution is to establish Leven 'B' primary substation with two 20MVA 33/11kV transformers and a 5-panel 11kV switchboard, located in a housing. Cameron Bridge Distillery CHP together with Cameron Bridge Distillery load (ca. 6MVA) will be relocated to the new primary. Leven 'B' primary will be connected at 33kV to the Leven GSP 33kV busbar and it will be double banked with the existing Leven primary. 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	Leven Primary Fault Level Mitigation	Establish Leven 'B' primary and relocate one of the connected generators from Leven primary	1.218	-

This solution creates additional fault level headroom at Leven 'B' and Leven primary substations as shown in Table 5.2.

Table 5.2. Baseline option fault levels at Leven and Leven 'B' 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
Leven 'B' primary	32.80	13.12	29.26	11.28	24.81	9.41	**89.21**	**85.98**
Leven primary	32.80	13.12	29.12	11.00	24.55	9.39	**88.78**	**83.84**

Leven 'B' primary will be located within the Leven GSP compound which is highlighted in red in Figure 4 and the proposed 33kV network is shown in Figure 5.

Figure 4. Leven 'B' primary proposed location

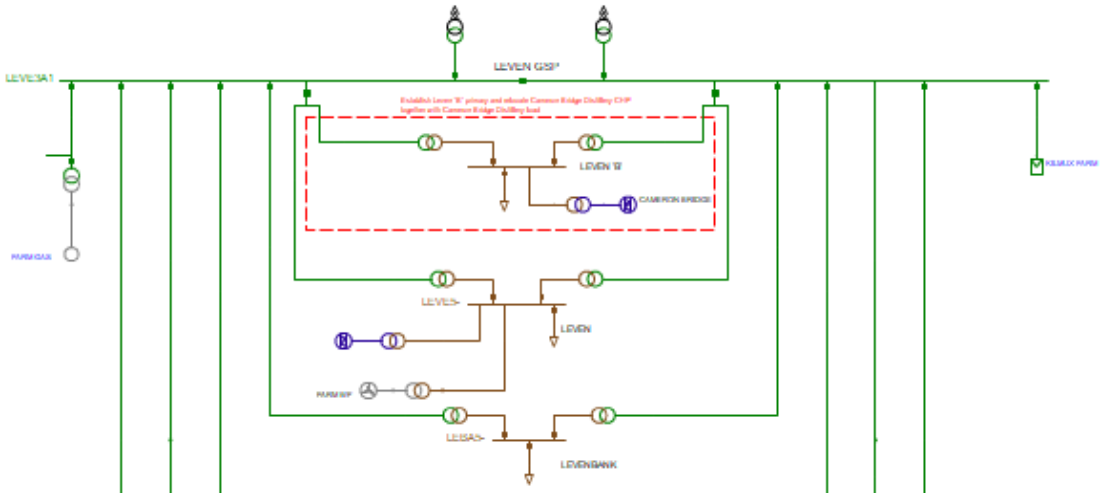

Figure 5. Proposed 33kV network with new Leven 'B' primary

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	0.3	0.035	0.035	-
6.6/11kV CB (GM) Primary	5	0.139	0.139	-
33kV UG Cable (Non Pressurised)	0.1	0.020	0.020	-
33kV Transformer (GM)	2	0.738	0.738	-
Batteries at 33kV Substations	1	0.009	0.009	-
Pilot Wire Underground	0.1	0.011	0.011	-
Civil Works at 33 kV & 66 kV Substations		0.195	0.195	-
Other Costs (Identify Below)		0.070	0.070	-
Total Costs		1.218	1.218	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£50k)				
Termination kit and protection (£20k)				

Open standby currently in place at Leven primary is a temporary measure as it increases security of supply risk, leads to premature asset aging and does not fully utilise existing assets. 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 40MVA of fault level headroom at Leven Primary and 35MVA of fault level headroom at Leven 'B' Primary.

5.2 Option 1 – Relocate Generators to Adjacent Primaries

In order to provide enough future fault level headroom, this option considers relocation of the Diageo Bottling Plant CHP 11kV generator to Levenbank primary by installing two new 11kV circuits and Woodbank Farm 11kV generator to Methilhill primary by moving HV network control points.

Table 5.4 shows the scheme summary. This option is not considered to offer value for money and has been discounted as it provides minimal fault level headroom.

Table 5.4. Option 1 summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional	Leven Primary Fault Level Mitigation	Relocate Diageo Bottling Plant CHP to Levenbank primary and Woodbank Farm to Methilhill primary	1.346	-

The proposed route for two new 11kV circuits to relocate the Diageo Bottling Plant CHP 11kV generator to Levenbank primary is shown in Figure 6 and Figure 7 shows 33kV network with relocated generators.

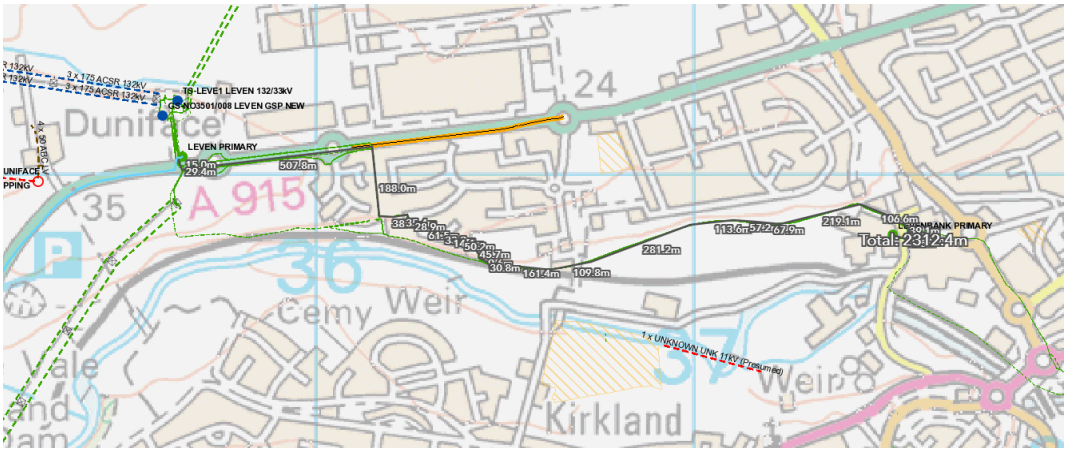

Figure 6. Proposed route for 11kV circuits for relocation of the Diageo Bottling Plant CHP 11kV generator to Levenbank primary

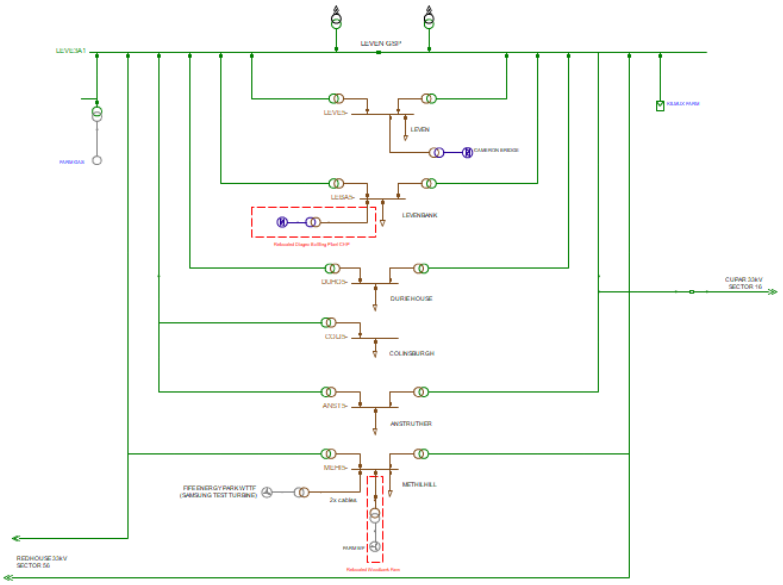

Figure 7. Option 1 Leven primary 33kV network

This solution creates only 34MVA of additional fault level headroom at Leven primary, while reducing fault level headroom at Levenbank and Methilhill primaries, by 48MVA and 11MVA respectively. This investment option provides an overall net loss in fault level headroom. Fault level results for Option 1 are shown in Table 5.5.

Table 5.5. Option 1 fault levels at Leven, Levenbank and Methilhill 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
Leven primary	32.80	13.12	29.72	11.36	25.03	9.63	**90.61**	**86.59**
Levenbank primary	32.80	13.12	28.14	10.51	24.50	9.32	**85.79**	**80.11**
Methilhill primary	32.80	13.12	26.08	9.93	24.58	9.55	**79.51**	**75.69**

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)
6.6/11kV UG Cable	5	0.587	0.587	-
6.6/11kV CB (GM) Primary	2	0.055	0.055	-
Pilot Wire Underground	5	0.554	0.554	-
Civil Works at 33 kV & 66 kV Substations		0.022	0.022	-
Wayleaves/Easements/Land Purchase		0.023	0.023	-
Other Costs (Identify Below)		0.105	0.105	-
Total Costs		1.346	1.346	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£50k)				
Environmental consideration (£25k)				
HV network control points (£30k)				

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 Leven 'B' primary and relocate generation from Leven primary	1.218
Option 1	Relocate Diageo Bottling Plant CHP to Levenbank primary and Woodbank Farm to Methilhill primary	1.346

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 establish Leven 'B' primary substation and relocate Cameron Bridge Distillery CHP together with Cameron Bridge Distillery load (ca. 6MVA) to the new primary. Leven 'B' primary will be connected at 33kV to the Leven GSP 33kV busbar and it will be double banked with the existing Leven 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-011-CV3-CBA – Leven 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 Leven 'B' primary and relocate generation from Leven primary	**Adopted**					
Option 1- Relocate Diageo Bottling Plant CHP to Levenbank primary and Woodbank Farm to Methilhill primary	Rejected	Discounted based on NPV.	-0.13	-0.15	-0.17	-0.18

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 £1.218m.

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	0.3	0.035	0.035	-
6.6/11kV CB (GM) Primary	5	0.139	0.139	-
33kV UG Cable (Non Pressurised)	0.1	0.020	0.020	-
33kV Transformer (GM)	2	0.738	0.738	-
Batteries at 33kV Substations	1	0.009	0.009	-
Pilot Wire Underground	0.1	0.011	0.011	-
Civil Works at 33 kV & 66 kV Substations		0.195	0.195	-
Other Costs (Identify Below)		0.070	0.070	-
Total Costs		1.218	1.218	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£50k)				
Termination kit and protection (£20k)				

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	**1.218**	-	-	0.731	0.487	-

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 infeeds during construction outages.

Existing fault level issues are managed operationally in terms of keeping the 33/11kV transformer T2 on open stand by. 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.

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	250		714	645	300	206	326	297	297
HPs	144		167	353	89	179	78	12	116

*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 Leven 'B' primary and relocate generation from Leven primary

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)	1.218	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 272 tonnes. The monetised embodied carbon value associated with this emission is £16.5k. 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 Leven Primary 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 Leven 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 Leven 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 Leven Primary Fault Level Mitigation programme will only affect developed sites 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 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

Leven 33/11kV primary group is geographically located in Leven town in Central & Fife district. The group currently serves 1,634 customers.

The peak-make and the RMS break duty fault levels at Leven primary 11kV already exceed the design fault level limits (250MVA) and are at around 110%. There is an operational measure to mitigate the fault level issue in terms of keeping the 33/11kV transformer T2 on open stand by.

In order to continue to maintain a safe and secure network, the proposed fault level mitigation solution is to establish a new Leven 'B' Primary substation with two 20MVA 33/11kV transformers and a 5-panel 11kV switchboard, located in a housing. One of the connected generators at Leven primary will be moved to the new primary. Leven 'B' primary will be double banked at the existing Leven primary 33kV circuit breakers connected at 33kV to the Leven Grid Supply Point (GSP) 33kV busbar.

The estimated cost for the above is £1.218m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Open standby is a temporary measure as it increases security of supply risk, leads to premature asset aging and does not fully utilise existing assets. 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 40MVA of fault level headroom at Leven Primary and 35MVA of fault level headroom at Leven 'B' Primary.