Prescot Grid 33kV Fault Level Mitigation

ED2 Engineering Justification Paper

ED2-LRE-SPM-010-CV3-EJP

Issue	Date	Comments
Issue 0.1	Jan 2021	Issue to SRG and external assurance
Issue 0.2	May 2021	Reflecting comments from SRG
Issue 0.3	Jun 2021	Reflecting assurance feedback
Issue 1.0	Jun 2021	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	Final Business Plan Submission

Scheme Name	Prescot Grid 33kV Fault Level Mitigation		
Activity	33kV Fault Level Reinforcement		
Primary Investment Driver	Fault Level Constraint		
Reference	ED2-LRE-SPM-010-CV3-EJP		
Output	Fault Level		
Cost	£0.943m		
Delivery Year	2027-28		
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**
	-	**£0.943m**	**-**

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:	Prescot Grid 33kV Fault Level Mitigation
Project Reference:	ED2-LRE-SPM-010-CV3-EJP
Decision Required:	To give concept approval for a 60MVA, 33kV 6% impedance series reactor in Prescot GT1A tails to mitigate the fault level exceedances.

Summary of Business Need:

Prescot 33kV grid substation is supplied from within the Rainhill 132kV GSP group via 2 x 60MVA GTs and is operated split, 'A' board supplying to Bold/Prescot/Widnes and 'B' board supplying to Gateacre/Huyton/Kirkby/Prescot 33kV grid groups.

The 'B' board currently experiences fault level exceedances under both normal and abnormal running arrangements of the upstream Rainhill 132kV substation, both make and break duties are in exceedance of the legacy switchgear ratings under abnormal running arrangements. The fault duty exceedances are operationally managed by placing one of 4 grid transformers in the Gateacre/Huyton/Kirkby/Prescot 33kV grid group on open-standby. This fault level constraint presents a barrier to low-cost timely connection of additional generation in the grid group in the RIIO-ED2 price control period and beyond.

The primary driver for the investment decision is to mitigate the fault level exceedances at Prescot Grid substation The proposed solution is to connect a new 60MVA, 6% impedance series reactor in the Prescot GT1A tails feeding the 'B' board; this will reduce the fault duties to within the switchgear rating under normal and abnormal running arrangements.

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

The proposed solution is to connect a new 60MVA, 33kV, 6% impedance series reactor in the Prescot GT1A tails feeding the 'B' board and undertake associated protection modifications at a cost of £0.943m to spent in RIIO-ED2 period under Fault Level Reinforcement / CV3 category.

Expenditure Forecast (in 2020/21 prices)

Licence Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPM	CV3	Fault Level Reinforcement	**0.943**	-	-	-	0.471	0.472
Total Expenditure within RIIO-ED2			**0.943**					

PART B – PROJECT SUBMISSION

Proposed by	Ramesh Pampana	Signature	P. Ramesh	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

Prescot 33kV grid substation is supplied from within the Rainhill 132kV GSP group via 2 x 60MVA Grid Transformers (GTs) and is operated split with the 33kV bus section run as a normal open point. The 'A' board supplies the Bold/Prescot/Widnes 33kV grid group. The 'B' board supplies the Gateacre/Huyton/Kirkby/Prescot 33kV grid groups respectively.

The primary driver for the investment decision is to mitigate the fault level exceedances at Prescot Grid substation. The 'B' board currently experiences fault level exceedances under both normal and abnormal running arrangements of the upstream Rainhill 132kV substation, both duties are in excess of the AEI/Metropolitan Vickers VLP.9 legacy switchgear ratings. This fault level constraint also presents a barrier to the connection of additional generation in the grid group entering the RIIO -ED2 price control period and beyond.

In order to comply with section 9 of the Electricity Act and Condition 21 of our license 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.

The proposed solution is to connect a new 60MVA, 6% impedance series reactor into the Prescot GT1A 33kV cable tails feeding the 'B' board; this will reduce the fault both the make and break fault level duties to within the switchgear rating, under normal and abnormal running arrangements of Rainhill 132kV substation. The scheme cost is £0.943m (2020/21 prices) under CV3 category, 100% funded through RIIO-ED2 load related expenditure. The works are proposed to start in 2026/27 and finish by 2027/28, a fault level headroom uplift of 1kA will be claimed at Prescot 'B' switchboard.

2 Background Information

2.1 Existing / Authorised Network

At 132kV, the Rainhill 132kV GSP group is fed via 4 x 180MVA, 275/132kV Super Grid Transformers (SGTs) and normally operated vertically split with 2 x 180MVA SGT's feeding each side of the split with the 132kV Bus Section open (2+2 split arrangement). Under single SGT outages, the GSP operates with 3 SGTs in-service and the Bus Section breaker closed (3 solid arrangement). The fault levels at 132kV level and underlying networks tend to be higher when the GSP is run in the 3 solid arrangement compared to the 2 + 2 split arrangement

Prescot 132kV substation is fed from Rainhill 132kV GSP via a 5.4km oil filled cable, the two Prescot GTs are teed off this cable circuit. The 33kV switchboard is normally operated 'split' with the bus section open; the 'A' board supplying the Bold/Prescot/Widnes and the 'B' board supplying to Gateacre/Huyton/Kirkby/Prescot 33kV grid groups as shown in Figure 2-1. As such, each of the groups contribute to fault flows into the adjacent group via the '132kV path' at Prescot. The physical substation layout and the geographic location are shown in Figure 2-1:Prescot grid .

The Prescot 33kV switchboard is of AEI/Metropolitan Vickers make, however previous network expansion in the 1970s' led to the 'A' and 'B' board being of different switchgear models; 'A' board is (including the bus section breaker) VRP30/10 type is built in 1975 rated for 17.5kA and 'B' board is of the earlier variant VLP.9 type built in 1965, rated for 13.12kA

The Gateacre/Huyton/Kirkby/Prescot 33kV grid group is fed by 4 x 60MVA GTs, which due to the existing fault level constraints within the group operates with the Kirkby GT3 transformer on open-standby under system normal conditions. It should be noted that this normal arrangement results in

the lowest fault level in the group compared to running with any other grid transformer on open-standby.

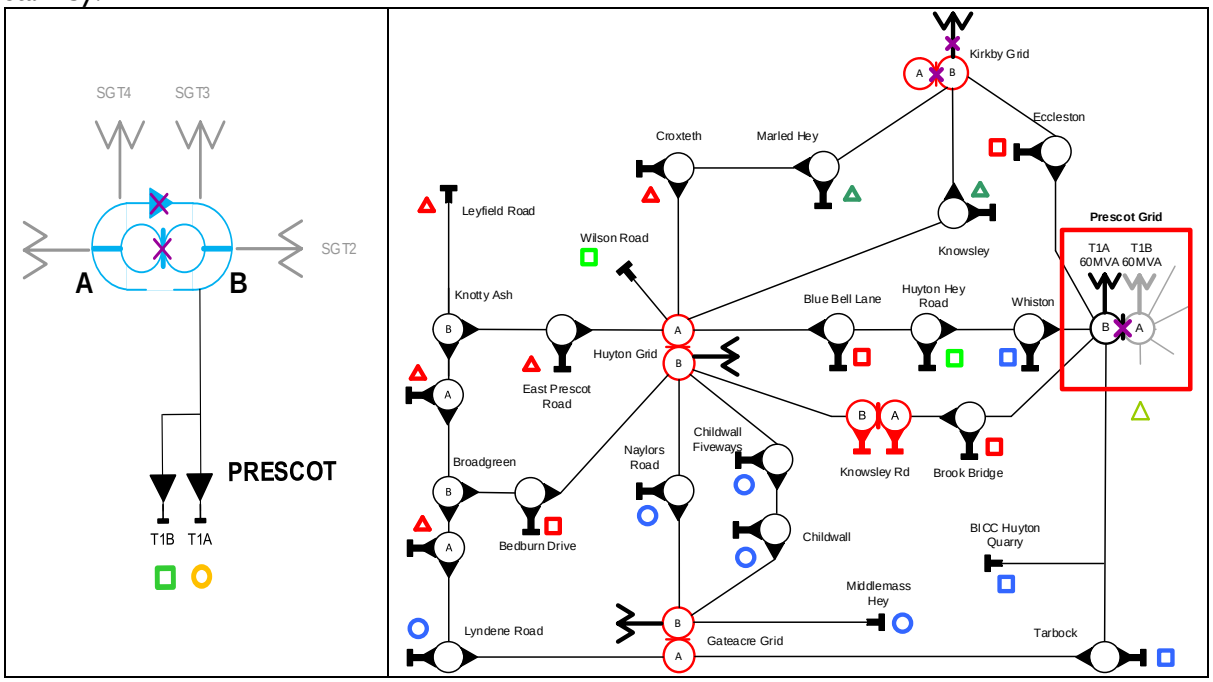

Figure 2-1:Prescot grid 33kV schematic

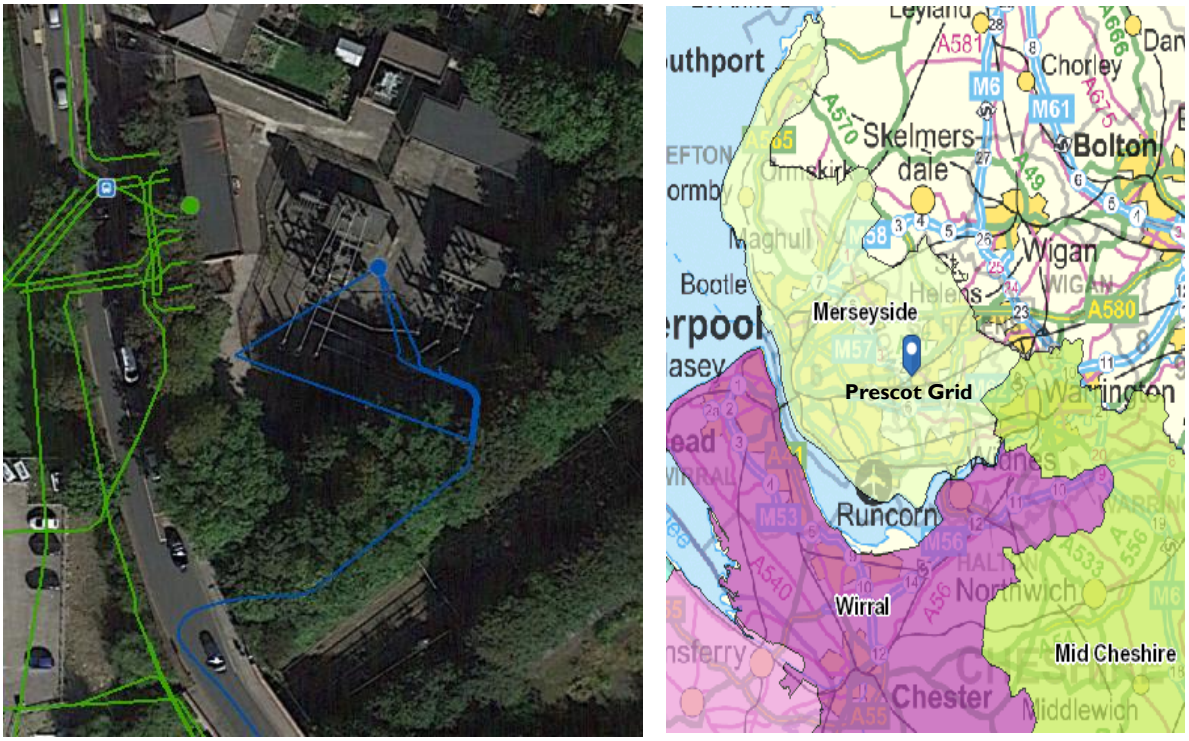

Figure 2-2: Prescot 33kV grid substation site

2.2 Network supply / circuit capacity

The current group demand is 85.2MVA, against the group firm capacity of 114.8 MVA, the load index group is LI1. The group is EREC P2/7 Class 'D' and requires N-2 redundancy at 132kV level to meet the security of supply requirements.

Table 2-1 shows the 33kV connected and contracted demand/generation capacities in the Gateacre/Huyton/Kirkby/Prescot 33kV grid group. Recent connections activity has offered an additional 20MVA of demand capacity to two prospective customers.

Table 2-1: Demand and generation data

Firm Capacity	Max demand	Load Index	Customers (#)	Generation Connected/Contracted	Contracted Demand
114.8 MVA	87.8 MVA	LI1	66,510	10.35MW / -	3

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 cope with a certain level of fault current. Increasing volumes of distributed generation will increase the level of network fault current. Fault level constraints limit the low-cost timely connection of future generation in this group.

3.1 Fault levels and switchgear

The Prescot 33kV switchboard is of legacy type (AEI/Metropolitan Vickers make,) oil medium switchgear planted in the years 1964 and 1975. The forecast risk index of the switchgear, by the end of RIIO-ED2 period is HI2 | C3, which indicates that the board does not merit asset replacement currently.

Fault level studies as shown in the subsequent sections indicate that fault level exceedances are on only on the 'B' board, while on the 'A' board the fault levels are well within the switchgear ratings.

As fault levels are directly dependent on the network impedance, traditional and effective options such as series reactors and/or higher impedance transformers have been explored to address the fault level exceedance on the Prescot grid substation.

The 33kV fault level design limit for RMS break duty is 17.5 kA. The usual design practice is to limit the network fault levels to 95% of the lowest of design fault levels and switchgear ratings, above this threshold fault level mitigations are deemed necessary.

Table 3-1 below shows the current 33kV fault levels as a percentage of the lowest of switchgear ratings / design limits at the grid Prescot Grid substation and the impact of the Rainhill 132kV GSP running arrangements.

Table 3-1: Existing fault levels at Prescot Grid board

Rainhill GSP running arrangement	Prescot Grid board	Switchgear Rating (kA)		Fault Levels (kA)		Duty (%)	
		Make	Break	Make	Break	Make	Break
Normal (2 + 2 split)	'A' board	43.75	17.5	30.56	12.61	70%	72%
	'B' board	33.46	13.12	**33.92**	12.30	**101%**	94%
Abnormal (3 solid)	'A' board	43.75	17.5	30.65	12.62	70%	72%
	'B' board	33.46	13.12	**36.58**	**13.58**	**109%**	**104%**

Fault level type 1 assessments identify fault level duties in excess/approaching the of switchgear ratings on the 'B' board, both under normal and abnormal running arrangements. The fault duty exceedances on the Prescot B board are presently operationally managed by placing the Kirkby GT3 grid transformer on open-standby and this is the preferred operating configuration as it results in the lowest fault level at all the sites in in the Gateacre/Huyton/Kirkby/Prescot 33kV grid group. Detailed Type-2 fault level assessments have been undertaken at Prescot grid substation to risk assess and manage the most onerous fault current condition seen by each individual circuit breaker.

For these reasons, it is necessary to mitigate the existing fault levels, to continue to maintain a safe and secure network and to provide additional fault level headroom to accommodate the decentralisation and decarbonisation of generation.

3.2 Forecast Demand

The peak group demand in the Gateacre/Huyton/Kirkby/Prescot group is 85.2MVA. The group is within Class 'D' under EREC P2/7 classification and is required to be secured for Second Circuit Outage (SCO / N-1-1) condition. With 4 grid transformers feeding the group (one on open-standby) the group is currently 'compliant' as per EREC P2/7 requirements.

Within the RIIO-ED2 period whilst the group demand is forecast to increase, it will remain within the firm capacity of the group. This forecast is based on actual system measurement data from the SPMW's PI system, stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers the pipeline of known developments in the group.

No additional thermal or voltage constraints were identified in the group during the RIIO-ED2 period resulting from the forecast demand growth. therefore, the group will remain compliant with the requirements of EREC P2/7 through the RIIO-ED2 period.

3.3 Forecast Generation

The adjacent Bold/Prescot/Widnes group has connected generation of 58.5MW and has contracted for 13.4MW battery connection. The SPEN DFES indicates across the Rainhill GSP, generation could increase by up to ca. 126MW by 2028 and 247MW by 2028 (end of ED2) under the Baseline View. This additional generation will certainly increase the fault level in the Rainhill 132kV GSP and consequentially increase the fault levels in the Gateacre/Huyton/Kirkby/Prescot groups and will exacerbate the existing fault level issues at Prescot grid substation.

4 Optioneering

Table 4-1shows the longlist of options considered mitigate the fault level constraints on the Prescot B 33kV board. Few of the options are rejected based on technical / commercial rustications, the rest of the options are taken forward for detail analysis and included in the cost benefit analysis. The shortlisted options are taken forward for detailed analysis and considered for cost benefit analysis.

Among the options taken forward, the **Option 1**comprising the new series reactor in Prescot GT1A tails is the minimum required works to mitigate the fault level issues.

Table 4-1 – Long list of options considered

Option	Description	Status	Reason for rejection
(a)	Do Nothing	Rejected	Rejected as this leads to perpetuation of fault level issues on the grid board and present a barrier to low-cost timely connection of generation in the group.
(b)	Intervention plan using only Energy Efficiency	Rejected	Rejected as it does not address the network fault level issues.

(c)	Replace the 11 panel Prescot Grid switchboard with higher rated switchgear	Shortlisted as **Baseline** option	
(d)	Install a 60MVA, 6% impedance series reactor in Prescot GT1A 33kV cable tails.	Shortlisted as **Option 1**	
(e)	Replace the existing 60MVA GT1A with higher impedance unit	Shortlisted as **Option 2**	
(f)	Bus Section reactor at Prescot Grid	Rejected	As the groups are operated split currently, coupling them via series reactor will only exacerbate the fault levels.
(g)	Install Active Fault Level Management (AFLM) scheme with Real-Time Fault Level Monitoring (RTFLM).	Rejected	This considered Active Network Management to operate the group with one GT on open standby. This was unable to sufficiently mitigate the already high fault levels.
(h)	Install a Fault Current Limiting (FCL) device in both Prescot GT tails	Rejected	Discounted based on safety concerns with the use of pyrotechnically assisted fuses coupled with the solution being unable to 'fail to safe'.
(i)	Install a Superconducting Fault Current Limiting (SFCL) device in both Prescot GT tails	Rejected	The technology is not ready for deployment at this time, experience from SPEN trials indicate that the maintenance requirements for the cooling systems is cost prohibitive
(j)	Split/Reconfigure the 33kV group	Rejected	This requires extensive studies and long lead times as the underlying HV groups need to be reconfigured as well and can impact the security of supply at both 33kV and HV level.

5 Detailed Analysis

The detailed network fault levels and power flow studies considering the connected and contracted customers and the forecast demand / generation in the group. This section details the recommended scheme and shortlisted alternative options.

5.1 Option 1 (Proposed) – New 33kV, 60MVA, 6% series reactor in Prescot GT1A tails

Table 5-1: Summary of proposed option

Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution(£m)
New 33kV, 60MVA, 6% impedance series reactor in Prescot GT1A tails	0.943	-

This **proposed solution** limits the fault infeed into the grid group from the 132kV network by installing a 60MVA, 33kV 6% impedance series reactor into the Prescot GT1A transformer tails. A such, the series reactor will help in reducing the fault levels across all the sites in the Gateacre/Huyton/Kirkby/Prescot 33kV group. The power flow studies indicate that, due to the additional impedance of the series reactor, the other GTs in the group see an increased flow however, the circuit ratings are well within the cyclic loadings .even for loss of two GTs (N-1-1 outage condition). The reactor's impedance was chosen to balance the power flows; however, this will be optimised at a detailed design stage.

Fault level studies indicate the proposed series reactor limits the fault levels below the switchgear ratings under both normal and abnormal running arrangements of Rainhill 132kV substation. The series reactor will create an additional fault level headroom of ca. 3kA (Peak Make) / 1kA (RMS Break) at the Prescot 'B' board, consider the switchgear rating of 33.46kA / 13.12kA. The proposed solution is expected to defer the switchboard replacement beyond RIIO-ED3 period. The series reactor will increase network losses by 321MWh/year in the network group (considered under societal benefits in CBA under Option 1).

Table 5-2: Prospective fault levels at Prescot Grid board(with series reactor)

Rainhill GSP running arrangement	Prescot Grid board	Switchgear Rating (kA)		Fault Levels (kA)		Duty (%)	
		Make	Break	Make	Break	Make	Break
Normal (2 + 2 split)	**'A' board**	43.75	17.5	30.54	12.60	70%	72%
	'B' board	33.46	13.12	30.89	11.33	92%	86%
Abnormal (3 solid)	**'A' board**	43.75	17.5	32.82	12.42	70%	72%
	'B' board	33.46	13.12	30.68	12.61	98%	95%

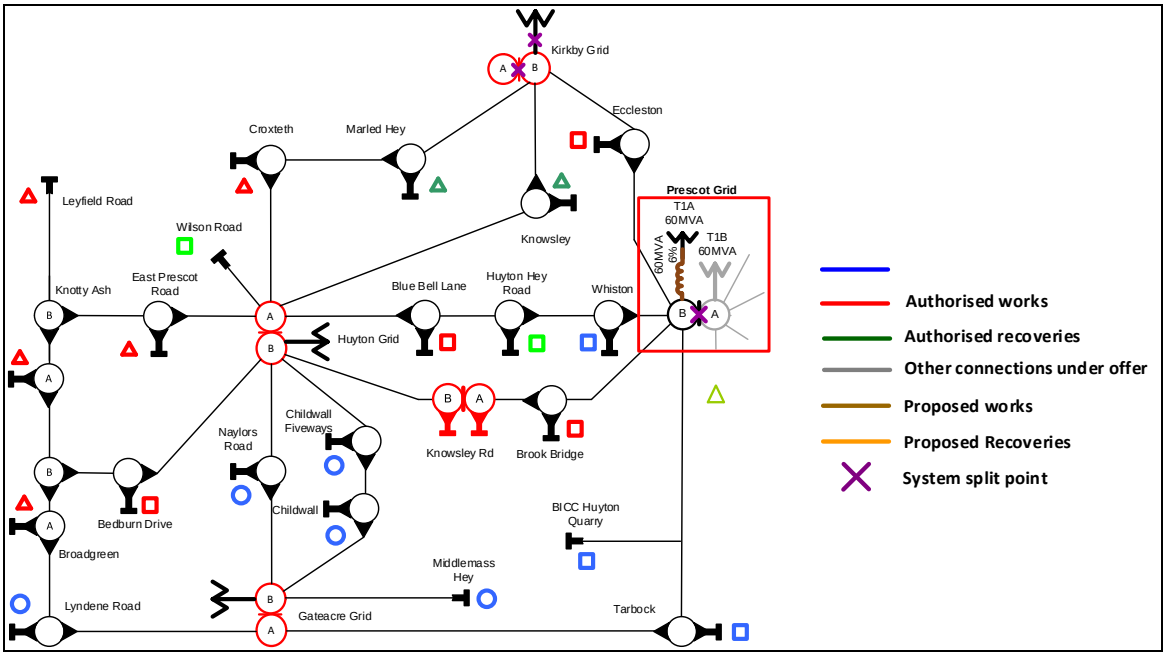

Figure 5-1: Prescot 33kV works under the proposed option

Table 5-3: Summary of cost and volumes under proposed option

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	0.38	0.093	0.093	-
Civil Works at 33 kV & 66 kV Substations	-	0.350	0.350	-
Series reactor, 33kV, 60MVA	1	0.350	0.350	-
Other Costs (Identify Below)	-	0.150	0.150	-
Total Costs		**0.943**	**0.943**	**-**
£100k for updating relay/protection changes				
£50k for engineering time and environmental considerations				

5.2 Baseline – Replant Prescot 33kV switchboard

The solution is to replace the existing 11 panel switchboard and the associated remote end protection modifications. As shown in Figure 2-2, the substation is space constrained. An offline build is not considered a feasible option, this solution considers an on-line build using half-board outages. The switchboard replacement creates additional fault level headroom of 4.4kA / 250MVA (RMS Break) on the Prescot 'B' board. It is not considered feasible to replace just the B board (5 panels) due to the required assurance of the interface between the existing 1970's oil filled switchgear and the current generation of GIS switchgear.

Table 5-4: Summary of Baseline option

Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution(£m)
Replace Prescot 33kV 11 panel switchboard with higher rated switchgear and associated remote end protection modifications.	2.815	-

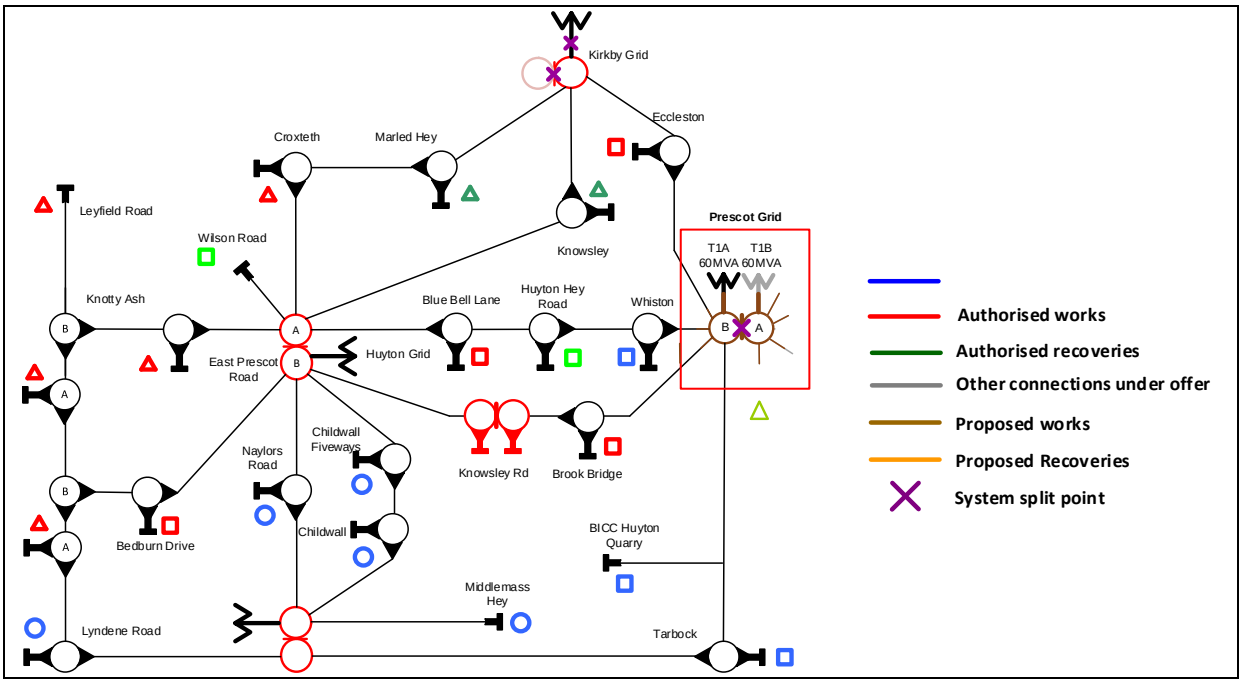

Figure 5-2: Prescot switchboard replacement under Baseline option

Table 5-5: Summary of cost and volumes under Baseline option

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	1.95	0.473	0.473	-
33kV CB (ID) (GM)	11	1.874	1.874	-
Civil Works at 33 kV & 66 kV Substations	-	0.132	0.132	
Other Costs (Identify Below)		0.336	0.336	-
Total Costs		**2.815**	**2.815**	**-**
£286k for updating relay/protection changes for all sites				
£50k for engineering time and environmental considerations				

5.3 Option 2 – Replant Prescot GT1A with higher impedance unit

The solution is to replace the existing 60MVA GT1A unit with higher impedance unit, an impedance of 22% is considered. The existing GT1A is an older Hackbridge unit with a 15.9% impedance and the current future risk index is estimated to be HI2|C2. Considering the 6% impedance required to reduce the fault levels below the switchgear ratings, the GT impedance of 22% is chosen. The GT replacement is proposed to be inline as the site is constrained as shown in Figure 2-2.

Fault level studies indicate the proposed GT1A replacement the fault levels below the switchgear ratings under both normal and abnormal running arrangements of Rainhill 132kV substation. The higher impedance GT will create an additional fault level headroom of ca. 3kA (Peak Make) / 1kA (RMS Break) at the Prescot 'B' board, consider the switchgear rating of 33.46kA / 13.12kA. The proposed solution is expected to defer the switchboard replacement beyond RIIO-ED3 period. The higher impedance GT will increase network losses by 394MWh/year in the network group (considered under societal benefits in CBA under Option 2).

Table 5-6: Summary of Option-2

Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution(£m)
Replace Prescot existing 60MVA GT1A with higher impedance (22%) unit	**1.667**	-

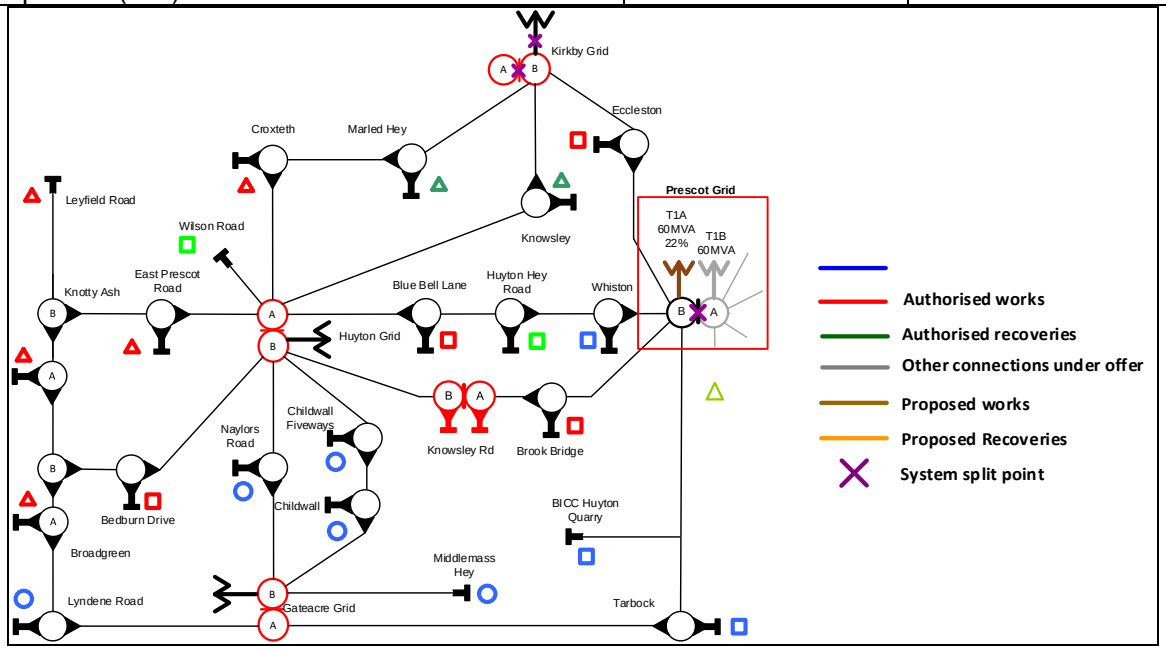

Figure 5-3: Prescot switchboard replacement under Option-2

Table 5-7: Summary of cost and volumes under Option-2

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	0.300	0.073	0.073	-
132kV UG Cable (Non-Pressurised)	0.10	0.111	0.111	-
132kV Transformer	1.00	1.214	1.214	-
Civil Works at 132 kV Substations		0.120	0.120	-
Other Costs (Identify Below)		0.150	0.150	-
Total Costs		**1.667**	**1.667**	**-**
£100k for updating relay/protection changes				
£50k for engineering time and environmental considerations				

5.4 Options Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5-8.

Table 5-8 –Technical summary for considered options

Options	Option Summary	Total Costs(£m)
Baseline	Replant Prescot 33kV, 11 panel switchboard with higher rated switchgear.	2.815
Option 1	New 60MVA, 33kV, 6% impedance series reactor in Prescot GT1A tails	0.943
Option 2	Replace the existing 60MVA GT1A with higher impedance unit	1.667

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 **Option 1** comprises installing a new 60MVA series reactor in the Prescot GT1A tails, increases the fault level headroom by ca. 1kA / 57MVA (RMS Break) at the 33kV board. This uplift in fault level headroom of ca. 1kA / 57MVA (RMS Break) to be claimed as output for the scheme upon completion.

6.2 Cost-Benefit Analysis

A cost benefit analysis (CBA) was carried out to compare the NPV of the three options discussed in the previous sections. Considering the lowest forecast capital expenditure, the adopted option has the highest NPV (across the lifetime of the asset) and represents the lowest-cost option.
Table 6-1 shows the results of CBA analysis supporting the adopted option. The full detailed CBA is provided within "ED2-LRE-SPM-010-CV3-CBA – Prescot Grid 33kV Fault Level Mitigation".

Table 6-1: Summary of Cost Benefit Analysis

Options	Description	Decision	Comment	NPVs based on payback periods from 2023/24 (£m)			
				10 years	20 years	30 years	45 years
Baseline	Switchboard Replacement	Rejected	Rejected based on NPV				
Option 1	New 33kV 60 MVA, 6% series reactor	**Proposed**		1.02	0.09	-0.18	-0.43
Option 2	Replace the existing 60MVA GT1A with higher impedance unit	Rejected	Rejected based on NPV	0.44	-0.65	-1.03	-1.36

For the Options 1& 2 option, the CBA indicates that a positive NPV result in assessment periods for up to 20 years and 10 years (correspondingly from the start of RIIO-ED2 period) and negative beyond. This is because these options defer the switchboard replacement beyond RIIO-ED3. Given that the health index of the switchboard and the GT is HI2, which indicates that the asset replacements does

not merit this time, the series reactor solution will mitigate the fault level issues as well as defer the switchboard replacement.

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 £0.943m to install a new 60MVA series reactor in Prescot GT1A tails.

Table 6.2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)
33kV UG Cable (Non-Pressurised)	0.38	0.093	0.093
Civil Works at 33 kV & 66 kV Substations	-	0.350	0.350
Series reactor, 33kV, 60MVA	1	0.350	0.350
Other Costs (Identify Below)	-	0.150	0.150
Total Costs		**0.943**	**0.943**
£100k for updating relay/protection changes			
£50k for engineering time and environmental considerations			

Table 6-3: Cost incidence over the RIIO-ED2 period, £m (2020/21 Prices)

Total Investment	Total (£m)	Cost Incidence (£m)				
		2023/24	2024/25	2025/26	2026/27	2027/28
Fault Level Reinforcement (CV3)	0.943	-	-	-	0.471	0.472

6.4 Risks

Fault level mitigation using series reactor is a BaU and hence the risks associated with the delivery of the proposed scheme are very minimal. The SPM network has series installed at several sites for fault level mitigation. The RIIO-ED1 track record is detailed in "Annex 4A.10: Substations & Switchgear; EHV to LV" of our ED2 business plan. The learnings from the delivery of the previous schemes will be useful in the delivery of the proposed scheme.

The Prescot grid substation has limited but sufficient space for accommodating the proposed series reactors. Two outage seasons are considered for delivery, owing to the civil works required; this will be co-ordinated with SPM ED2 delivery plan and the network outage requirement, the cost incidence is reflective of this.

The series reactors are well known to introduce transient recovery voltages during reactor switching, however this can be mitigated by introducing additional capacitance in series with the reactor (for e.g. additional cable length would add this capacitance).

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 driver for the proposed reinforcement is to address the fault level exceedances at the Prescot Grid substation, both Peak Make and RMS Break duties (under both intact and abnormal operating conditions) in exceeding the switchgear ratings.

6.6.2 Payback Periods

The CBA indicates that a positive NPV result in assessment periods for up to 20 years (from the start of RIIO-ED2 period) and negative beyond. This is because the proposed option defers the switchboard replacement beyond RIIO-ED3. Given that the health index of the switchboard is HI2, which indicates that the board does not merit asset replacement at this time. Consumers 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 has been tested against and has been found to be 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 SPENs DSO vision and future energy strategy.

For the Gateacre/Huyton/Kirkby/Prescot 33kV group, Table 6.4 shows electric vehicle and heat pump uptakes across a range of future pathways, the G74 fault contributions from the forecast uptakes along with the generation will exacerbate the existing fault levels in the group. 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 6.4: 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	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
EVs	11,711	8,716	16,054	18,276	16,933	11,711	18,410	16,787	16,787
HPs	5,482	1,379	8,511	6,438	6,364	5,169	6,974	6,344	6,057

** 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: Sensitivity of the proposed solution against future pathways

Solution Requirements	RIIO-ED1				RIIO-ED2					RIIO-ED3				
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Baseline								R1						
Consumer Transformation							R1							R2
Leading the Way										R1				R2
Balanced Net Zero							R1						R2	
Headwinds									R1					
Widespread Engagement							R1						R2	
Widespread Innovation							R1					R2		
Tailwinds							R1						R2	

R1 – New series reactor 60MVA (Option 1 - proposed solution)
R2 – Replace Prescot 11 panel 33kV grid switchboard (Baseline)

The proposed solution is robust across all pathways. As this is the minimum requirement to mitigate the fault levels in the group, the proposed solution is required under all the future pathways. Under higher LCT / generation uptake scenarios, an additional reinforcement might be required in the form of switchboard replacement towards the end of RIIO-ED3.

Table 6.6: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	0.943	0.0
Comment	Proposed option.	N/A

6.6.4 Asset Stranding Risks & Future Asset Utilisation

Electricity demand and generation uptakes are forecast to increase under all scenarios. The stranding risk is therefore considered to be low and it is predicted asset utilisation will not exceed the design/switchgear ratings in the RIIO-ED2 period.

6.6.5 Losses / Sensitivity to Carbon Prices

Losses have been considered in accordance with License 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 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. A higher impedance solution was proposed for this scheme; however, the CBA indicates that the increased losses does not alter the proposed solution.

6.6.6 Future Asset Utilisation

It has been assessed that the preferred option is consistent with the future generation and demand scenarios and that the risk of stranding is very low.

6.6.7 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 safe operation of the distribution network and its enduring ability to facilitate wider whole system benefits.

6.7 Environment and Sustainability Considerations

6.7.1 Operational and embodied carbon emissions

The scheme 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).

During the evaluation of the options associated with the Prescot 33kV Fault Level Mitigation 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.

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

6.7.2 Supply chain sustainability

For us to take full account of the sustainability impacts associated of the scheme, 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 proposed scheme 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 proposed scheme 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

The fault level make duty at Prescot Grid is in exceedance of the switchgear rating and the break duty is approaching its ratings. The site is operationally managed requiring switching actions to temporarily reduce the fault levels prior to certain switching actions on the Prescot switchgear. The high fault levels at this site present a barrier to low-cost timely connection of generation

The proposed scheme is the Option 1 involves installing a new 60MVA series reactor in the Prescot GT1A tails to reduce the fault infeed from the upstream 132kV network. The proposed option also defers the switchboard replacement to beyond ED3. The total cost of the scheme is £0.943m to spend entirely within the RIIO-ED2 period.

The works for the proposed schemed are to commence in 2026/27 and expected to be delivered in 2027/28, an increment in the fault level headroom of ca. 1kA / 57MVA (RMS Break) to be claimed as output for the scheme upon completion.