SPM 33kV RMUs Fault Level Mitigation

ED2 Engineering Justification Paper

ED2-LRE-SPM-011-CV3-EJP

Issue	Date	Comments
Issue 0.1	Feb 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	SPM 33kV RMUs Fault Level Mitigation		
Activity	33kV RMU Replacements and Monitoring		
Primary Investment Driver	Fault Level Mitigation		
Reference	ED2-LRE-SPM-011-CV3-EJP		
Output	Fault Level Reinforcement		
Cost	£6.057m		
Delivery Year	2024-28		
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**
	-	**£6.057m**	**-**

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:	SPM 33kV RMUs Fault Level Mitigation
Project Reference:	ED2-LRE-SPM-011-CV3-EJP
Decision Required:	To give concept approval for fault level mitigation through RMU replacement at 15 primary substations and fault level monitoring at 6 primary substations.

Summary of Business Need:

SP Manweb (SPM) network fault levels have considerably increased over the years due to significant accommodation of distributed energy resources (DER) and the traditional demand growth. By the end of RIIO-ED2 period, our Baseline View forecasts an additional 1.7GW of generation connecting to the network. This combined with the accelerated uptake of low carbon technologies (LCT) will significantly increase the exiting fault levels This result in the fault levels approaching/exceeding the switchgear ratings and/or the network design fault level limits.

In order to comply with the ESQCR regulations, section 9 of the Electricity Act and the Condition 21 of the licence obligation "to develop and maintain an efficient, coordinated and economical system for the distribution of electricity" an enduring design solution is required to satisfy the existing requirements and accommodate future growth and it is deemed that the fault level monitoring and mitigation have to be applied at the primary substations approaching/ exceeding the design rating.

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

The primary driver for the reinforcement is the need to mitigate the fault level exceedances at the primary substations with legacy RMUs. The proposed scheme is a combination of conventional RMU replacement and innovative real-time fault level monitoring at 21 primary substations in total. Summary of the proposed fault level mitigation solution includes:

1. Replace 33kV RMUs at 15 primary substations to increase the fault level headroom at a total cost of £6.057m.
2. Install RTFLM devices at 6 primary substations to monitor fault levels and facilitate better network operational risk management.

The total cost of the proposed solution is £6.057m to spend in the RIIO-ED2 period under Fault Level Reinforcement / CV3 category. Please note, this paper only identifies the 6 primary substations for fault level monitoring but does not include the costs. The cost of these RTLM installations are included in our wider fault level innovation rollout scheme ED2-LRE-SPEN-001-CV3-EJP (Fault Level Monitoring and Management).

Expenditure Forecast (Where available based on Regulatory Allowance – 2020/21)

Licence Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPM	CV3	Fault Level Reinforcement	**6.057**	1.781	1.069	1.069	1.069	1.069
Total Expenditure within RIIO-ED2			**6.057**					

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

SP Manweb (SPM) network fault levels have considerably increased over the years due to significant accommodation of distributed energy resources and the traditional demand growth. By the end of RIIO-ED2 period, the SPM Baseline View forecast an additional 1.7GW of generation connecting to the network, which will significantly increase the fault levels. The fault levels are further exacerbated by the accelerated uptake in low carbon technologies. Combined with forecast generation can result in the fault levels approaching/exceeding the switchgear ratings and/or the network design fault level limits.

In order to comply with the ESQCR regulations, 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 to satisfy the existing requirements and accommodate future growth and it is deemed that the network fault level to be mitigated at the primary substations approaching/exceeding the design rating.

The primary driver for the scheme is to address the fault levels at the primary substation that are approaching / exceeding the switchgear ratings. This scheme proposes fault level mitigation at a total of 21 primary substations through a mix of switchgear replacement and real-time fault level monitoring.

Summary of the proposed fault level mitigation solution is to:

1. Replace 13 single and 2 double 33kV RMUs (total of 17 RMUs) to increase the fault level headroom at 15 primary substations at the cost of £6.057m.
2. Install RTFLM devices at 6 primary substations to monitor and better manage the existing and prospective 33kV fault levels.

The total cost of the proposed solution is £6.057m with 100% contributions to spent under Fault Level Reinforcement (CV3) in the RIIO-ED2 period. The RMU replacements will create a 4.4kA /250MVA fault level headroom. The RMU replacements are spread across the 5 years with 5 RMUs replaced in 2023/24 and 3 each in the subsequent years, a total of 17RMUs in the ED2 period.
Please note, this paper only identifies the 6 primary substations for real-time fault level monitoring but does not include the cost. The cost of these RTFLM installations is included in our wider fault level innovation rollout scheme ED2-LRE-SPEN-001-CV3-EJP (Fault Level Monitoring and Management).

2 Background Information

2.1 Existing / Authorised Network

The SPM distribution system comprises networks operating at the standard voltages of 132kV, EHV (33kV), HV (11kV, with few legacy 6.6/6.3kV) and LV(0.4kV) networks. shown in Figure 1. The 33kV grid groups are supplied from the 132kV network at Bulk Supply Point (BSP) substations via 132/33kV, YNd1 45/60MVA grid transformers and operated in parallel through an interconnected network of 33kV circuits. The number of grid transformers that can be operated in parallel is restricted by the short circuit design limit of the network. The grid transformer is solidly earthed on the 132kV side and resistively earthed on the 33kV side, and the interconnected 33kV network is generally run ungrounded and hence on the 33kV networks the 3 phase fault duties are more onerous compared to the 1 phase duties

The HV network is supplied from the 33kV network at primary substations via standard transformer Dyn11 vector group, 7.5/10MVA and very few 4MVA capacity ratings. The HV and underlying LV networks are generally run solidly grounded.

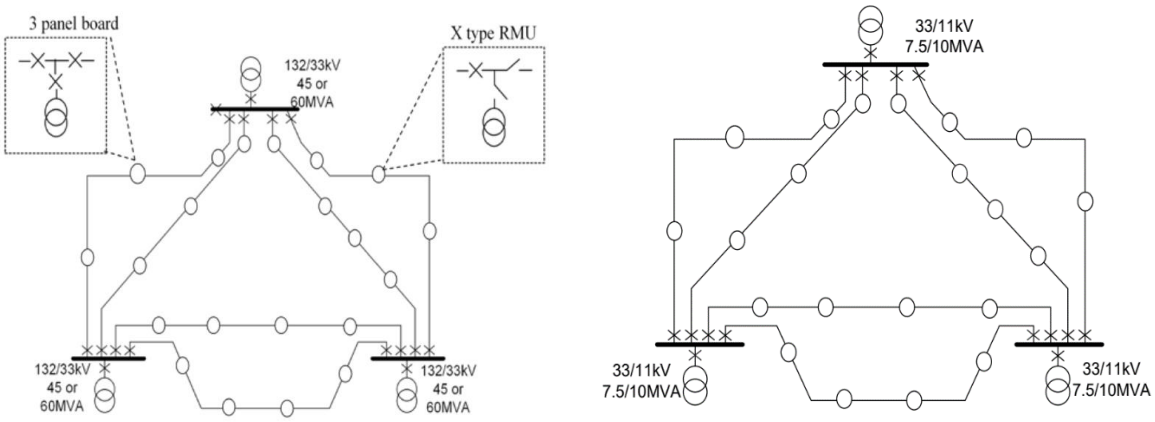


Figure 1: Typical grid and primary groups in SPM network

2.2 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 SPM network are shown in Table 2-1. These are the design limits for the respective voltage networks and substations exceeding these values will require the provision of fault level mitigation measures. Some of the SPM EHV sites are limited to 13.1kA / 750 MVA due to legacy switchgear and these are the site that usually comes on top of the list requiring mitigation measures.

Table 2-1: SPM fault level design limits

System Voltage(kV)	Three Phase Fault Limits(kA)		Single Phase Fault Limits (kA)	
	Peak Make	RMS Break	Peak Make	RMS Break
EHV	44.6	17.5	12.5	5
HV	33.5	13.1	33.5	13.1

The switchgear fault level duty assessments are based on the SP Energy Networks (SPEN) design policies ESDD-02-006[1] and ESDD-02-014, 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.

3 Needs Case

The SPM distribution network is atypical in terms of the degree of interconnectivity at each of the voltage levels, adopted to better network asset utilisation. The inadvertent outcome of the heavily interconnected networks is that the fault levels are higher compared to radially fed networks. In general, for such networks, besides the connected levels of generation and demand, the network configuration (i.e. open and closed points on the network) dictates the fault levels. As the switchgear is designed to withstand a rated level of fault level duty, the exceedance of these ratings increases the

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

risk of failure during switching operations either as a mechanical failure or electrical failure, which could be a health and safety concern.

As indicated above, the SPM network has few substations with legacy oil medium switchgear which is rated only for 13.1kA/750MVA RMS break duty. As more and more DERs connect to the network, substations with this legacy switchgear are fast approaching/exceeding the ratings and leaving with little to no headroom to operate the network in a reliable and safe manner. The lack of fault level headroom also deters the prospective generation/demand customers as well as result on delayed access to the network capacity.

Also, due to the age and unavailability of spares is making the option of refurbishing / retrofitting infeasible for such type of switchgear and it is prudent to replace as it cost-effective, reduces the risk of failure and more increases the fault headroom to accommodate more generation.

The modern switchgear installed in SPM network is rated higher than the design limit of 17.5kA. For the sites exceeding the design limits but within the switchgear ratings on make duties, the fault levels can be operationally managed. Currently, in SPM network it is done by placing Technical Limitation Record (TLR) flags on the Network Manage System(NMS) and thereby sequencing switching actions to maintains fault levels within plant ratings The network switching activity is assessed based on analytical modelling which cannot take into account the real-time fault level. The knowledge of real-time fault level information will help to improve network security during operational switching that is currently carried out at sites where there are fault make issues and also provides the realistic fault level headroom to facilitate greater interconnection.

Additionally, SPEN have been progressing ground-breaking innovations to measure and manage fault level challenges in real-time. Within the RIIO-ED1 period, SPEN have successfully trialled and tested Real-time Fault Level Monitors (RTFLM) technology at substations in Chester, Warrington and Liverpool and continue to rollout as BaU at more substation during the RIIO-ED1 period. The technology has proven to predict the fault level accurately within a 5% error margin. Further rollout of this RTFLM technology will benefit in better operational management, outages and can provide cost-benefit in terms of releasing currently restricted capacity to facilitate new connections.

3.1 Fault Levels and Switchgear Ratings

Fault level type 1 assessments identify either make or break duties are in excess of switchgear rating under normal running arrangements. Detailed Type-2 fault level assessments have been undertaken to risk assess and manage the most onerous fault current seen by each switchgear component.

Table 3-1 below shows the 33kV fault levels of primary substations at/above 95% design rating (lowest of switchgear ratings and design limits), in terms of 3 phase Peak Make and RMS Break duties. A total of 21 primary substations, involving 17 single and 4 double RMUs are identified to be exceeding the fault level limits. As identified below, these primary substations have legacy RMUs rated only for 750MVA /13.12kA. These primary substations are constrained in terms of fault level headroom and require mitigation.

Table 3-1: Primary Substation fault levels at 33kV voltage level

Substation Name	Equipment Rating (kA)		Make Duty	Break Duty	Switchgear	Volumes
	Make	Break	%	%	Type	#
WOODEND AVENUE	33.46	13.12	107	87	RMU	1
MOBIL OIL (WALLASEY)	33.46	13.12	104	101	RMU	1
B R SHORE ROAD	33.46	13.12	103	101	RMU	2
BLUNDELL STREET	33.46	13.12	103	93	RMU	1
HAMMOND ROAD	33.46	13.12	102	93	RMU	1

WEAVER IND ESTATE	32.8	13.12	101	92	RMU	1
ST JAMES	33.46	13.12	100	93	RMU	2
REGENT ROAD	33.46	13.12	99	94	RMU	1
DICKINSONS	33.46	13.12	99	91	RMU	1
LITTLEWOODS	33.46	13.12	98	95	RMU	1
MANNINGS LANE	33.46	13.12	98	95	RMU	1
SHEIL PARK	33.46	13.12	98	93	RMU	1
ST IVEL FOODS	32.8	13.12	98	91	RMU	1
GARDNERS ROW	33.46	13.12	97	93	RMU	1
HILLS MOSS	33.46	13.12	96	99	RMU	1
STONEYCROFT	33.46	13.12	96	92	RMU	1
STOCKTON HEATH	32.8	13.12	96	85	RMU	2
NORTHGATE TERRACE	33.46	13.12	95	94	RMU	1
SUBURBAN ROAD	32.8	13.12	95	91	RMU	1
HAWLEYS LANE	33.46	13.12	95	84	RMU	1
JACOBS	33.46	13.12	95	82	RMU	2

3.2 Forecast Demand

Within the RIIO-ED2 period, under the Baseline View, additional demand of ca. 290MW is forecast to be connected to be within the SPM network, this can add to the existing fault levels in the form of G74[2] contributions. The growth of LCT uptake in the form of heat pumps and electric vehicles is ca. 147, 500 and 473, 800 respectively across the SPM network.

3.3 Forecast Generation

The Baseline View indicates across the SPM distribution network ca. 1.7GW of additional generation is forecast to connect within the ED2 period. Table 3-2 below shows the additional forecast generation under Baseline View in SPM network. Figure 3-1 and Figure 3-2 show the geographic incidence and split by technology of the forecast generation.

Table 3-2: Additional forecast generation volumes

Generation Type	Additional Forecast Volumes (MW)
Wind	132
PV	273.9
Hydro	120.8
Renewable CHP	291.7
Other renewable	33.2
Other Non-renewable	255.3
Storage	561.1
PV / Storage (Behind the Meter)	25.0
Total	**1693**

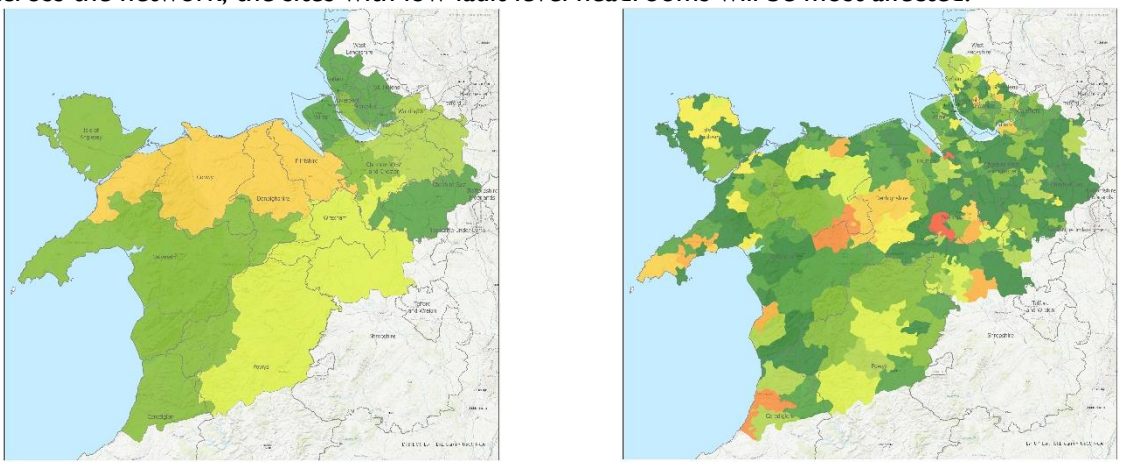
The increase in network fault level constraints that SPM network experiences are generally a result of connecting relatively high volumes of "rotating" renewable generation and invertor based (such as PV, battery storage) etc. The typical fault contributions are,

- Wind turbine per 1MW rating, typical fault level contribution (3 - 5MVA)
- Solar generation per 1MW rating, typical fault level contribution (1.0 -1.2MVA)

As the typical fault contribution from these technologies vary from 1x – 5x per each MW connected, this would result in significant fault level contributions. In a highly interconnected networks such as SPM, the fault level increase due to these generation connections are not just limited to the local

[2] ENA EREC G74 - Procedure to Meet the Requirements of IEC 909 for the Calculation of Short-circuit Currents in Three-phase AC Power Systems.

network, but can increase the overall network fault levels as the interconnected networks offer more 'parallel paths' for the fault current flows. It should be noted that as the generation incidence is diverse across the network, the sites with low fault level headrooms will be most affected.



GSP level forecast | Primary level forecast

Figure 3-1: SPM generation forecast for 2030

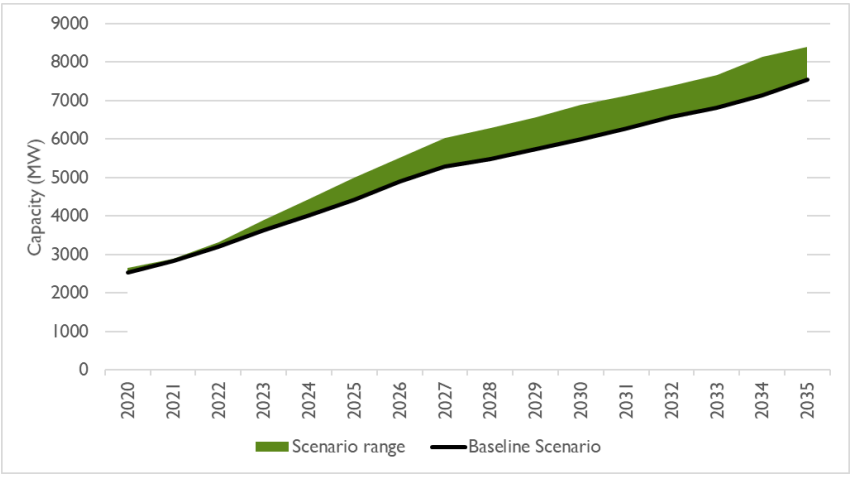


Figure 3-2: SPM range of Net Zero compliant distributed generation forecasts

4 Optioneering

Table 4-1 below presents a long list of options considered for this scheme. Few of the longlist options are rejected based on the technical and commercial rustications, the reasons are provided in the table. The shortlisted options are taken forward for detailed analysis and included in the cost-benefit analysis. Option-1 which is a combination of conventional switchgear replacement and innovative fault level monitoring is the "do minimum" option among the considered options.

Table 4-1 – Long list of options considered

Option	Description	Status	Reason for rejection
1	Do Nothing	Rejected	Rejected as it presents unacceptable safety and performance. Would deter new DER connections across the network and would impact the path to achieving Net Zero targets.
2	Intervention plan using only Energy Efficiency	Rejected	Rejected as it does not address the network fault level issues.

3	Replace switchgear at all 21 primary substations in excess/close to fault duties	Considered (**Baseline)**	
4	Replace legacy switchgear and fault level monitoring	Considered (**Option1)**	
5	Install RTFLM devices at all 21 primary substations	Rejected	Although beneficial in better operational switching, this presents unacceptable safety and performance and would not benefit the network as there is no headroom created
6	Series reactors	Rejected	Not a cost-effective solution, require at least 20MVA units, not feasible due to space constraints at primary substations and will also increase network losses.
7	Fault Current Limiters (FCL)	Rejected	Due to the usage of explosive fuse element which is not 'fail-safe' and can be a safety issue and requires maintenance & operational costs
8	Superconducting Fault Current Limiters (SFCL)	Rejected	The technology is not ready for BaU and present experience from SPEN trials indicate that maintenance requirements for the cryogenic systems are prohibitive
9	HV group reconfiguration	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 and Costs

The detailed fault level analysis had been carried out for SPM network considering the current pipeline of generation connections as well as the forecast generation from DFES. The network fault levels are certain to increase with the growth of distributed generation, as mentioned above, the primary substation with legacy switchgear (RMUs) are the ones to exceed the fault level limits due to the limited rating.

The two options considered aim to mitigate the fault levels through switchgear (RMU) replacements and innovation through fault level monitoring. All other conventional listed in Table 4-1 are discarded as the fault level headroom created will be less than the considered solutions and often times, they come out be expensive than the proposed 'in-situ' switchgear replacements.

The proposed options are aimed to address the existing/prospective fault level constraints at these primary substations, thereby creating fault level headroom to accommodate the future generation as well as facilitates operating the network safely.

5.1 Baseline – Replace the switchgear with fault level issues.

This option proposes to replace the existing (legacy) switchgear with modern[3] units at sites exceeding/approaching the switchgear duties (make/break duties >95%). As shown in Table 3-1, the fault level exceedance are at sites with legacy switchgear rated for 13.12kA. Replacing the switchgear with modern units, would create additional fault level headroom ca. 4.4kA/250MVA at each of the primary substations.

[3] The selected units will be replaced with the modern equivalents, compact fixed pattern 36kV switchgear such as the Siemens 8DJH 36.

Under this option, 21 primary substations are identified for replacement, so a total of 17 single RMUs and 4 double RMUs, totalling 25 RMUs need to be replaced at a total cost of £8.937m, the cost breakdown is provided in Table 5-1 below.

Table 5-1 – Cost breakdown for Baseline option

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV RMU	25	5.847	5.847	-
Batteries at 33kV Substations	25	0.229	0.229	-
Civil Works at 33 kV & 66 kV Substations	25	1.625	1.625	-
Protection changes and relay upgrades	25	1.235	1.235	-
	Total Costs	**8.937**	**8.937**	**-**

5.2 Option1– Replace legacy switchgear and fault level monitoring

This **proposed option** is a combination of replacing the (legacy) switchgear exceeding fault level duties and real-time monitoring of fault level duties at sites approaching the design limit / switchgear duties. Of the 21 primary substations showing fault level exceedances, 15 are considered for switchgear(RMU) replacement due to the level of exceedance, whereas 6 are considered for real-time monitoring, as the exceedance are mainly on the peak-make duty which is manageable through planned and sequenced network switching operations.

The scope of the proposed scheme is,

5.2.1 Replace the legacy switchgear

- Replant the switchgear exceeding both make and break duties (>95%) with modern switchgear rated above17.5kA.
- A total of 15 primary substations, of which 13 single RMUs and 2 double RMUs are proposed for replacement.
- The total cost of replacement for 17 RMUS at 15 sites, including the protection upgrades is £6.057m.

The RMU replacement will increase the fault level limit to 17.5kA (network design limit) at each of the primary substation, creating ca. 4.4kA/250MVA headroom. The fault level headroom is sufficient to accommodate additional forecast generation in the network groups.

5.2.2 Real-Time Fault Level Monitoring (RTFLM)

This is progressed based on SPEN's ground-breaking innovations to measure and manage fault level challenges in real-time. There is a strong requirement to obtain visibility of actual fault levels and how they vary in constrained locations. Measurement of actual fault levels, in real-time, will significantly improve our understanding of the network constraints and allows to make better informed design decisions at these sites. These also helps to calibrate the network fault-level models, forecast actual faut levels and will enable more lower cost and timely connections of low carbon generation onto the network. Where appropriate, this can then be used to drive advance network automation solutions to reconfigure network and constrain generation to maintain fault level limits also possible deferral of switchgear reinforcement

The proposed option only identifies the 6 primary substations for fault level monitoring but does not include the costs. The cost of these installations is included in our wider fault level innovation rollout scheme ED2-LRE-SPEN-001-CV3-EJP (Fault Level Monitoring and Management).

The cost of deploying a RTFLM device is ca. £50k each, so for the 6 proposed sites, the total cost of fault level monitoring will be £300k. However, these costs are excluded while costing this option, but

included in our wider fault level innovation rollout scheme ED2-LRE-SPEN-001-CV3-EJP (Fault Level Monitoring and Management).

The total cost of the scheme to replace the 17 RMUs at 15 primary substations is £6.057m under the CV3 category to spend across the RIIO-ED2 period, the cost breakdown is provided in Table 5.2 below.

Table 5.2. Cost and volumes breakdown for Option 1

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV RMU	17	3.976	3.976	-
Batteries at 33kV Substations	17	0.136	0.136	-
Civil Works at 33 kV & 66 kV Substations	17	1.105	1.105	-
Protection changes and relay upgrades	17	0.840	0.840	-
	Total Costs	**6.057**	**6.057**	**-**

5.3 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.3.

Table 5.3. Cost summary for considered options

Options	Option Summary	Cost (£m)
Baseline	Replace switchgear at all 21 primary substations in excess/close to fault duties	8.937
Option 1	• Replace switchgear at 15 primary substations in excess/close to fault duties. • Install RTFLM devices at 6 primary substations approaching fault level duties	6.057

The options are costed using the derived costs in 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** involving a combination conventional switchgear replacement at 15 primary substations and innovative solution real-time fault level monitoring at 6 primary substations. The adopted option increases the fault level headroom at each of the 15 primary substations by ca. 4.4kA/250MVA; the real-time fault level monitoring will help in assessing the actual fault levels at 6 primary substations thereby facilitating operationally managing the network fault levels.

For each of the primary substations where RMUs are replaced, fault level headroom of 4.4kA/250kA is achieved, the fault level limit will increase to 17.5kA / 1000MVA which is the network design limit.

6.2 Cost-Benefit Analysis

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 adopted option has the highest NPV and represents the lowest-cost option, considering this option reduces the number of switchgear (RMU) replacements.
Table 6-1 shows the results of CBA analysis supporting the adopted option. The full detailed CBA is provided within "ED2-LRE-SPM-011-CV3-CBA– SPM 33kV RMUs Fault Level Mitigation".

Table 6-1: Summary of Cost-Benefit Analysis

Options	Decision	Comment	NPVs based on payback periods from 2023/24 (£m)			
			10 years	20 years	30 years	45 years
Baseline-Replace the switchgear with fault level issues.	Rejected	Rejected based on NPV				
Option 1*- Replace legacy switchgear and manage the fault level using RTFLM	Adopted		1.42	1.2.02	2.38	2.65

*The cost of the 6 fault level monitoring sites is £300k(£50k/unit) and excluded from Option-1 and NPV is reflective of this. Including these RTFLM costs within CBA under Option 1 does not change the adopted solution.

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 £6.057 to replace 17 RMUs in total at 15 primary substations.

Table 6.2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)
33kV RMU	17	3.886	3.886
Batteries at 33kV Substations	17	0.136	0.136
Civil Works at 33 kV & 66 kV Substations	17	1.105	1.105
Protection changes and relay upgrades	17	0.840	0.840
Total Costs		**6.057**	**6.057**

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

Total Investment	Total	Cost Incidence (£m)				
		2023/24	2024/25	2025/26	2026/27	2027/28
CV3 - Fault Level Reinforcement (£m)	**6.057**	1.781	1.069	1.069	1.069	1.069
RMU Volumes (#)	**17**	5	3	3	3	3

6.4 Risks

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

The delivery of the proposed scheme aims to replace a total of 17 RMUs, 5 RMUs in the 2023/24 year and 3 RMUs in each of the subsequent years in the RIIO-ED2 period. It is anticipated that the primary substation with maximum exceedances will be on the top of the delivery plan, but the actual realisation of the forecast generation and network constraints could alter the delivery plan. Further, the delivery of this scheme will be co-ordinated with the delivery of SPM non-load EHV switchgear modernisation(underCV7) for operational efficiencies and 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 driver is fault level mitigation, the proposed reinforcement is based on the maximum fault levels at primary approaching/ exceeding the switchgear ratings and thus the fault level limitation deterring the connection of DERs.

6.6.2 Payback Periods

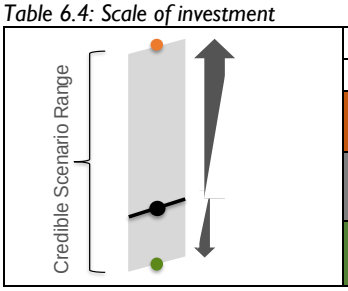
The CBA indicates that a positive NPV result in all assessment periods (10, 20, 30 & 45 years) which are consistent with the lifetime of the intervention. Consumers benefit from reduced network risk immediately on completion of the project.

6.6.3 Sensitivity to Future Pathways

The network capacity and capability that result from the proposed option has been tested against and is consistent with the network requirements determined in line with 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 SPM network area, Table 6.4 shows the sensitivity of the proposed solution and Table 6.5 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: Scale of investment



End of ED2 2028	Scheme Cost (£m)	Volumes (#) Sites / RMUs
High	6.769	16 / 19
Baseline	6.057	15 / 17
Low	6.057	15 / 17

The proposed solution is a combination of conventional and innovation, enables to manage the network fault levels for the generation growth as per the Baseline forecasts. For the higher generation growth under higher scenarios, the fault levels at the proposed sites could exceed the switchgear/design limits at additional sites. The RIIO-ED2 regulatory framework will need to allow DNOs' allowances to flex in response to higher uptakes.

Table 6.5: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	6.057	0.712
Comment	Proposed option.	Under high generation uptakes, it is expected that the Yorkshire Imperial Metals double RMU site would need to be replaced.

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 very little to no impact in this scheme and it has not been necessary to carry out any Losses justified upgrades.

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 safe operation of the distribution network and its enduring ability to facilitate wider whole system benefits such as accommodating more distributed generation.

6.7 Environment and Sustainability Considerations
6.7.1 Operational and embodied carbon emissions
The proposed 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 fault level mitigation programme, 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

SP Manweb (SPM) network fault levels have considerably increased over the years due to significant accommodation of distributed energy resources (DER) and the traditional demand growth. By the end of RIIO-ED2 period, our Baseline View forecasts an additional 1.7GW of generation connecting to the network. This combined with the accelerated uptake of low carbon technologies (LCT) will significantly increase the exiting fault levels This result in the fault levels approaching/exceeding the switchgear ratings and/or the network design fault level limits.

The adopted option involves fault level mitigation at primary substations through a combination conventional switchgear replacement at 15 primary substations and innovative solution real-time fault level monitoring at 6 primary substations. The adopted option increases the fault level headroom at each of the 15 primary substations by ca. 4.4kA/250MVA; the real-time fault level monitoring will help in assessing the actual fault levels at 6 primary substations thereby facilitating operationally managing the network fault levels.

8 Appendices

8.1 Proposed fault level mitigation

Table 8.1: Primary substations with fault level duties and proposed solutions

Substation Name	Equipment Rating (kA)		Make Duty	Break Duty	Switchgear Type	Volumes (#)	Proposed Solution
	Make	Break	%	%			
WOODEND AVENUE	33.46	13.12	106.96	87.29	RMU	1	Replace
MOBIL OIL WALLASEY)	33.46	13.12	104.17	101.38	RMU	1	Replace
B R SHORE ROAD	33.46	13.12	102.85	100.5	RMU	2	Replace
BLUNDELL STREET	33.46	13.12	102.84	93.23	RMU	1	Replace
HAMMOND ROAD	33.46	13.12	101.83	93.2	RMU	1	Replace
WEAVER IND ESTATE	32.8	13.12	100.61	91.97	RMU	1	Replace
ST JAMES	33.46	13.12	99.64	93.03	RMU	2	Replace
REGENT ROAD	33.46	13.12	98.89	93.65	RMU	1	Replace
DICKINSONS	33.46	13.12	98.77	91.39	RMU	1	Replace
ST. IVEL FOODS	32.8	13.12	98.22	90.97	RMU	1	Replace
MANNINGS LANE	33.46	13.12	98.12	95.18	RMU	1	Replace
SHEIL PARK	33.46	13.12	97.99	93.29	RMU	1	Replace
LITTLEWOODS	33.46	13.12	97.83	95.03	RMU	1	Replace
GARDNERS ROW	33.46	13.12	97.36	93.09	RMU	1	Replace
HILLS MOSS	33.46	13.12	95.95	99.36	RMU	1	Replace
STONEYCROFT	33.46	13.12	96.34	92.18	RMU	1	RTFLM
STOCKTON HEATH	32.8	13.12	95.62	85.28	RMU	2	RTFLM
NORTHGATETERRACE	33.46	13.12	95.34	93.51	RMU	1	RTFLM
JACOBS	33.46	13.12	95.2	82.29	RMU	2	RTFLM
HAWLEYS LANE	33.46	13.12	95.18	84.05	RMU	1	RTFLM
SUBURBAN ROAD	32.8	13.12	95.11	91.38	RMU	1	RTFLM