Fault Level Monitoring and Management

ED2 Engineering Justification Paper

ED2-LRE-SPEN-001-CV3-EJP

Issue	Date	Comments
Issue 0.1	Apr 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	Nov 2021	Reflecting updated CBA results
Issue 1.2	Nov 2021	Reflecting updated DFES forecasts
Issue 2	Dec 2021	Final Business Plan Submission

Scheme Name	Fault Level Monitoring and Management		
Activity	Fault Level Mitigation		
Primary Investment Driver	Fault Level Constraints		
Reference	ED2-LRE-SPEN-001-CV3-EJP		
Output	Fault Level Reinforcement		
Cost	SPD - £1.325m	SPM - £1.075m	
Delivery Year	2023-2028		
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
	-	£2.400m	-

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:	Fault Level Monitoring and Management
Project Reference:	ED2-LRE-SPEN-001-CV3-EJP
Decision Required:	To approve installation of Real Time Fault Level Monitors (RTFLM) and Active Fault Level Management (AFLM) schemes to measure and manage fault levels in real time

Summary of Business Need:

Distribution networks will be a key enabler to Net Zero. Growth in generation connections is expected to continue and indeed accelerate as UK generation decentralises to meet Net Zero targets. SP Energy Networks (SPEN) Distribution Future Energy Scenarios (DFES) forecast that by 2030 distribution generation could up to triple in SPD (reaching 6.9GW) and more than double in SPM (reaching 5.5GW).

To achieve this, one of the largest challenges that networks must overcome is the management of fault level. New generation connections into some areas of network are already limited by Fault Level capacity. When generators connect to the network, they increase the maximum energy released during a fault. The network has a safe Fault Level design limit which cannot be exceeded without replacing the limiting equipment or splitting up the network. In areas where there is limited Fault Level headroom for new connections, this can prevent the low cost and timely connection of low carbon generation onto the network.

SPEN have been progressing ground-breaking innovations to measure and manage Fault Level challenges in real-time. Within ED1 we have successfully trialled and tested Real-time Fault Level Monitors (RTFLM) and we have ongoing trials of Active Fault Level Management (AFLM). Together these two innovations will give us greater visibility of network fault levels and enable us to accommodate more generation whilst triggering fewer equipment replacements / network reconfigurations. Within ED2 we will build on our ground-breaking ED1 innovations.

Within the ED2 period due the forecast generation volumes, many of the sites in both licence areas are expected to approach /exceed the fault level limits and required motivational measures. We will roll out fault level monitoring in constrained areas, targeting a total of 38 sites. We will use innovative active fault level management automation systems to facilitate new generation in 3 fault level constrained areas.

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

- Install RTFLM devices at 22 sites in SPD and 16 sites in SPM to monitor fault levels in real-time.
- Install AFLM at 1 GSP in SPD and 2 grid groups in SPM to manage the fault levels in real-time.

The total cost of the scheme is £2.4m under Fault Level Reinforcement (CV3) fully funded by SPEN in the RIIO- ED2 period.

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
SPD	CV3	Fault Level Reinforcement	**1.325**	0.325	0.550	0.450	-	-
SPM	CV3	Fault Level Reinforcement	**1.075**	0.200	0.325	0.250	0.150	0.150
Total Expenditure in RIIO-ED2			**2.400**	0.525	0.875	0.700	0.150	0.150

PART B – PROJECT SUBMISSION

Proposed by	Ramesh Pampana	Signature	P. Ramesh	Date: 30/11/2021
Endorsed by	Russell Bryans	Signature	[signature]	Date: 30/11/2021

PART C – PROJECT APPROVAL

Approved by	Malcolm Bebbington	Signature	[signature]	Date: 30/11/2021

Contents

1 Introduction

Distribution networks will be a key enabler to Net Zero. Growth in generation connections is expected to continue and indeed accelerate as UK generation decentralises to meet Net Zero targets. SP Energy Networks (SPEN) Distribution Future Energy Scenarios (DFES) forecast that by 2030 distribution generation could up to triple in SPD (reaching 6.9GW) and more than double in SPM (reaching 5.5GW).

To achieve this, one of the largest challenges that networks must overcome is the management of fault level. New generation connections into some areas of network are already limited by Fault Level capacity. When generators connect to the network, they increase the maximum energy released during a fault. The network has a safe fault level design limit which cannot be exceeded without replacing the limiting equipment or splitting up the network. In areas where there is limited Fault Level headroom for new connections, this can prevent the low cost and timely connection of low carbon generation onto the network.

SPEN have been progressing ground-breaking innovations to be able to measure and manage Fault Level challenges in real-time. Within ED1 we have successfully trialled and tested Real-time Fault Level Monitors (RTFLM) on the network and we have ongoing trials of Active Fault Level Management (AFLM). Together these two innovations will give us greater visibility of network fault levels and enable us to accommodate more generation whilst triggering fewer equipment replacements / network reconfigurations. New approaches required to manage this whilst maintaining public and staff safety. Innovation key to avoid fault level becoming a barrier to low carbon transition.

Within the ED2 period due the forecast generation volumes, many of the sites in both licence areas are expected to approach /exceed the fault level limits and required motivational measures. As such, the primary driver for the investment decision is to manage the network fault levels through innovation and accommodate more generation either without or deferring the reinforcement need. Within ED2 we will build on our ground-breaking ED1 innovations. We will roll out fault level monitoring in constrained areas, targeting a total of 38 sites. We will use innovative active fault level management network automation systems to facilitate new generation in 3 fault level constrained areas. These reconfigure network and constrain generation to maintain fault level limits.

Summary of the innovative schemes:

- Install RTFLM devices at 22 sites in SPD and 16 sites in SPM to monitor fault levels in real-time.
- Install AFLM at 1 GSP in SPD and 2 grid groups in SPM to manage the fault levels in real-time.

The total cost of the scheme is £2.400m under Fault Level Reinforcement (CV3) fully funded by SPEN in the RIIO- ED2 period.

2 Background Information

Historically network operators have relied on network modelling to determine FL. These models need to be kept up to date with network changes and they do not reflect the FL fluctuations a network will experience during a typical day or year. The models are a mathematical representation of network behaviour at any one time, and modellers rely on information supplied by Transmission Network Operators (TNOs), the DNOs themselves and Customers (end users).

The capability to measure actual Fault Level significantly improves our understanding of the network constraints and allows us to make better informed decisions. SPEN is at the forefront of innovation with fault level monitoring/management applications within distribution networks. Since 2011, SPEN has been leading innovation in this area and supported by Outram Research Ltd to develop the world's first commercially available Fault Level Monitor (PM7000FLM). This works by using natural disturbances on the network (large loads switching on/off, switching events, etc.) to measure various characteristics of the network and calculate Fault Level. The fault level innovation evolvement is further explained below in the following sections.

2.1 Natural Disturbance Fault Level Monitor (NDFLM)

SPEN completed an Innovation Funding Incentive (IFI) project in May 2013 (IFI1007) with industry partners to develop a portable NDFLM device capable of reliably measuring fault level on distribution networks by observing naturally occurring network disturbances.

Within the RIIO-ED1 period, SPEN have rolled out two staged Fault Level Monitoring programme installing NDFLM devices at sites approaching fault level limits, Stage1 targeting the radial type network sites and ongoing Stage2 targeting interconnected network groups, in total at 20 sites. These actual fault level measurements complement the analytical modelling currently used to assess fault level and helped refine/validate the network models and is successfully utilised in 33kV &11kV network voltage levels and being trialled at 132kV voltage level.

2.2 Real-time Fault Level Monitor (RTFLM)

SPEN have been granted funding under Network Innovation Allowance (NIA) for a two staged RTFLM project (NIA_SPEN0015 and NIA_SPEN_0050), the Stage 1 project concluded in 2019 and the Stage 2 is due to finish by May 2023. The RTFLM creates artificial load disturbances on the network and estimates the fault levels in real time.

RTFLM Stage 1 project demonstrated a proof-of-concept design to measure network fault levels in real time at substations in Chester & Liverpool. The RTFLM device has substantially reduced the estimation time typically to <20seconds compared to the NDFLM which relied on naturally occurring disturbance on the network. RTFLM Stage 2 trials are ongoing at Warrington Grid in SPM distribution network, which involves measuring fault levels on a much complex and interconnected network.

2.3 Active Fault Level Management (AFLM)

SPEN also have been granted NIA funding to trial AFLM solution (NIA_SPEN0014) to trial the concept of actively managing the network fault levels in real time. The AFLM schemes use the SGS ANM Strata® platform to monitor and control the status of the network switching points such as transformer / series reactor breakers, bus section breakers and any participating generators. AFLM consists of the real-time control of network topology and DER connectivity, enhanced by fault level monitoring where possible, maintaining network fault levels within secure limits and enhancing hosting capacity for DER customers.

3 Needs Case

High fault level sterilises areas of network against low cost, timely connections. DG growth will accelerate with decarbonisation and decentralisation to meet net-zero targets. Innovation is key to avoid fault level becoming a barrier to the low carbon transition. Fault level monitoring and real-time network automation are key enablers in achieving this.

SP Energy Networks (SPEN) Distribution Future Energy Scenarios (DFES) forecast that by 2030 distribution generation could up to triple in SPD (reaching 6.9GW) and more than double in SPM (reaching 5.5GW).

New generation connections into some areas of network are already limited by Fault Level capacity. When generators connect to the network, they increase the maximum energy released during a fault. The network has a safe Fault Level design limit which cannot be exceeded without replacing the limiting equipment or splitting up the network.

The increase in network fault level constraints that SPEN experiences across both networks are generally a result of connecting relatively high volumes of "rotating" renewable generation. This is not a uniform problem across the UK as it is directly related to the type of generation connected:

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

As the incidence of distributed generation across the UK is dominated more by wind in the North of England, Wales and in Scotland, Fault Level is a greater concern in these areas than in the South of England where solar generation plays a much greater role.

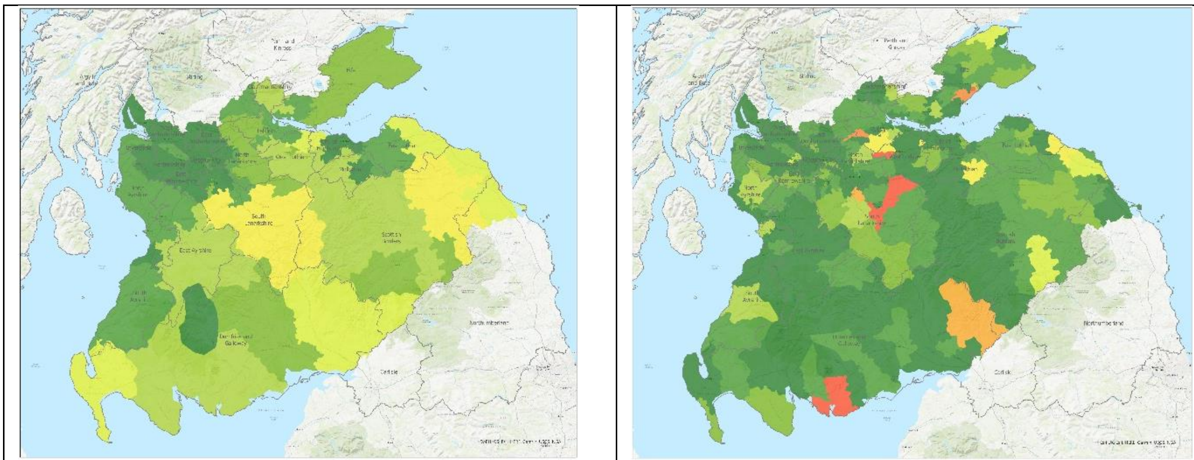
Accurate fault level information is key to planning, operations, and management of the electrical networks. Historically network fault level assessments are based on analytical models which typically consider worst case scenarios and can be sensitive to third party data, National Grid generation dispatch, machine responses, network configurations. Fault Level modelling is becoming more complex at all voltage levels with generating technology advancement, network automation etc. Understanding maximum fault levels is required for equipment specification, protection studies and system earthing design/assessment which ensure safe operation of the network.

There is a strong requirement to obtain visibility of actual fault levels and how they vary in constrained locations. Where appropriate, this can then be used to drive advance network automation solutions to reconfigure network and constrain generation to maintain fault level limits.

3.1 Forecast Generation

Growth in generation connections is expected to continue and indeed accelerate as UK generation decentralises to meet Net Zero targets. SP Energy Networks (SPEN) Distribution Future Energy Scenarios (DFES) forecast that by 2030 distribution generation could up to triple in SPD (reaching 6.9GW) and more than double in SPM (reaching 5.5GW).

All scenarios show a significant increase in generation. Most of the increase in capacity is expected to come from wind, PV, and storage. Figure 3-1and Figure 3-2 shows the geographical and technology split of the DFES generation forecast at 2030 and 2050 across the four DFES scenarios.



GSP level forecast | Primary level forecast

Figure 3-1: SPD generation forecast for 2030

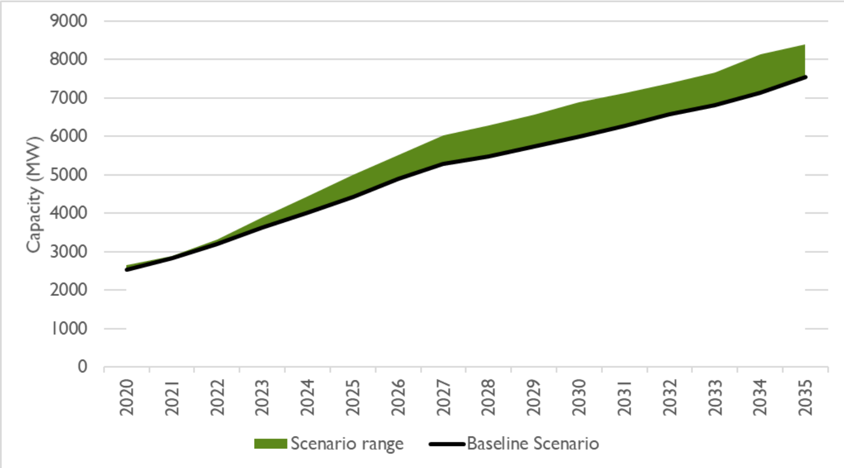
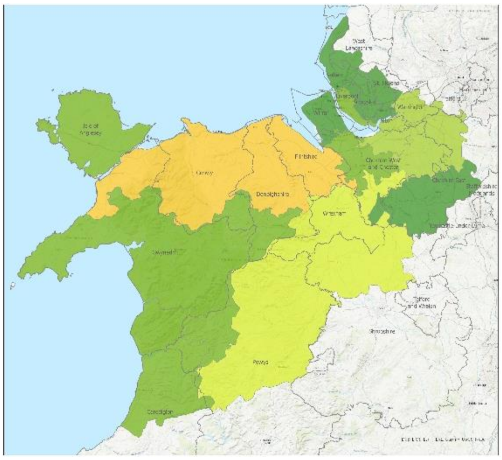
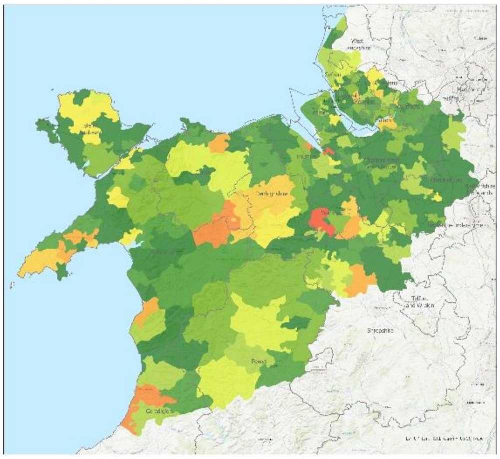


Figure 3-2: SPD range of Net Zero compliant distributed generation forecasts



GSP level forecast



Primary level forecast

Figure 3-3. SPM generation forecast for 2030

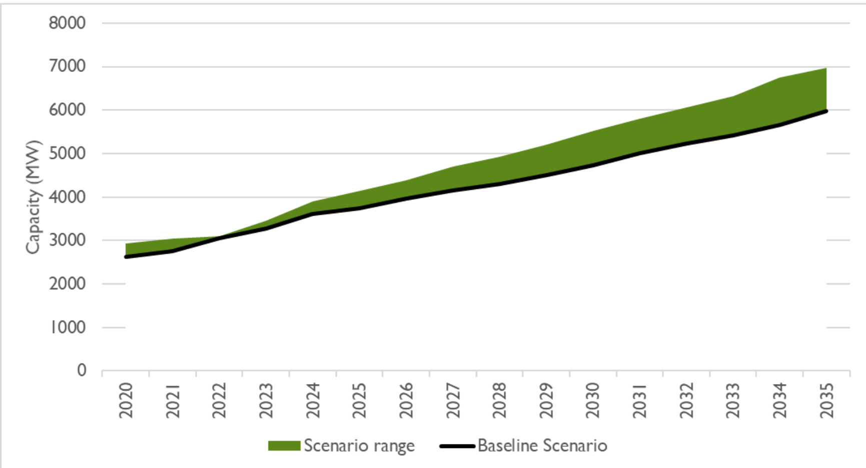


Figure 3-4: SPM range of Net Zero compliant distributed generation forecasts

3.2 Baseline View

Figure 3-5 shows the generation forecast under our Baseline View for the RIIO-ED2 period for both licence areas. As seen, the generation volumes are forecast to increase by up to 1.84GW in SPM and

3.12 GW in SPD areas by 2030. Again, most of the increase in capacity is expected to come from wind, PV, and storage technology types.

As discussed in section 3, the typical fault contribution from these technologies vary from 1x – 5x per each MW connected, this would result in significant fault level contributions. It should be noted that as the generation incidence is diverse across the network, the sites with low fault level headroom will be most affected. Accurate fault level headroom information is vital for these sites which would help in determine the justified level of intervention and investment.

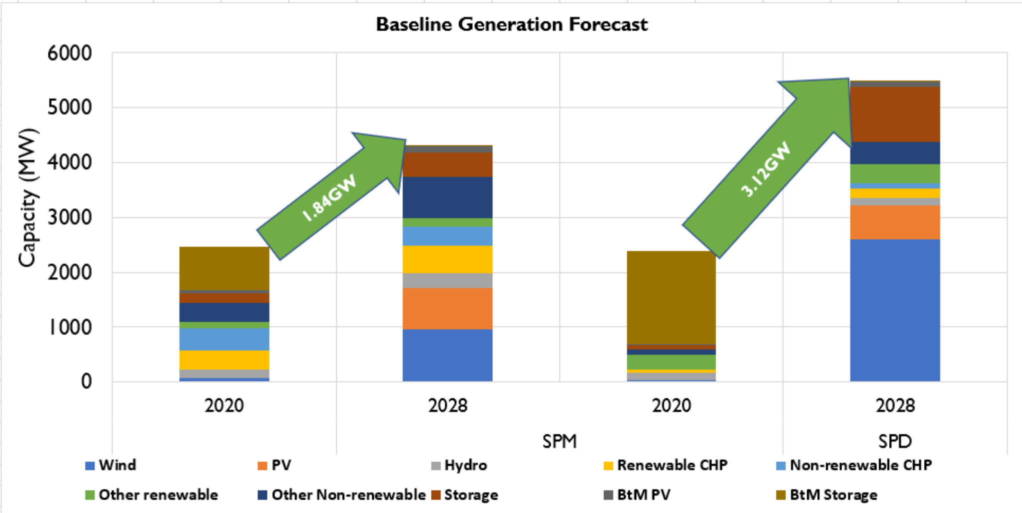


Figure 3-5: Baseline View generation forecasts

3.3 Forecast of Substation Fault Levels

Network wide assessments have been undertaken considering the change in Fault Levels at all Primary, Grid and GSP substations due to the forecast generation. Table 3-1 shows the number of switchboards, not already scheduled for upgrade, which are forecast to exceed 95% of switchgear rating or the network design limit. These assessments include consideration of the growth of fault level infeed due to generation at lower voltages.

Measurement of actual Fault Levels, in real-time, will significantly improve our understanding of the network constraints and allow us to make better informed design decisions at these sites. These help us to calibrate our network fault-level models and will enable more lower cost and timely connections of low carbon generation onto the network.

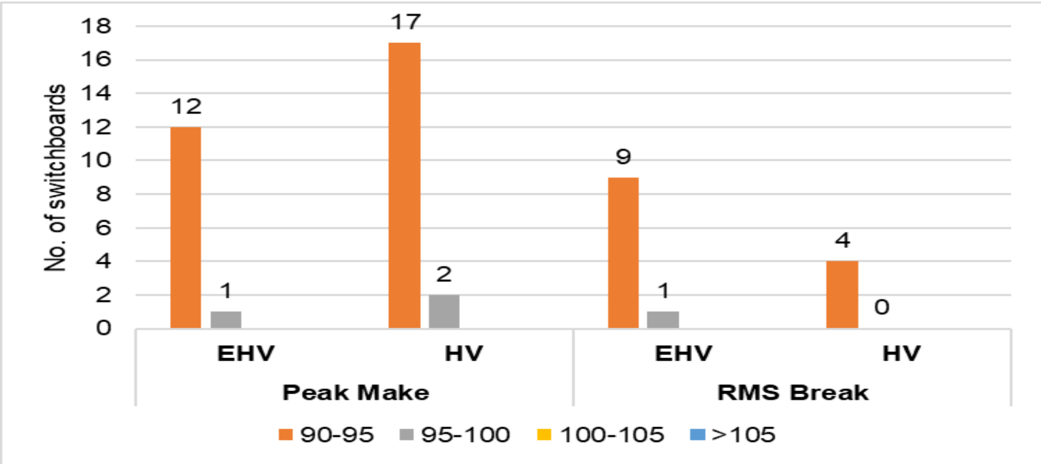


Figure 3-6: SPD switchboards forecast position

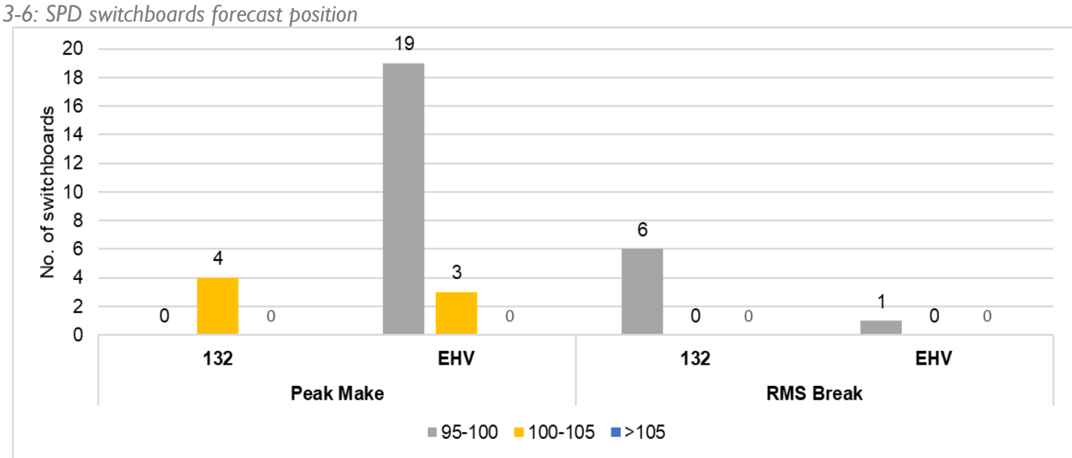


Figure 3-7:SPM switchboards forecast position

Table 3-1: Forecast fault level constrained sites due to DFES generation

Licence area	Voltage Level	Forecast Fault Level Constraints (2028)		
		Sites	Peak Make	RMS Break
SPD	EHV	13	13	10
	HV	19	19	4
SPM	132kV	2	4*	6*
	EHV	19	19	1

* Multiple switchboards at same site.

4 Optioneering

Table 4-1 below presents the options considered for the scheme. 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 innovative solution of fault level monitoring and management is the 'do minimum' requirement for this scheme.

Table 4-1- List of options considered

Option	Description	Status	Reason for rejection
(a)	Do Nothing	Rejected	Fault level limits cannot be exceeded without replacing the limiting equipment or splitting up the network. In areas where there is little Fault Level

			headroom, this can deter new connections, delays low cost and timely connection of low carbon generation onto the network.
(b)	Intervention plan using only Energy Efficiency	Rejected	Rejected as it does not address the network fault level issues.
(c)	Operationally manage the fault level exceedances	Rejected	This option is rejected because the operational management does not create fault level headroom. Besides, there is an inherent safety issue at sites requiring manual switching/control actions.
(d)	Network split points	Rejected	This option is rejected because this could lead to radialised network groups, could exacerbate thermal constraints, reduce security of supply and increased customer restoration times.
(e)	Fault level mitigation through reinforcement (new switchgear, reactor solutions etc)	Considered (**Baseline**)	
(f)	Innovative approach using fault level monitoring and management	Considered (**Option 1**)	
(g)	Fault Current Limiting devices (FCL)	Rejected	Rejected due to the usage of explosive fuse element, which can be a safety issue and requires significant maintenance & operational costs.
(h)	Superconducting Fault Current Limiting devices (SFCL)	Rejected	Rejected as the technology is not ready for BaU and present experience from SPEN trials indicate that maintenance requirements for the cryogenic systems are prohibitive.

Of the considered options, the **Baseline** option involves fault level mitigation through conventional reinforcements, while **Option 1** involves the innovative solution of fault level monitoring and management. While Baseline's conventional reinforcement gives benefit in creating additional fault level headroom but expensive solution, Option 1's fault level monitoring and management facilitates rationalising the fault level reinforcement and defer the need depending on the accurate fault level headroom.

5 Detailed Analysis & Costs

5.1 Proposed Solution (Option 1) – Fault level monitoring and management

The **proposed solution** is innovative and involves real-time fault level monitoring and management to facilitate the access of real-time fault level information and actively managing the network fault levels, which helps in connecting more distributed generation, reducing barriers to transitioning toward a low carbon economy which can be experienced where connections trigger major works, facilitate efficient and safe network operations in real-time and planning time scales and rationalising/optimising the investment towards fault level mitigation.

The proposed solution is not an alternative to conventional reinforcement but facilitates validating the reinforcement need and where possible to defer the reinforcement by making the best use of the network capabilities and extend those capabilities without compromising the network safety and security.

The proposed scheme scope involves installing,

1. Real Time Fault Level Monitor (RTFLM) devices to monitor the fault levels in real-time at individual primary/grid substations approaching the switchgear/design limits.
2. Active Fault Level Management (AFLM) schemes in the network groups where multiple substations are approaching the switchgear/design limits.

5.1.1 Real Time Fault Level Monitor (RTFLM)

RTFLM device is a real-time fault level monitoring device developed by Outram Research Ltd in partnership with SPEN through the NIA funding and has been successfully trialled at HV and EHV voltage levels. The device uses the previous successfully trialled/tested NDFLM(PM7000FLM[1]), coupled with a built in artificial disturbance generator to create a series of artificial network disturbances over a short period of time which are read by the device and estimates the fault levels in near real-time (typically <20s) at primary/grid substations and can be ideally transmitted on demand in real time over the SPEN's Operational Data Network(ODN) to the control room or integrated with PowerOn to help the control engineer with operational switching. The estimated fault level information is available in the form of Peak Make fault level and RMS Break fault levels, for both upstream and downstream fault current flows. Figure 5-1 shows the simplified working topology and the electrical connectivity of an RTFLM device[2].

The RTFLM kit requires LV supplies to create the artificial disturbances and a voltage transformer at the monitored primary/grid substation. It should be noted that estimated fault levels are sensitive to the level of network interconnection, the accuracy is better when connected LV supplies directly to the measured node/busbar ideally secondary transformer for monitoring HV node and via dedicated auxiliary transformer for monitoring EHV node. The RTFLM tests within the RIIO-ED1 period have shown that, with the appropriate measurement configurations, the devices can estimate the fault levels within 1% error margin when compared to the analytical models which is well below the acceptable margin of 5%.

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[1] https://www.outramresearch.co.uk/fault-level-monitoring/pm7000-flm/

[2] M Khaddoumi et. al, "Real Time Fault Level Monitoring for Network Capacity Management", Cigre Paris Session 2020.

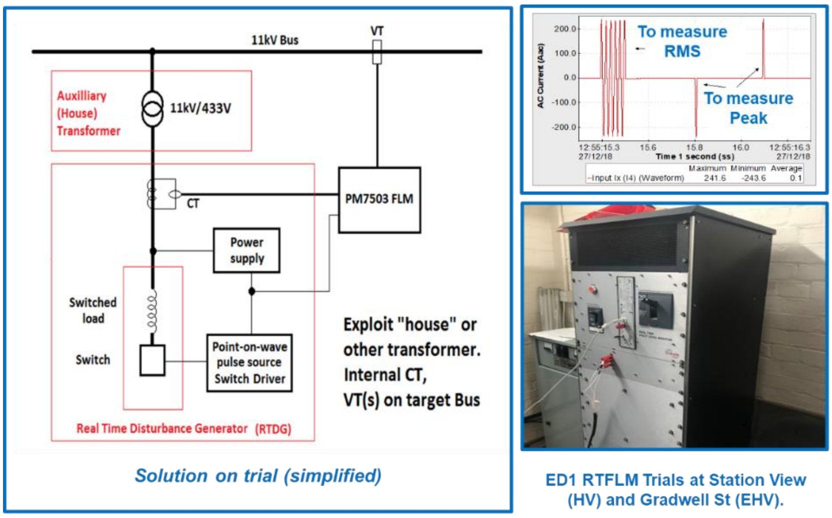


Figure 5-1: RTFLM topology and electrical connections

5.1.2 RTFLM Scope

The scheme proposes to deploy RTFLM devices at substations where the switchgear duties assessed falls in the criteria listed below,

1. Peak Make duty >=95% and <100%, and/or
2. RMS Break duty >=90% and <95%.

The above criterion is selected considering the error margins of measurements and based on the operational practise that the make duty exceedances are manageable and break duty exceedances are more onerous compared to make duties. The deployment at the sites meeting this criterion can give accurate fault level information, thereby the actual fault level headroom. For sites exceeding 100% duty, the guidance specified in design policy document ESDD-02-014 is applicable.

Within the RIIO-ED2 period, under the proposed scheme, 22 primary substations in SPD and 16 primary substations in SPM area are identified as target sites for deployment of RTFLM to monitor the fault levels. It should be noted that, in SPM area, 6 primary substations have been identified for RTFLM deployment as part primary substation fault level mitigation scheme, ED2-LRE-SPM-004-CV3, and will be part of the overall portfolio of real-time fault level monitoring. The full list of SPD and SPM sites selected for RTFLM deployment are listed in Appendix - 8.1 and Appendix - 8.2.

5.1.3 Active Fault Level Management (AFLM)

The main objective of an AFLM scheme is to manage network fault levels in real-time by actively controlling the existing network assets and/or altering network configuration while ensuring the network operates within the switchgear/design limits and security of supply is maintained. The AFLM controls network topology in real-time, thereby actively managing the network fault levels using a predefined set of logic tables involving the real-time status of the network switching points (circuit breakers) of cable/OHL circuits, transformers, series reactor and bus sections etc. The AFLM schemes use Smarter Grid Solutions (SGS) proprietary ANM Strata[3] platform to host the network configuration logic tables and makes decisions to reduce fault level in the network. The AFLM scheme, where possible, can be extended to control the distribution generation connectivity, thereby facilitating flexible & non-firm connections to maximise opportunities for new DER connections otherwise restricted by fault level issues where such connections trigger major reinforcement works. Figure 5-2 shows the high level functional of AFLM device.

[3] https://www.smartergridsolutions.com/products/strata-grid/

Within the RIIO-ED1 period, SPEN collaborated with SGS under NIA project (NIA_SPEN0014) to trial the AFLM concept in multi-phased approach. Phase 1 and 2 were aimed at developing the AFLM concept, modelling and simulating deployment to a case study network and demonstrating its functionalities. Phase 3 of the project proceeds to deploy to AFLM on a live network to advance the solution and to demonstrate the functionality using the predefined logic tables and real-time fault level measurements from the monitored substations in the network.

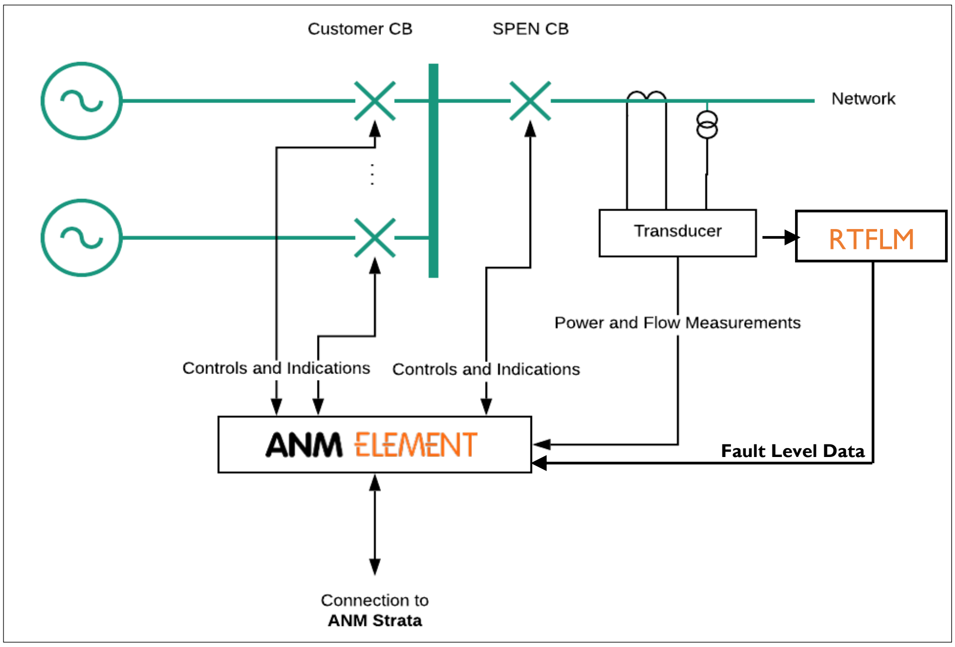


Figure 5-2: AFLM high-level functional layout

5.1.4 AFLM Scope

The application of AFLM is towards network groups with multiple substations approaching/exceeding the fault level limits. These groups are with little to no fault level headroom, requiring fault level mitigation at multiple substations and usually deter any future generation connections due to requiring costly reinforcement solutions and lengthy connection time scales.

For such groups, alternate network running configurations like keeping a transformers on open-standby, opening bus section circuit breakers and/or closing bus section/series rectors etc, can reduce the fault levels and create additional fault level headroom, while operating the group within the network limits and maintaining security of supply. Additionally, the AFLM schemes can be applied to network groups, with high levels of forecast generation which collectively could exceed the fault level limits in the group. Where applicable, offering this new generation connection flexible and non-firm connections (in line with design policy ESDD-01-009, Flexible Connections and Principles of Access Policy), the generation can be connected/disconnected from the network to operate the group within fault level limits.

The advantages of this AFLM solution are:

- Will facilitate future connections at lower cost and in shorter time scales without being dependent on the required network reinforcement.
- Provides better value for customers as a single co-ordinated platform is more cost efficient than individual, bespoke and non-coordinated flexible connections.
- Facilitates real-time operation and control of customers connected to the Distribution network which is a pre-requisite for transitioning toward a Distribution System Operator (DSO).

- Aligns with licence obligations to develop, operate & maintain an efficient and coordinated distribution system.

Across both licences, within the RIIO-ED2 period, 2 grid groups in SPM and 1 GSP in SPD are selected for deployment of AFLM, the sites are listed in Appendix - 8.1.

5.1.5 Cost Estimates & Capital Expenditure

Table 5-2 to Table 5-1 shows the unit costs, costing and volumes breakdown, cost incidence and volumes incidence for the proposed scheme (in 2020/21 prices).

Table 5-1- Unit Costs for the proposed option

Solution	Unit Cost	Description
RTFLM1 (kit alone)	£ 50,000	The costs are associated with purchase and kit installation. No auxiliary supply transformer required
RTFLM2 (kit + aux. transformer)	£ 75,000	The costs are associated with purchase and kit installation. The costs also include additional auxiliary transformer for drawing LV supplies for the kit
AFLM	£ 100,000	The costs associated with purchase and kit installation.

Table 5-2- Cost and Volumes for the proposed option

Licence area	Asset Type	No of sites	Unit Cost(£m)	Total Cost(£m)
SPM	RTFLM1	13	0.05	0.650
	RTFLM2	3	0.075	0.225
	AFLM	2	0.100	0.200
SPD	RTFLM1	17	0.05	0.850
	RTFLM2	5	0.075	0.375
	AFLM	1	0.100	0.100
			Total Expenditure	**2.400**

Table 5-3- Cost incidence of proposed option

Licence area	Total (£m)	2023/23	2024/25	2025/26	2026/27	2027/28
SPD	1.325	0.325	0.550	0.450	-	-
SPM	1.075	0.200	0.325	0.250	0.150	0.150
CV3 (Fault Level Reinforcement)	2.400	0.525	0.875	0.700	0.150	0.150

Table 5-4- Volumes of proposed option

Licence area	Solution	2024	2025	2026	2027	2028
SPD	RTFLM1	5	6	6	-	-
	RTFLM2	1	2	2	-	-
	AFLM	-	1	-	-	-
SPM	RTFLM1	1	3	3	3	3
	RTFLM2	2	1	-	-	-
	AFLM	-	1	1	-	-

5.1.6 Fault Level capacity release

With the deployment of real-time fault level monitoring on the network and the measured fault level headroom available, it is anticipated that additional generation can be accommodated within the network groups based on the measure data.

Based on the current network fault levels, an estimation is carried to determine the generation volumes that can be accommodated post installation of real-time fault level monitoring and management. It is estimated generation capacity of ca. 59MW in SPM and ca. 103MW in SPD could be accommodated. The site wise capacity release is provided in the Appendix in Table 8-5 and Table 8-6.

5.2 Baseline (Conventional) - Fault level mitigation through reinforcement

This option considers traditional fault level reinforcements at sites forecast to approach/exceed fault level limits. The conventional strategy of fault level mitigation is usually:

- Switchgear rated below design limits – Replant / replace the switchgear rated above design limits
- Switchgear rated at/above the design limits – Install fault limiting equipment such as series reactors or replant the in-feeding transformer with higher impedance etc.

Table 5-5 shows the asset volumes and costs in both SPD and SPM license areas identified requiring fault level mitigation through conventional reinforcements.

Table 5-5- Cost and Volumes for the Option 1

Licence area	Asset Type	No. of sites	Volumes	Cost (£m)	Total Cost(£m)
SPM	33kV RMU replacement	12	16	5.700	13.436
	33kV CB (Indoor) replacement	6	20	3.485	
	Series reactors on 33kV network	2	5	4.250	
SPD	11kV CB (Indoor) replacement	9	133	5.158	31.743
	33kV CB (Indoor) replacement	3	42	7.319	
	33kV CB (Outdoor) replacement	1	15	2.066	
	Series reactors in Grid transformer tails (SPT solution)	6	6	13.800	
	33kV Bus section reactors (SPD solution)	4	4	3.400	
				Total Costs (£m)	**45.179**

5.3 Options Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5-6.

Table 5-6 –Technical summary for Baseline option

Options	Summary	Total Costs (£m)
Baseline	Fault level mitigation through reinforcement	45.179
Option 1	Innovative approach using Fault Level Real-time Monitoring and Management	2.400

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. The costs for Option -1 is based on the derived costs from our ongoing trials in the RIIO-ED1 period.

6 Deliverability & Risk

6.1 Preferred Options & Output Summary

The adopted option is the Option 1, an innovative solution to operationally manage the fault levels through real-time monitoring and management and it be noted that there is no additional fault level headroom created by deploying fault level monitors.

The adopted will help estimate the network fault levels accurately, thereby giving greater visibility of actual network fault levels and enables to accommodate more generation whilst triggering fewer equipment replacements / network reconfigurations.

6.2 Cost Benefit Analysis

A cost-benefit analysis was carried out to compare the NPV of the baseline and alternate options discussed in the previous sections. Considering the lowest forecast capital expenditure, the adopted option i.e., Option 1 has the highest NPV as it can defer the reinforcement need beyond the RIIO-ED2 period. Based on the outcome of the CBA, the 'Option 1' is adopted which is an innovative solution. The summary of the cost benefit analysis is presented in Table 6-1. The full detailed CBA is provided within "ED2-LRE-SPEN-001-CV3-CBA- Fault Level Monitoring and Management."

Table 6-1: Summary of Cost Benefit Analysis

Options	Description	Decision	Comment	NPVs based on payback periods from 2023/24 (£m)			
				10 years	15 years	30 years	45 years
Baseline	Conventional reinforcement- Replant /replace the switchgear and/or fault limiting options such as series reactors	Rejected	The conventional reinforcement solution does not offer cost benefit compared to the innovation solution				
Option 1	Fault level monitoring and management	**Adopted**		7.62	6.40	5.60	4.86

6.3 Cost & Volumes Profile

Table 6-2 shows the breakdown of expenditure for the proposed scheme (in 2020/21 prices) and the cost incidence (in 2020/21 prices) over the RIIO-ED2 period is shown in Table 6-3. The total cost of the proposed scheme is £2.40m.

Table 6-2- Cost and Volumes for the adopted options

Licence area	Asset Type	No of sites	Unit Cost(£m)	Total Cost(£m)
SPD	RTFLM	17 / 5 (22)	0.05/0.075	1.225
	AFLM	1	0.100	0.100
SPM	RTFLM	13 / 3 (16)	0.05/0.075	0.825
	AFLM	2	0.100	0.200
			Total Costs (£m)	**2.400**

Table 6-3- Cost incidence over the RIIO-ED2 of adopted option

Licence area	Total (£m)	2023/23	2024/25	2025/26	2026/27	2027/28
SPD	1.325	0.325	0.550	0.450	-	-
SPM	1.075	0.200	0.325	0.250	0.150	0.150
CV3 (Fault Level Reinforcement)	2.400	0.525	0.875	0.700	0.150	0.150

6.4 Risks

SPEN have successfully trialled and tested the real-time faut level monitors (both passive/NDFLM and active/RTFLM types) in the RIIO-ED1 period. The active fault level management (AFLM) phased trials are ongoing in SPM's Warrington area expected to complete by the end of RIIO-ED1 period. The learnings from these completed and ongoing trail will benefit in the delivery of the adopted solution.

SPEN also has been actively engaging with the manufacturers in design and customising the equipment to best fit the needs of SPEN networks. The suitable network configurations were also being assessed to optimise the costs for deploying the RTFLM devices.

The proposed sites are earmarked based on the forecast generation growth and the consequential increase in fault levels. As the monitoring will provide better visibility of fault levels, this will help in rationalise the investment towards fault level mitigation thereby reducing the network risks. Further, the requirement for fault level mitigation requirement is expected to be sooner in the SPD licence area compared to SPM due to the higher forecast generation volumes (3GW in SPD compared to 1.69GW in SPM) and this is reflected in the proposed delivery schedule over the RIIO-ED2 period.
Network areas, where accelerated uptake of generation connections compared to the Baseline forecast, will be prioritised in terms of fault level monitoring and management and therefore the delivery of the scheme should be amenable.

Other key risks / constraints include the

1. Co-ordinating the outage seasons with the overall RIIO-ED2 delivery plan to install/accommodate the monitoring devices.
2. Supply and installation of the monitoring equipment to align with overall RIIO-ED2 plan.
3. Monitored sites that show probable fault level exceedance require conventional mitigation solution (see Section 6.6.3)

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 driver for the proposed reinforcement is to accurately measure and to manage the network fault levels in real-time, thereby to facilitate efficient and safe network operations in real-time and planning time scales and rationalising/optimising the investment towards fault level mitigation

6.6.2 Payback Periods

The CBA indicates that a positive NPV result in all assessment periods (10, 15, 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 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 both SPD and SPM areas,
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.

Table 6-4: Scale of investment

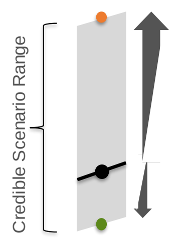
	End of ED2 2028	Solution Type	SPD Cost (£m)/Sites (#)	SPM Cost (£m)/Sites (#)	Total Cost (£m)/Sites (#)
	High	Conventional & Innovation	5.075 / 23	5.887 / 18	10.952 / 41
	Baseline	Innovation	1.375 / 23	1.075 / 18	2.400 / 41
	Low	Innovation	1.375 / 23	1.075 / 18	2.400 / 41

Table 6-5: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	2.400	8.802
Comment	Proposed option.	Additional expenditure under high uptake of generation.

The proposed solution is innovative and enables to manage the network fault levels for the generation growth as per the Baseline forecasts. For the higher generation growth scenarios, the fault levels at some of the proposed sites is likely to exceed the switchgear/design limits requiring additional interventions as shown in Table 6-6. The RIIO-ED2 regulatory framework will need to allow DNOs' allowances to flex in response to higher uptakes.

Table 6-6: Additional volumes and cost under high uptake scenarios.

Licence Area	Substation	Switchgear Type	Reinforcement	Costs (£m)
SPD	CHAPELCROSS GSP	33kV CB ID/GM	1 x BS reactor + 2 x CBs	0.850
	COATBRIDGE GSP	33kV CB ID/GM	1 x BS reactor + 2 x CBs	0.850
	WESTERTON	33kV CB ID/GM	Series Reactors in SGT tails	2.300
SPM	HOOTON PARK GRID 'B'	33kV CB/ID/GM	Grid board change (10 panels)	1.700
	BOOTLE GRID 'B'	33kV CB/ID/GM	Grid board change (14 panels)	2.400
	YORKSHIRE IMPERIAL METALS	33kV RMU	2 x RMU changes	0.702
			Total Cost(£m)	**8.802**

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. Further to this, the RTFLM devices are nearly 'plug & play' in terms of installation, hence they can be moved around the network where needed.

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. Solution selection was not found to be sensitive to the impact of the carbon cost of losses.

Losses have been considered as part of this design solution and it has not been necessary to carry out any losses justified upgrades.

As part of the Baseline option, series reactors were considered as conventional reinforcements at sites exceeding design limits but within the switchgear ratings. As such the series reactors would increase the network losses, however these would be evaluated during the design stage of the scheme.

6.6.6 Whole Systems Benefits

The capacity and capability of the preferred option is consistent with the provision of whole system solutions.

6.7 Sustainability and Environmental Considerations

The adopted solution will take account sustainability initiatives associated with this scheme and reflect wider licenced business sustainable development objectives set out in the Environmental Action Plan (EAP). The scheme will avoid environmental impacts where possible and provide mitigation and improvements when required, and all relevant environmental and planning consents will be secured.

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. For the Baseline option involving conventional build solution, the CO2 emissions based on the asset category are calculated and included in the CBA. The installation of the series reactors will increase the network losses in the group and hence the resulting in additional CO2 emissions that form part of SPEN's Business Carbon Footprint; however this adopted option represents a lower life-time cost than the alternative option of replacing the switchboard.

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 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 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 primary driver for the expenditure is to drive innovation in terms of monitoring and managing the network fault levels while accommodation further generation connections in the constrained areas. This engineering justification paper proposes an innovative solution of deploying RTFLM / AFLM devices to measure, monitor and to manage the network fault levels in real-time, thereby facilitating efficient and safe network operations in real-time and planning time scales and rationalising/optimising the investment towards fault level mitigation and where possible deferring the network's reinforcement need. The proposed option also provides accurate fault level headroom in the network, thereby facilitating the opportunity to accommodate more distributed generation without driving additional reinforcements, can lead to faster connection time scales through the RIIO-ED2 period and probably beyond.

Summary of the proposed scheme:

- Install RTFLM devices at 22 in SPD and 16 sites in SPM areas to monitor the fault levels in real-time
- Install AFLM schemes at 1 GSP in SPD and 2 grid groups in SPM to manage the fault levels in real-time.

The total cost of the scheme is £2.4m under Fault Level Reinforcement (CV3) fully funded by SPEN in the RIIO- ED2 period.

It is anticipated that under high generation uptake scenarios, few of the substations in both licence areas are expected to exceed the switchgear/design limits requiring conventional/build solutions to mitigate, the additional(uncertain) costs are forecast to £8.802m.

8 Appendices

8.1 Proposed fault level solutions in RIIO- ED2

Table 8-1: Proposed SPD sites for fault level monitoring and management

Substation	Voltage kV	Switchgear Type	Equipment Rating (kA)		Max Duty (%)	Proposed Solution
			Peak Make	RMS Break		
BATHGATE GSP	33	33kV CB ID/GM	50	17.5	92	RTFLM
BONNYBRIDGE GSP	33	33kV CB ID/GM	50	17.5	90	RTFLM
RENFREW FERRY	11	11kV CB ID/GM	32.8	13.12	92	RTFLM
CHAPELCROSS GSP	33	33kV CB ID/GM	50	17.5	92	RTFLM
COATBRIDGE GSP	33	33kV CB ID/GM	50	17.5	94	RTFLM
DEVONSIDE GSP	33	33kV CB ID/GM	50	17.5	94	RTFLM
WESTERTON	11	11kV CB ID/GM	32.8	13.12	93	RTFLM
DEANS	11	33kV CB ID/GM	32.8	13.12	95	RTFLM
EASTERHOUSE GSP	33	33kV CB ID/GM	50	17.5	94	RTFLM
ERSKINE	11	11kV CB ID/GM	32.8	13.12	98	RTFLM
GOVAN GSP	33	33kV CB ID/GM	50	17.5	93	RTFLM
POLMONT	11	11kV CB ID/GM	32.8	13.12	93	RTFLM
HUNTERSTON FARM GSP	33	33kV CB ID/GM	43.75	17.5	93	RTFLM
KILMARNOCK SOUTH GSP	33	33kV CB D/GM	50	17.5	92	RTFLM
LEVEN GSP	33	33kV CB ID/GM	50	17.5	94	RTFLM
NEWHOUSE	11	11kV CB ID/GM	32.8	13.12	93	RTFLM
REDHOUSE GSP	33	33kV CB ID/GM	50	17.5	90	RTFLM
SALTCOATS MAIN	11	11kV CB ID/GM	32.8	13.12	94	RTFLM
SHRUBHILL GSP	33	33kV CB ID/GM	50	17.5	96	AFLM/ RTFLM
GIRVAN	11	11kV CB ID/GM	32.8	13.12	91	RTFLM
WEST GEORGE STREET GSP	33	33kV CB ID/GM	43.75	17.5	94	RTFLM
WESTBURN ROAD	11	11kV CB ID/GM	32.8	13.12	94	RTFLM
WISHAW GSP	33	33kV CB ID/GM	50	17.5	95	RTFLM

Table 8-2: Proposed SPM sites for fault level monitoring and management

Substation	Voltage kV	Switchgear Type	Equipment Rating(kA)		Max Duty (%)	Proposed Solution
			Peak Make	RMS Break		
EAST PRESCOT RD (FINCH LANE)	33/11	33kV RMU	33.46	13.10	97	RTFLM
HOOTON PARK GRID 'B'	33	33kV CB / ID / GM	33.46	13.10	99	RTFLM
BOOTLE GRID 'B'	33	33kV CB / ID / GM	33.46	13.10	99	RTFLM
DEESIDE IND PK 6TH AVENUE	33/11	33kV RMU	43.75	17.5	98	RTFLM
HALEWOOD GRID	33	33kV CB / ID / GM	33.46	13.10	98	RTFLM
ACORNFIELD RD	33/11	33kV RMU	33.46	13.10	97	RTFLM
YORKSHIRE IMPERIAL METALS	33/11	33kV RMU	33.46	13.10	97	RTFLM
CROSSFIELDS	33/11	33kV RMU	33.46	13.10	97	RTFLM
PARADISE ST GRID	33	33kV CB / ID / GM	43.75	17.5	95	RTFLM

SOLVAY INTEROX	33/11	33kV RMU	33.46	13.10	95	RTFLM
ST ASAPH GRID (HOLYWELL/RHYL/ST ASAPH GRID GROUP)	33	33kV CB / ID / GM	62.5	25	101*	AFLM/ RTFLM
OSWESTRY GRID (LEGACY/NEWTOWN/ OSWESTRY/ WELSHPOOL GRID GROUP)	33	33kV CB / ID/ GM	62.5	25	106*	AFLM/ RTFLM

*Exceeding design limits, but well within switchgear limits

8.2 Additional SPM sites for fault level monitoring in RIIO-ED2 period

The following are the 6 proposed sites for RTFLM deployment proposed as part of SPM primary substation fault level mitigation scheme (ED2-LRE-SPM-004-CV3-EJP).

Table 8-3: Additional SPM sites for fault level monitoring

Substation	Voltage kV	Substation Type	Equipment Rating(kA)		Max Duty (%)	Proposed Solution
			Peak Make	RMS Break		
STONEYCROFT	33/11	33kV RMU	33.46	13.1	96	RTFLM
STOCKTON HEATH	33/11	33kV RMU	32.8	13.1	96	RTFLM
NORTHGATE TERRACE	33/11	33kV RMU	33.46	13.1	95	RTFLM
JACOBS	33/11	33kV RMU	33.46	13.1	95	RTFLM
SUBURBAN RD	33/11	33kV RMU	32.8	13.1	95	RTFLM
HAWLEYS LANE	33/11	33kV RMU	33.46	13.1	95	RTFLM

8.3 SPEN Fault Level design limits

Table 8-4 shows the maximum Fault Level design limits for SPEN substations at each voltage level.

Table 8-4: SPEN Distribution network 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
132	50	20	62.5	25
EHV	43.74 / 44.61 / 50	17.5	12.5	5
HV	32.8	13.1	32.8	13.1

8.4 Estimated Generation Capacity Release

Table 8-5 and Table 8-6 shows estimated generation capacity release for each site.

Table 8-5: SPD generarion capacity release volumes

Substation	Voltage	Equipment Rating (kA)		Max Duty (%)	Proposed Solution	Capacity released (MW)
	kV	Peak Make	RMS Break			
ERSKINE	11	32.8	13.12	98	RTFLM	4.24
BATHGATE GSP	33	50	17.5	92	RTFLM	5
DEANS	11	32.8	13.12	95	RTFLM	0
BONNYBRIDGE GSP	33	50	17.5	90	RTFLM	8
CHAPELCROSS GSP	33	50	17.5	92	RTFLM	5
COATBRIDGE GSP	33	50	17.5	94	RTFLM	2
DEVONSIDE GSP	33	50	17.5	94	RTFLM	2
EASTERHOUSE GSP	33	50	17.5	94	RTFLM	2
SALTCOATS MAIN	11	32.8	13.12	94	RTFLM	2.3
GOVAN GSP	33	50	17.5	93	RTFLM	3
WESTBURN ROAD	11	32.8	13.12	94	RTFLM	0.92
WESTERTON	11	32.8	13.12	93	RTFLM	3.5

HUNTERSTON FARM GSP	33	43.75	17.5	93	RTFLM	3
POLMONT	11	32.8	13.12	93	RTFLM	0.75
KILMARNOCK SOUTH GSP	33	50	17.5	92	RTFLM	5
NEWHOUSE	11	32.8	13.12	93	RTFLM	1.52
LEVEN GSP	33	50	17.5	94	RTFLM	2
RENFREW FERRY	11	32.8	13.12	92	RTFLM	4.19
REDHOUSE GSP	33	50	17.5	90	RTFLM	8
SHRUBHILL GSP	33	50	17.5	96	AFLM/RTFLM	39
GIRVAN	11	32.8	13.12	91	RTFLM	0
WEST GEORGE STREET GSP	33	43.75	17.5	94	RTFLM	2
WISHAW GSP	33	50	17.5	95	RTFLM	0
						103.1

Table 8-6: SPD generarion capacity release volumes

Substation	**Voltage**	**Equipment Rating(kA)**		**Max Duty (%)**	**Proposed Solution**	**Capacity released (MW)**
	kV	**Peak Make**	**RMS Break**			
OSWESTRY GRID(LEGACY/NEWTOWN/ OSWESTRY/ WELSHPOOL GRID GROUP)	33	62.5	25	106	AFLM/RTFLM	15.68
ST ASAPH GRID (HOLYWELL/RHYL/ST ASAPH GRID GROUP)	33	62.5	25	101	AFLM/RTFLM	15
HOOTON PARK GRID 'B'	33	33.46	13.1	99	RTFLM	0
BOOTLE GRID	33	33.46	13.1	99	RTFLM	7.83
DEESIDE IND PK 6TH AVENUE	33/11	43.75	17.5	98	RTFLM	3.56
HALEWOOD GRID	33	33.46	13.1	98	RTFLM	0
EAST PRESCOT RD (FINCH LANE)	33/11	33.46	13.1	97	RTFLM	0
ACORNFIELD RD	33/11	33.46	13.1	97	RTFLM	0
YORKSHIRE IMPERIAL METALS	33/11	33.46	13.1	97	RTFLM	0
CROSSFIELDS	33/11	33.46	13.1	97	RTFLM	0
STONEYCROFT	33/11	33.46	13.1	96	RTFLM	2.37
STOCKTON HEATH	33/11	32.8	13.1	96	RTFLM	5.32
NORTHGATE TERRACE	33/11	33.46	13.1	95	RTFLM	3.09
JACOBS	33/11	33.46	13.1	95	RTFLM	4.5
SUBURBAN RD	33/11	32.8	13.1	95	RTFLM	0
HAWLEYS LANE	33/11	33.46	13.1	95	RTFLM	1.88
PARADISE ST GRID	33	43.75	17.5	95	RTFLM	0
SOLVAY INTEROX	33/11	33.46	13.1	95	RTFLM	0
						59.23

8.5 SPM AFLM: St Asaph Grid (Holywell – Rhyl – St Asaph group)

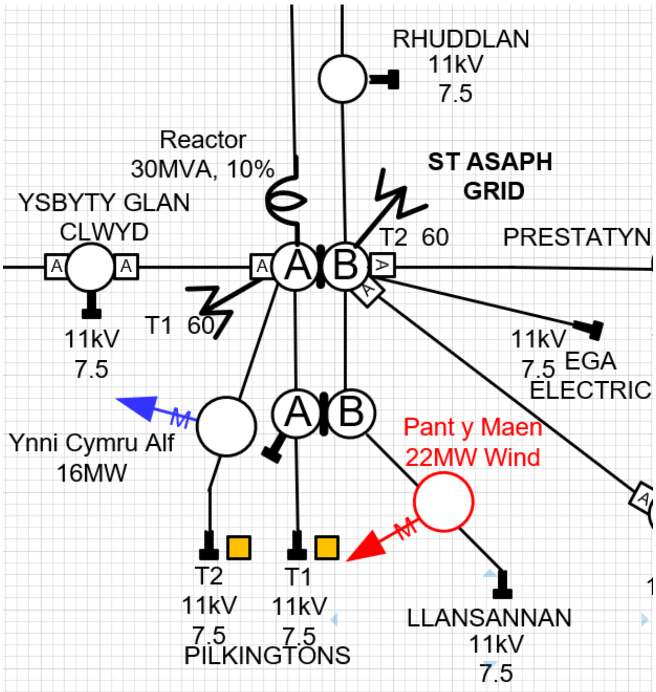


Figure 8-1: St Asaph grid substation

- At St Asaph grid, the future fault levels will exceed the limits of the substation (Peak make – 101% and RMS Break - 93%). Also fault levels St Asaph Business Park primary substations likely to exceed 95% of design limits.
- Type-2 assessments indicate fault current flows will exceed the switchgear duty of the breaker on the radial feed to EGA Electric primary substation.
- This grid group is an interconnected group of Holywell, Rhyl and St Asaph grid substations., total of 5 grid infeeds. The group is 'security of supply' complaint for future demand growth with a firm capacity 113MVA.
- **Proposed AFLM solution scope is monitor status of both St Asaph grid transformers and take one of them on open-standby under high fault level conditions.**

8.6 SPM AFLM: Oswestry Grid (Legacy - Newtown - Oswestry – Welshpool Group)

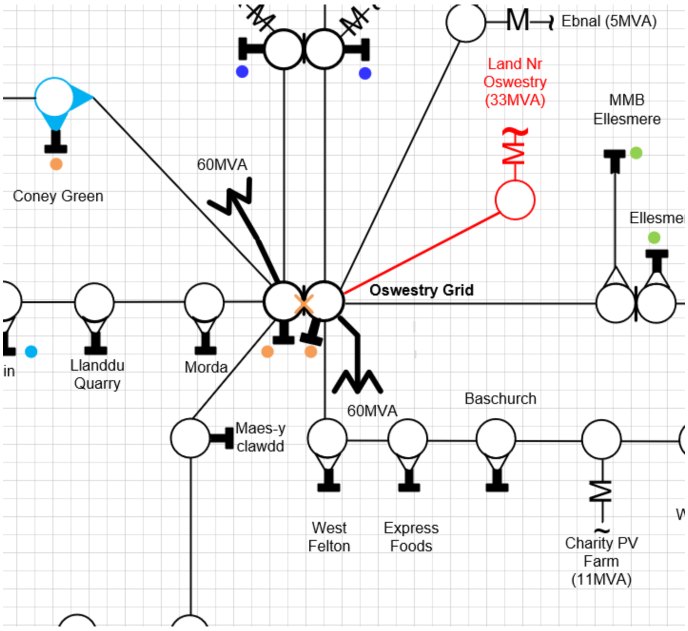
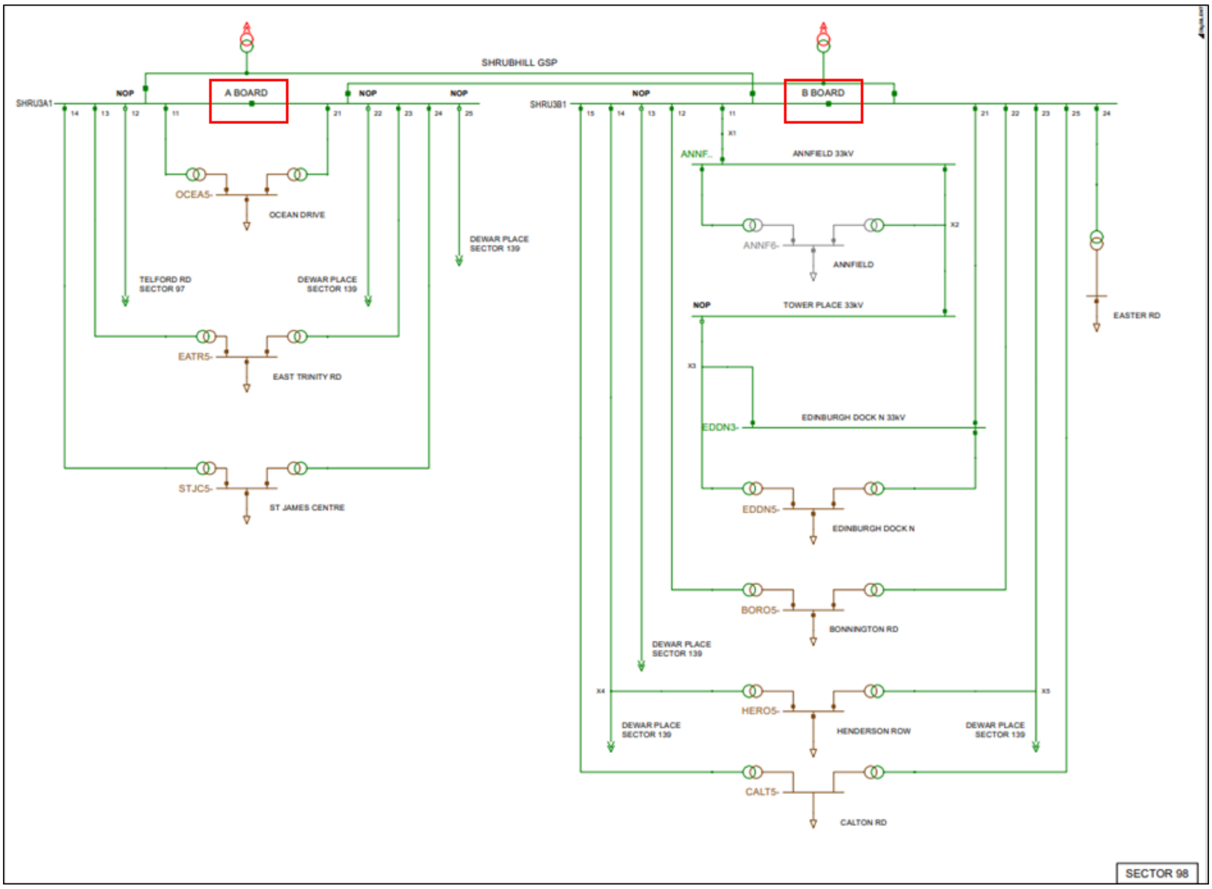


Figure 8-2: Oswestry grid substation

- At Oswestry grid substation, existing fault levels exceeding the design limits of the substation. (Peak make – 101% and RMS Break -106%). Type-2 assessments indicate fault current flows are within the switchgear ratings(25kA).
- Contracted generation requires the grid site to operate with the bus section breaker open.
- **Proposed AFLM solution scope is to monitor and control the status of future generation to manage the fault levels.**

8.7 SPD AFLM: Shrubhill GSP



- At Shrubhill GSP the future fault levels will be greater than 95% of the design limits. The fault levels at Edinburgh Dock North primary substation will be 90% of design limits.
- **Proposed AFLM solution scope:**
    1. **Monitor and control the status of future generation to manage the fault levels.**
    2. **Monitor the status of bus section breakers on A & B boards, open the bus sections under high fault level conditions.**